# CURRICULUM 2024 (Autonomous)

Version 1.0

# M.TECH
# ELECTRONICS AND COMMUNICATION ENGINEERING

## COMMUNICATION ENGINEERING & SIGNAL PROCESSING

**JAWAHARLAL COLLEGE OF ENGINEERING AND TECHNOLOGY**

**2024-2025**

CURRICULUM

FOR

M. TECH DEGREE PROGRAMME

IN

# COMMUNICATION ENGINEERING & SIGNAL PROCESSING

## 2024 SCHEME

## (AUTONOMOUS)

JAWAHARLAL COLLEGE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University), Jawahar gardens, Mangalam (PO), Ottapalam, Palakkad, Kerala – 679301

Phone: 0466 2344800

Web: www.jawaharlalcolleges.com

Mail: sandeepcs4080.ece@jawaharlalcolleges.com

# JAWAHARLAL COLLEGE OF ENGINEERING AND TECHNOLOGY

## DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

M.TECH DEGREE PROGRAMME

IN

COMMUNICATION ENGINEERING & SIGNAL PROCESSING

CURRICULUM AND FIRST YEAR SYLLABI

2024 SCHEME

| ITEM | BOARD OF STUDIES (BOS) | ACADEMIC COUNCIL (AC) |
|---|---|---|
| DATE OF APPROVAL | | |

HEAD OF THE DEPARTMENT
Chairman, Board of Studies

PRINCIPAL
Chairman, Academic Council

# JAWAHARLAL COLLEGE OF ENGINEERING AND TECHNOLOGY

## VISION OF THE INSTITUTE

Emerge as a center of excellence for professional education to produce high quality engineers and entrepreneurs for the development of the region and the Nation.

## MISSION OF THE INSTITUTE

- To become an ultimate destination for acquiring latest and advanced knowledge in the multidisciplinary domains.
- To provide high quality education in engineering and technology through innovative teaching-learning practices, research and consultancy, embedded with professional ethics.
- To promote intellectual curiosity and thirst for acquiring knowledge through outcome based education.
- To have partnership with industry and reputed institutions to enhance the employability skills of the students and pedagogical pursuits.
- To leverage technologies to solve the real life societal problems through community services.

# DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

## VISION OF THE DEPARTMENT

To become a Centre of Academic Excellence and Research in the field of ECE to raise Engineers with International standards and ethical values with the ability to apply acquired knowledge to find solutions for technologically challenging practical problems.

## MISSION OF THE DEPARTMENT

- To impart high-quality education through innovative and comprehensive instructional materials.
- Establishing suitable environment for students to nurture talent and to obtain entrepreneurial skills and leadership qualities for self and social development.
- To develop research linkage with leading organisations in India.
- To cultivate a committed group of faculty striving for excellence in teaching and research.

- To provide ethical and value-based education for promoting a sense of responsibility towards nation-building, social causes and environment conservation

## PROGRAM OUTCOMES (POs)

Outcomes are the attributes that are to be demonstrated by a graduate after completing the programme

**PO1:** An ability to independently carry out research/investigation and development work in engineering and allied streams

**PO2:** An ability to communicate effectively, write and present technical reports on complex engineering activities by interacting with the engineering fraternity and with society at large.

**PO3:** An ability to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

**PO4:** An ability to apply stream knowledge to design or develop solutions for real world problems by following the standards

**PO5:** An ability to identify, select and apply appropriate techniques, resources and state-of-the-art tool to model, analyse and solve practical engineering problems.

**PO6:** An ability to engage in life-long learning for the design and development related to the stream related problems taking into consideration sustainability, societal, ethical and environmental aspects

**PO7:** An ability to develop cognitive load management skills related to project management and finance which focus on Entrepreneurship and Industry relevance.

The departments conducting the M.Tech programme shall define their own PSOs, if required, and assessment shall also be done for the same.

## PEOs OF THE DEPARTMENT

- To provide a solid foundation in Electronics and Communication Engineering essentials with an attitude to pursue higher education, participation in Research & Development activities, and involvement in lifelong learning & professional development.
- Obtain in-depth knowledge of the core discipline of Electronics & Communication Engineering so that they will be able to establish Engineering Standards and overcome realistic constraints in systematic engineering processes with the incorporation of industries' expectations and design socially accepted and economically feasible solutions in the respective fields.
- To make the student Communicate effectively, lead a team with good leadership traits, and exhibit professional conduct.

## PSOs OF THE PROGRAMME

Graduates will be able to

**PSO 1**: Demonstrate the ability to analyze and solve complex engineering problems in by integrating the knowledge of basic sciences, engineering mathematics, engineering fundamentals, and modern analytical tools, including the application and integration of hardware and software to design and develop innovative systems.

**PSO 2**: Develop the capability to apply interdisciplinary engineering approaches to design, analyze, and implement advanced systems in various specialized fields such as Communications and Signal Processing fostering a proactive attitude towards utilizing modern tools and techniques to create effective and efficient electronic and communication solutions.

# DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

## M. TECH IN ELECTRONICS AND COMMUNICATION ENGINEERING

## COMMUNICATION ENGINEERING & SIGNAL PROCESSING

For the students admitted from 2024

## SCHEDULING OF COURSES

### Knowledge Segments and Credits

Every course of the M. Tech Programme is placed in one of the eleven categories as listed in the following table.

| SL NO | CATEGORY | CATEGORY CODE | CREDIT |
|---|---|---|---|
| 1. | Discipline core courses | DCC | 6 |
| 2. | Programme core courses | PCC | 9 |
| 3. | Programme Elective courses | PEC | 12 |
| 4. | Interdisciplinary Elective courses | IEC | 3 |
| 5. | Audit course | AUC | No Credit |
| 6. | MOOC | MOC | 2 |
| 7. | Internship Programme | INP | 3 |
| 8. | Research Methodology & IPR | RMI | 2 |
| 9. | Mini project | MIP | 2 |
| 10. | Laboratory work | PCL | 2 |
| 11. | Dissertation/Research work | DRW | 27 |
| TOTAL MANDATORY CREDIT | | | **68** |

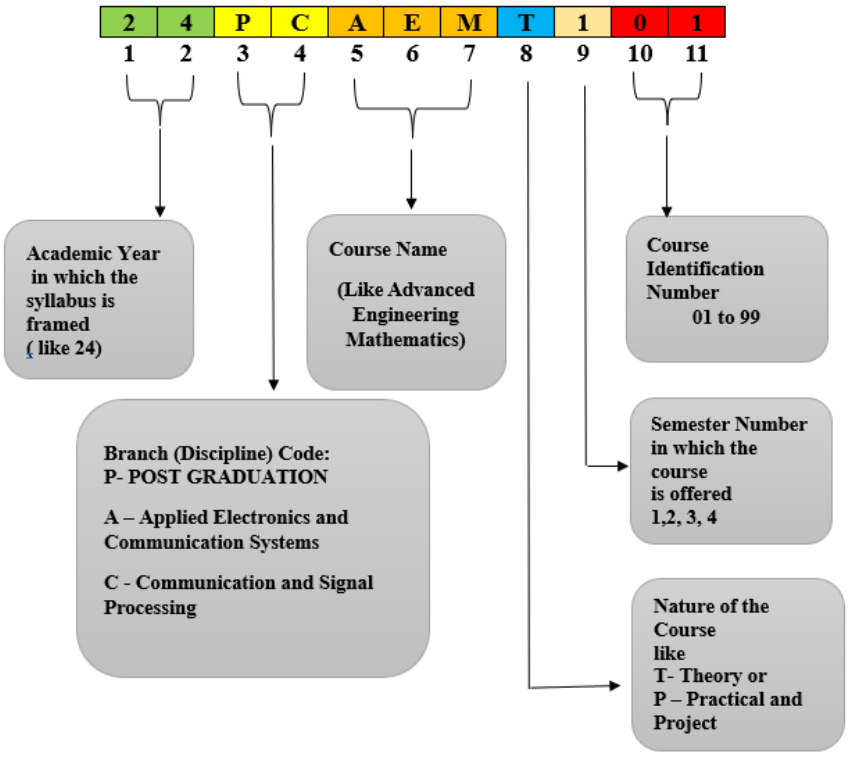
**Semester-wise Credit Distribution**

| SEMESTER | I | II | III | IV | TOTAL |
|---|---|---|---|---|---|
| CREDIT | 18 | 18 | 16 | 16 | 68 |
| TOTAL | 36 | | 32 | | |

**PROGRAM STRUCTURE:**

| Semester | Course Credit | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DCC | PCC | PEC | IEC | AUC | MOC | INP | RMI | MIP | PCL | DRW | Total |
| I. | 3 | 6 | 6 | - | - | - | - | 2 | - | 1 | - | 18 |
| II. | 6 | - | 6 | 3 | - | - | - | - | 2 | 1 | - | 18 |
| III. | - | - | - | - | 0 | 2 | 3 | - | - | - | 11 | 16 |
| IV. | - | - | - | - | - | - | - | - | - | - | 16 | 16 |

**COURSE CODE:**



| SEMESTER -I | | | | | | | |
|---|---|---|---|---|---|---|---|
| SL. No. | COURSECODE | COURSE NAME | MARKS | | L-T-P | HOURS | CREDIT |
| | | | CIA | ESE | | | |
| 1 | 24PCAEMT101 | ADVANCED ENGINEERING MATHEMATICS | 40 | 60 | 3-0-0 | 3 | 3 |
| 2 | 24PCASPT102 | ADVANCED DIGITAL SIGNAL PROCESSING | 40 | 60 | 3-0-0 | 3 | 3 |
| 3 | 24PCTMLT103 | TOPICS IN MACHINE LEARNING | 40 | 60 | 3-0-0 | 3 | 3 |
| 4 | 24PCXXXT1N4 | PROGRAM ELECTIVE 1 | 40 | 60 | 3-0-0 | 3 | 3 |
| 5 | 24PCXXXT1N5 | PROGRAM ELECTIVE 2 | 40 | 60 | 3-0-0 | 3 | 3 |
| 6 | 24PCRMIT106 | RESEARCH METHODOLOGY ANDIPR | 40 | 60 | 2-0-0 | 2 | 2 |
| 7 | 24PCCSPRP107 | SIGNAL PROCESSING LAB I | 100 | -- | 0-0-2 | 2 | 1 |
| Total | | | 340 | 360 | | 19 | 18 |

**Teaching Assistance: 6 hours**

| **PROGRAM ELECTIVE 1** | | | | | |
|---|---|---|---|---|---|
| **SL NO** | **COURSE CODE** | **COURSE NAME** | **L-T-P** | **HOURS** | **CREDIT** |
| 1 | 24PCADCT114 | ADVANCED DIGITAL COMMUNICATION | 3-0-0 | 3 | 3 |
| 2 | 24PCPANT124 | PATTERN ANALYSIS | 3-0-0 | 3 | 3 |
| 3 | 24PCSSPT134 | SPEECH SIGNAL PROCESSING | 3-0-0 | 3 | 3 |
| 4 | 24PCAEPT144 | ADVANCED EMBEDDED PROCESSORS | 3-0-0 | 3 | 3 |
| 5 | 24PCIDET154 | INFORMATION HIDING AND DATA ENCRYPTION | 3-0-0 | 3 | 3 |
| 6 | 24PCPMST164 | PROGRAMMING TOOLS FOR MODELING AND SIMULATION | 3-0-0 | 3 | 3 |

| **PROGRAM ELECTIVE 2** | | | | | |
|---|---|---|---|---|---|
| **SL NO** | **COURSE CODE** | **COURSE NAME** | **L-T-P** | **HOURS** | **CREDIT** |
| 1 | 24PCDPAT115 | DSP PROCESSORS AND ARCHITECTURE | 3-0-0 | 3 | 3 |
| 2 | 24PCCOTT125 | CODING THEORY | 3-0-0 | 3 | 3 |
| 3 | 24PCMSWT135 | MULTIRATE SIGNAL PROCESSING AND WAVELETS | 3-0-0 | 3 | 3 |
| 4 | 24PCASPT145 | ADAPTIVE SIGNAL PROCESSING | 3-0-0 | 3 | 3 |
| 5 | 24PCIOTT155 | INTERNET OF THINGS | 3-0-0 | 3 | 3 |
| 6 | 24PCOPTT165 | OPTIMIZATION TECHNIQUES | 3-0-0 | 3 | 3 |

| SEMESTER -II | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SLOT** | **COURSE CODE** | **COURSE NAME** | **MARKS** | | **L-T-P** | **HOURS** | **CREDIT** |
| | | | **CIA** | **ESE** | | | |
| 1 | 2PCFDST201 | FOUNDATIONS OF DATA SCIENCE | 40 | 60 | 3-0-0 | 3 | 3 |
| 2 | 24PCEDTT202 | ESTIMATION AND DETECTION THEORY | 40 | 60 | 3-0-0 | 3 | 3 |
| 3 | 24PCXXXT2N3 | PROGRAM ELECTIVE 3 | 40 | 60 | 3-0-0 | 3 | 3 |
| 4 | 24PCXXXT2N4 | PROGRAM ELECTIVE 4 | 40 | 60 | 3-0-0 | 3 | 3 |
| 5 | 24PCXXXT2N5 | INTERDISCIPLINARY ELECTIVE | 40 | 60 | 3-0-0 | 3 | 3 |
| 6 | 24PCMIPR206 | MINI PROJECT | 100 | -- | 0-0-4 | 4 | 2 |
| 7 | 24PCSPRP207 | SIGNAL PROCESSING LAB II | 100 | -- | 0-0-2 | 2 | 1 |
| **Total** | | | **400** | **300** | | **21** | **18** |

**Teaching Assistance: 6 hours**

| PROGRAM ELECTIVE 3 | | | | | |
|---|---|---|---|---|---|
| **SL NO** | **COURSE CODE** | **COURSE NAME** | **L-T-P** | **HOURS** | **CREDIT** |
| 1 | 24PCWSNT213 | WIRELESS SENSORNETWORKS | 3-0-0 | 3 | 3 |
| 2 | 24PCIPCT223 | IMAGE PROCESSING AND COMPUTER VISION | 3-0-0 | 3 | 3 |
| 3 | 24PCASPT233 | ARRAY SIGNAL PROCESSING | 3-0-0 | 3 | 3 |
| 4 | 24PCEMNT243 | EMBEDDED NETWORKS | 3-0-0 | 3 | 3 |
| 5 | 24PCSCTT253 | SIGNAL COMPRESSION TECHNIQUES | 3-0-0 | 3 | 3 |
| 6 | 24PCFOCT263 | FIBER OPTIC COMMUNICATION SYSTEMS | 3-0-0 | 3 | 3 |

| PROGRAM ELECTIVE 4 | | | | | |
|---|---|---|---|---|---|
| **SL NO** | **COURSE CODE** | **COURSE NAME** | **L-T-P** | **HOURS** | **CREDIT** |
| 1 | 24PCWMCT214 | WIRELESS AND MOBILE COMMUNICATION | 3-0-0 | 3 | 3 |
| 2 | 24PCBSPT224 | BIOMEDICAL SIGNAL PROCESSING | 3-0-0 | 3 | 3 |
| 3 | 24PCAUPT234 | AUDIO PROCESSING | 3-0-0 | 3 | 3 |
| 4 | 24PCDEPT244 | DEEP LEARNING | 3-0-0 | 3 | 3 |
| 5 | 24PCSPAT254 | SIGNAL PROCESSING FOR AUTOMATION | 3-0-0 | 3 | 3 |
| 6 | 24PCESRT264 | EMBEDDED SYSTEMS AND RTOS | 3-0-0 | 3 | 3 |

| INTERDISCIPLINARY ELECTIVE | | | | | |
|---|---|---|---|---|---|
| **SL NO** | **COURSE CODE** | **COURSE NAME** | **L-T-P** | **HOURS** | **CREDIT** |
| 1 | 24PCAUET215 | AUTOMOTIVE ELECTRONICS | 3-0-0 | 3 | 3 |
| 2 | 24PCMAST225 | MEMS AND SENSORS | 3-0-0 | 3 | 3 |
| 3 | 24PCNMDT235 | NANO MATERIALS FOR DRUGDELIVERY | 3-0-0 | 3 | 3 |

| SEMESTER -III | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SL.No.** | **COURSE CODE** | **COURSE NAME** | **MARKS** | | **L-T-P** | **HOURS** | **CREDIT** |
| | | | **CIA** | **ESE** | | | |
| **TRACK 1** | | | | | | | |
| 1 | 24PCMOCT3N1 | MOOC | To be completed successfully | | -- | -- | 2 |
| 2 | 24PCAUCT3NN | AUDIT COURSE | 40 | 60 | 3-0-0 | 3 | - |
| 3 | 24PCINTP303 | INTERNSHIP | 50 | 50 | -- | -- | 3 |
| 4 | 24PCDIPP304 | DISSERTATION PHASE1 | 100 | -- | 0-0-17 | 17 | 11 |
| **Total** | | | **190** | **110** | | **20** | **16** |
| **TRACK 2** | | | | | | | |
| 1 | 24PCMOCT3N1 | MOOC | To be completed successfully | | -- | -- | 2 |
| 2 | 24PCAUCT3NN | AUDIT COURSE | 40 | 60 | 3-0-0 | 3 | - |
| 3 | 24PCINTP303 | INTERNSHIP | 50 | 50 | --- | -- | 3 |
| 4 | 24PCRPPP304 | RESEARCH PROJECT PHASE 1 | 100 | -- | 0-0-17 | 17 | 11 |
| **Total** | | | **190** | **110** | | **20** | **16** |

**Teaching Assistance: 6 hours**

***MOOC Course to be successfully completed before the commencement of the fourth semester (starting from semester 1).**

| AUDIT COURSE | | | | | |
|---|---|---|---|---|---|
| SLNO | COURSECODE | COURSE NAME | L-T-P | HOURS | CREDIT |
| 1 | 24PCAUCT301 | ACADEMIC WRITING | 3-0-0 | 3 | - |
| 2 | 24PCAUCT302 | ADVANCED ENGINEERING MATERIALS | 3-0-0 | 3 | - |
| 3 | 24PCAUCT303 | FORENSIC ENGINEERING | 3-0-0 | 3 | - |
| 4 | 24PCAUCT304 | DATA SCIENCE FOR ENGINEERS | 3-0-0 | 3 | - |
| 5 | 24PCAUCT305 | DESIGN THINKING | 3-0-0 | 3 | - |
| 6 | 24PCAUCT306 | FUNCTIONAL PROGRAMMINGIN HASKELL | 3-0-0 | 3 | - |
| 7 | 24PCAUCT307 | FRENCH LANGUAGE (A1LEVEL) | 3-0-0 | 3 | - |
| 8 | 24PCAUCT308 | GERMAN LANGUAGE (A1LEVEL) | 3-0-0 | 3 | - |
| 9 | 24PCAUCT309 | JAPANESE LANGUAGE (N5LEVEL) | 3-0-0 | 3 | - |
| 10 | 24PCAUCT310 | PRINCIPLES OF AUTOMATION | 3-0-0 | 3 | - |
| 11 | 24PCAUCT311 | REUSE AND RECYCLE TECHNOLOGY | 3-0-0 | 3 | - |
| 12 | 24PCAUCT312 | SYSTEM MODELING | 3-0-0 | 3 | - |
| 13 | 24PCAUCT313 | EXPERT SYSTEMS | 3-0-0 | 3 | - |

| SEMESTER -IV | | | | | | | |
|---|---|---|---|---|---|---|---|
| SLNo. | COURSECODE | COURSE NAME | MARKS | | L-T-P | HOURS | CREDIT |
| | | | CIA | ESE | | | |
| TRACK 1 | | | | | | | |
| 1 | 24PCDIPP401 | Dissertation Phase II | 100 | 100 | 0-0-24 | 24 | 16 |
| Total | | | 100 | 100 | | 24 | 16 |
| TRACK 2 | | | | | | | |
| 1 | 24PCRPPP401 | Research ProjectPhase II | 100 | 100 | 0-0-24 | 24 | 16 |
| Total | | | 100 | 100 | | 24 | 16 |

**Teaching Assistance: 6 hours**

# SEMESTER I

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCAEMT101 | ADVANCED ENGINEERING MATHEMATICS | DISCIPLINE CORE | 3 | 0 | 0 | 3 |

**Preamble:** The purpose of this course is to expose students to the basic theory of linear algebra and probability.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs. After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO 1 | To analyze distributions of random variables and make computations based on that. | An |
| CO 2 | evaluate average behaviour of random variables, and analyze their converging behaviors | E |
| CO 3 | To analyze behaviour of random processes and explain basis of vector spaces. | An |
| CO 4 | To evaluate properties of linear transformations | E |
| CO 5 | To evaluate if a linear transformation is diagonalizable and decompose it using spectral decomposition theorem. | E |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 | PSO1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | | 3 | | 3 | 3 | | 3 | |
| CO 2 | 3 | | 3 | | 3 | 3 | | 3 | |
| CO 3 | 3 | | 3 | | 3 | 3 | | 3 | |
| CO 4 | 3 | | 3 | | 3 | 3 | | 3 | |
| CO 5 | 3 | | 3 | | 3 | 3 | | 3 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 10 |
| Apply | 20 |
| Analyse | 20 |
| Evaluate | 10 |
| Create | |

**Mark distribution**

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 3 hours |

**Continuous Internal Assessment Pattern:**

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

The project shall be done individually. Group projects are not permitted. The projectmay include the implementation of theoretical computation using software packages. The test papers hall include a minimum 80% of the syllabus.

**End Semester Examination Pattern:**

End Semester Examination: 60 marks

There will be two parts; Part A and Part B

- Part A will contain 5 numerical/short answer questions with 1 question from eachmodule, having 5 marks for each question. Students should answer all questions.
- Part B will contain 7 questions with minimum one question from each module of whichstudent should answer any five. Each question can carry 7 marks.

**Syllabus**

| Module No | Description | Contact Hours |
|---|---|---|
| **1** | Axiomatic definition of probability. Independence. Bayes' theorem and applications. Random variables. Cumulative distribution function, Probability Mass Function, Probability Density function, Conditional and Joint Distributions and densities, Independenceof random variables. Functions of Random Variables: | **9** |

| | | |
|---|---|---|
| | Two functions of two random variables. Pdf of functions of random variables using Jacobian. | |
| **2** | Expectation, Fundamental theorem of expectation, Moment generating functions, Characteristic function. Conditional expectation. Covariance matrix. Uncorrelated random variables. Pdf of Jointly Gaussian random variables, Markov and Chebyshev inequalities, Chernoff bound. Central Limit theorem. Convergence of random variables. Weak law of large numbers, Strong law of large numbers | **9** |
| **3** | Random Processes. Poisson Process, Wiener Process, Markov Process, Birth- Death Markov Chains, Chapman- Kolmogorov Equations,<br><br>Groups, Rings, homomorphism of rings. Field. Vector Space. Subspaces. direct sum. Linear independence, span. Basis. Dimension. Finite dimensional vector spaces. Coordinate representation of vectors. Row spaces and column spaces of matrices. | **9** |
| **4** | Linear Transformations. Four fundamental subspaces of a linear transformation. Rank and Rank-nullity theorem. Matrix representation of linear transformation. Change of basis transformation. System of linear equations. Existence and uniqueness of solutions. Linear functionals. Dual, double dual and transpose of a linear transformation. | **9** |
| **5** | Eigen values, Eigen vectors, Diagonizability.<br>Inner product. Norm. Projection. Least-squares solution. Cauchy-Schwartz inequality. Orthonormal bases. Orthogonal complement. Spectral decomposition theorem. | **9** |

| | | |
|---|---|---|
| | | |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| | **Module I** | |
| 1.1 | Axiomatic definition of probability. Independence. Bayes' theorem and applications. | 2 |
| 1.2 | Random variables. Cumulative distribution function, Probability Mass Function, | 2 |
| 1.3 | Probability Density function, Conditional and Joint Distributions and densities, Independence of random variables. | 2 |
| 1.4 | Functions of Random Variables: Two functions of two random variables. Pdf of functions of random variables using jacobian. | 3 |
| | **Module II** | |
| 2.1 | Expectation, Fundamental theorem of expectation, Conditional expectation. | 2 |
| 2.2 | Moment generating functions, Charectristic function. | 1 |
| 2.3 | Covariance matrix. Uncorrelated random variables. Pdf of Jointly Guassian random variables, | 2 |
| 2.4 | Markov and Chebyshev inequalities, Chernoff bound. Central Limit theorem. | 2 |
| 2.5 | Convergence of random variables. Weak law of large numbers,Strong law of large numbers. | 2 |
| 3 | **Module III** | |
| 3.1 | Random Processes. Poisson Process, Wiener Process, | 2 |
| 3.2 | Markov Process, Birth-Death Markov Chains, Chapman-Kolmogorov Equations, | 2 |
| 3.3 | Groups, Rings, homomorphism of rings. Field. Vector Space.Subspaces. direct sum. | 2 |
| 3.4 | Linear independence, span. Basis. Dimension. Finite dimensional vector spaces. | 2 |

| | | |
|---|---|---|
| 3.5 | Coordinate representation of vectors. Rowspaces and column spaces of matrices. | 1 |
| 4 | **Module IV** | |
| 4.1 | Linear Transformations. Four fundamental subspaces of a linear transformation. Rank and Rank-nullity theorem. | 2 |
| 4.2 | Matrix representation of linear transformation. Change of basis transformation. | 3 |
| 4.3 | System of linear equations. Existence and uniqueness of solutions. | 2 |
| 4.4 | Linear functionals. Dual, double dual and transpose of a linear transformation. | 2 |
| 5 | **Module V** | |
| 5.1 | Eigen values, Eigen vectors, Diagonizability. | 3 |
| 5.2 | Inner product. Norm. Projection. Least-squares solution. Cauchy-Schwartz inequality. | 3 |
| 5.3 | Orthonormal bases. Orthogonal complement. Spectral decomposition theorem. | 3 |
| | Total | 45 |

**Text Books**

1. Hoffman Kenneth and Kunze Ray, Linear Algebra, Prentice Hall of India.

**Reference Books**

1.Jimmie Gilbert and Linda Gilbert, Linear Algebra and Matrix Theory, Elsevier

2.Henry Stark and John W. Woods "Probability and Random Processes with Applications toSignal Processing", Pearson Education, Third edition.

3.Athanasios Papoulis and S. Unnikrishnan Pillai. Probability, Random Variables andStochastic Processes, TMH

| CODE | COURSE | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCASPT102 | ADVANCED DIGITAL SIGNAL PROCESSING | PROGRAM CORE 1 | 3 | 0 | 0 | 3 |

**Preamble:** The course is intended to impart comprehensive knowledge in the domain of advanced digital signal processing

**Prerequisite:** Digital Signal Processing

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcome | Description | Level |
|---|---|---|
| **CO 1** | Assimilate the Non-parametric and parametric methods for spectral estimation | An |
| **CO 2** | Distinguish between forward and backward linear prediction | U |
| **CO 3** | Illustrate the use of Levinson Durbin algorithm for the solution of normal equations | A |
| **CO 4** | Compare and contrast LMS algorithm and RLS Algorithm for Adaptive Direct form FIR filters | An |
| **CO 5** | Develop the efficient realization of QMF filter bank using polyphase decomposition and multirate identities | E |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | 3 | 2 | 2 | | | 3 | |
| **CO 2** | 3 | | 3 | 2 | 2 | | | 3 | 2 |
| **CO 3** | 3 | 2 | 1 | - | - | | | 3 | 2 |
| **CO 4** | 3 | | 3 | 3 | 3 | 2 | | 3 | |
| **CO 5** | 3 | | 3 | 2 | 2 | | | 3 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| **Understand** | **10** |
| Apply | 20 |
| Analyse | 20 |
| Evaluate | 10 |

**Mark distribution**

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**CORE COURSES**

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

**Continuous Internal Assessment :** 40marks

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

**End Semester Examination:** 60 marks

The end semester examination will be conducted by the Institution. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in thetesting of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which studentshall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes**.**

**Syllabus and Course Plan**(For 3 credit courses, the content can be for 45 hrs and for 2 credit courses, the content can be for 30 hrs)
Syllabus

| Module No | Description | Contact Hours |
|---|---|---|
| 1 | **Power spectrum estimation** | |
| | Estimation of spectra from finite duration observation of signals: Computation of Energy density spectrum-Estimation of theAutocorrelation and power spectrum of random signals - The periodogram,Use of DFT in power spectrum estimation - Non-parametric methods for spectral estimation:Barlett method-Averaging Periodogram, Welch method-Averaging Modified Periodogram Blackman and Tukey Method-Performance characteristics & Computational requirements of non-parametric methodsfor spectral estimation: | **9** |
| 2 | **Parametric spectral estimation** | |
| | Parametric spectral estimation: Relationship between Autocorrelation and Model parameters, Yule-Walker method for AR model parameters, Burg method for AR model parameters Selection of AR model order- MA and ARMA models for power spectrum estimation | 9 |
| 3 | **Linear Prediction and optimum linear filters** | |
| | Linear Prediction : Forward and Backward Linear Prediction Optimum reflection coefficients for the Lattice Forward and Backward Predictors, Solution of the Normal Equations: Levinson Durbin Algorithm, Schur Algorithm ,Properties of Linear PredictionFilters | **9** |
| 4 | **Adaptive filters** | |
| | Adaptive filters for adaptive channel equalization, adaptive noise cancellation and Linear Predictive Coding of Speech Signals Adaptive Direct form FIR filters: Minimum mean square criteria, LMS algorithm ,Adaptive Direct form filters: The RLS | 9 |

| | | |
|---|---|---|
| | algorithm, Fast RLS Algorithm, Properties of Direct Form RLS algorithm. | |
| 5 | **Multirate Signal Processing** | |
| | Mathematical description of sampling rate converters-Interpolator and Decimator,Multirate Identities | 9 |
| | The Polyphase decomposition-Applications to sub band coding - Two Channel QMF filer bank-PR condition. | |
| | Fourier transform,Short-time(windowed) Fourier transform,The discrete wavelet transform-Wavelet- admissibility condition.MRA Axioms,scaling and wavelet function | |
| | Total Hours | **45** |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Power spectrum estimation** | |
| 1.1 | Estimation of spectra from finite duration observation of signals: Computation of Energy density spectrum-Estimation of the Autocorrelation and power spectrum of random signals -The periodogram,Use of DFT in power spectrum estimation - | 3 |
| 1.2 | Non-parametric methods for spectral estimation: Barlett method-Averaging Periodogram, Welch method-Averaging Modified Periodogram | 3 |
| 1.3 | Blackman and Tukey Method-Performance characteristics & Computational requirements of non-parametric methodsfor spectral estimation: | 3 |
| 2 | **Parametric spectral estimation** | |
| 2.1 | Parametric spectral estimation:Relationship between Autocorrelation and Model parameters | 2 |
| 2.2 | Yule-Walker method for AR model parameters, Burg method for AR model parameters. | 3 |
| 2.3 | Selection of AR model order- MA and ARMA models for power | 4 |

| | | |
|---|---|---|
| | spectrum estimation | |
| 3 | **Linear Prediction and optimum linear filters** | |
| 3.1 | Linear Prediction : Forward and Backward Linear Prediction Optimum reflection coefficients for the Lattice Forward andBackward Predictors. | 3 |
| 3.2 | Solution of the Normal Equations: Levinson Durbin Algorithm, Schur Algorithm | 3 |
| 3.3 | Properties of Linear Prediction Filters | 3 |
| 4 | **Adaptive filters** | |
| 4.1 | Adaptive filters for adaptive channel equalization ,adaptive noise cancellation and Linear Predictive Coding of Speech Signals | 3 |
| 4.2 | Adaptive Direct form FIR filters: Minimum mean square criteria,LMS algorithm | 3 |
| 4.3 | Adaptive Direct form filters:The RLS algorithm,Fast RLS Algorithm,Properties of Direct Form RLS algorithm | 3 |
| 5 | **Multirate Signal Processing** | |
| 5.1 | Mathematical description of sampling rate converters- Interpolator and Decimator,Multirate Identities | 3 |
| 5.2 | The Polyphase decomposition-Applications to sub band coding - Two Channel QMF filer bank-PR condition. | 3 |
| 5.3 | Fourier transform,Short-time(windowed) Fourier transform,The discrete wavelet transform-Wavelet- admissibility condition.MRA Axioms,scaling and wavelet function | 3 |
| | Total Hours | **45** |

**Text books:**

1. John G. Proakis, Dimitris G. Manolakis, “Digital Signal Processing”, Pearson Education,India, 2007
2. Monson H. Hayes, “Statistical Digital Signal Processing and Modeling”, John Wiley andSons Inc., New York, 2006.
3. P. Vaidyanathan, “Multirate Systems and Filter Banks”, Pearson Education

**References:**

1. Simon Haykin, "Adaptive Filter Theory", Prentice Hall, Englewood Cliffs, NJ1986.

2. Steven M Kay," Modern spectrum Estimation theory and application", PearsonIndia,January 2009

3. D.G. Manolakis, V.K. Ingle and S.M. Kogon: Statistical and Adaptive Signal Processing,McGraw Hill, 2000

4. Sophoncles J. Orfanidis, "Optimum Signal Processing ", McGraw-Hill, 2000

5. S K Mitra,"Digital Signal Processing: A computer based approach", Tata-McGraw Hill

4. C S Burrus, R A Gopinath, H. Guo, "Introduction to Wavelets and Wavelet Transforms: A primer", Prentice Hall.

| CODE | COURSE | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCTMLT103 | TOPICS IN MACHINE LEARNING | PROGRAM CORE 2 | 3 | 0 | 0 | 3 |

**Preamble:** Machine learning is a subfield of artificial intelligence, which is broadly defined as the capability of a machine to imitate intelligent human behavior. Artificial intelligence systems are used to perform complex tasks in a way that is similar to how humans solve problems. Machine learning allows software applications to become more accurate at predicting outcomes without being explicitly programmed to do so. Machine learning algorithms use historical data as input to predict new output values. Students will be able to learn machine learning fundamentals, understand the different types of algorithms in machinelearning, develop in-depth knowledge of machine learning tasks such as regression, classification, clustering etc.

**Prerequisite:** A sound knowledge of the fundamentals and basics of probability, statistics and algorithms.

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO 1 | Understand and apply the fundamentals, concepts and terminologies in machinelearning, Deep learning and artificial intelligence. | A |
| CO 2 | Understand and analyze the principles of supervised and unsupervised learning and illustrate the functionalities of the supervised and unsupervised learning algorithms. | An |
| CO 3 | Understand and analyze the principles of semi-supervised and reinforcement learning and illustrate the functionalities of the semi-supervised and reinforcement learning learning algorithms. | An |
| CO 4 | Analyze and evaluate the performance of artificial neural networks and deep learningneural architectures. | E |
| CO 5 | Create and evaluate critically the domain specific applications of Machine learning. | E |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 2 | 3 | | 2 | | | | | 2 |
| CO 2 | 2 | 3 | | | 2 | | | | 2 |
| CO 3 | 3 | 2 | | | 2 | 2 | 3 | | 2 |
| CO 4 | | | | | 2 | 2 | 3 | | 2 |
| CO 5 | 3 | 3 | | 2 | | | | | 2 |

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 10 |
| Analyse | 40 |
| Evaluate | 30 |
| Create | 20 |

**Mark distribution**

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment Pattern:**

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of thesyllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

**End Semester Examination: 60 marks**

The end semester examination will be conducted by the Institution. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in thetesting of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer question relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which studentshall answer any five. Each question can carry 7 marks. Total duration of the examination willbe 150 minutes.

**Syllabus**

| Module No | Description | Contact Hours |
|---|---|---|
| 1 | **Basics of machine learning.** | |
| | Introduction to machine learning.<br>Artificial intelligence and deep learning.Learning algorithms-overfitting and under fitting, hyperparameters and validation sets.Estimators, bias and variance, Maximum Likelihood Estimation. Machine learning process flow- define problem, objective, data acquisition and preprocessing, feature engineering, model buildingand validation. | 9 |
| 2 | **Semi-supervised and Reinforcement Learning** | |
| | Supervised Learning- Basic principles of linear regression, logistic regression. Classification-Supervised algorithms-Decision trees, k-Nearest Neighbour, Naive Bayes.Support vector machines, ensemble learning techniques.<br>Unsupervised Learning- Basic principles of clustering.<br>Clustering algorithms-hierarchical algorithms-agglomerative, divisive algorithms. Partitioning algorithms- k-means, k medoids algorithms, density based algorithms.Partitioning algorithms- k-means, k medoids algorithms, density based algorithms. Case study in clustering- Medical image segmentation. | **11** |
| 3 | **Semi-supervised and Reinforcement Learning** | |
| | Semi-supervised learning – Types of semi-supervised learning-Self learning, graph-based SSL-label propagation.<br>Reinforcement Learning-Taxonomy, Reinforcement Learning Algorithms-Value based, Policy based and model-based algorithms. Characteristics and types of reinforcement learning. Reinforcement learning models- Markov decision process, Q-learning. Characteristics and types of reinforcement learning. Reinforcement learning models- Markov decision process, Q-learning. | 9 |
| 4 | **Artificial Neural Networks and Deep Learning** | |
| | Artificial neural networks- Basic principles of Back propagation,Gradient Descent.Training Neural Network, Initials,action and activation functions.<br>Deep learning principles and achitectures-Dropout, Batch normalisation, | **8** |

| | | |
|---|---|---|
| | Ensemble learning, Data augmentation, Transfer learning.<br>Convolutional Neural Networks, Recurrent Neural Networks,LSTM, Data augmentation-GAN. | |
| 5 | **Applications of Machine Learning**<br>Machine learning applications for prediction-weather, sales of a store, eligibility of loan.Medical diagnoses, Financial industry and trading.Image recognition, classification and segmentation.<br>Speech recognition, automatic language translation and auto corrections, recommendation engines. | **8** |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Basics of machine learning.** | |
| 1.1 | Introduction to machine learning. | 1 |
| 1.2 | Artificial intelligence and deeplearning. | 2 |
| 1.3 | Learning algorithms-over fitting and under fitting, hyperparameters and validation sets. | 2 |
| 1.4 | Estimators, bias and variance, Maximum Likelihood Estimation. | 2 |
| | Machine learning process flow- define problem, objective, data acquisition and preprocessing, feature engineering, model building and validation. | 2 |
| 2 | **Semi-supervised and Reinforcement Learning** | |
| 2.1 | Supervised Learning- Basic principles of linear regression, logistic regression. | 2 |
| 2.2 | Classification-Supervised algorithms-Decision trees, k-Nearest Neighbour, Naive Bayes. | 2 |
| 2.3 | Support vector machines, ensemble learning techniques. | 2 |
| 2.4 | Unsupervised Learning- Basic principles of clustering. | 1 |
| 2.5 | Clustering algorithms-hierarchical algorithms-agglomerative,divisive algorithms. Partitioning algorithms- k-means, k medoids algorithms, density based algoritms. | 2 |

| | | |
|---|---|---|
| 2.6 | Partitioning algorithms- k-means, k medoids algorithms, density based algoritms. Case study in clustering- Medical image segmentation. | 2 |
| 3 | **Semi-supervised and Reinforcement Learning** | |
| 3.1 | Semi-supervised learning – Types of semi-supervised learning- Self learning, graph based SSL-label propagation. | 3 |
| 3.2 | Reinforcement Learning-Taxonomy, Reinforcement Learning Algorithms-Value based, Policy based and model based algorithms. Characteristics and types of reinforcement learning. Reinforcement learning models- Markov decision process, Q-learning. | 3 |
| 3.3 | Characteristics and types of reinforcement learning. Reinforcement learning models- Markov decision process, Q-learning. | 3 |
| 4 | **Artificial Neural Networks and Deep Learning** | |
| 4.1 | Artificial neural networks- Basic principles of Back propagation, Gradient Descent. | 2 |
| 4.2 | Training Neural Network, Initials,action and activation functions. | 1 |
| 4.3 | Deep learning principles and achitectures-Dropout, Batch normalisation, Ensemble learning, Data augmentation, Transfer learning. | 2 |
| 4.4 | Convolutional Neural Networks, Recurrent Neural Networks,LSTM, Data augmentation-GAN. | 3 |
| 5 | **Applications of Machine Learning** | |
| 5.1 | Machine learning applications for prediction-weather, sales of astore, eligibility of loan. | 2 |
| 5.2 | Medical diagnoses, Financial industry and trading. | 2 |
| 5.3 | Image recognition, classification and segmentation. | 2 |
| 5.4 | Speech recognition, automatic language translation and autocorrections, recommendation engines. | 2 |
| | Total Hours | 45 |

**Text Book**s

1. Machine Learning: The Art and Science of Algorithms that Make Sense of Data, Peter AFlach, Cambridge Institution Press, ISBN-10 1107422221, 2012.

2. Applied Machine Learning, 2nd Edition, M. Gopal, Mc Graw Hill Education, ISBN-10 :9789353160258, 2018.

3. Neural Networks and Learning Machines, Simon S. Haykin, 3rd Edition, Pearson-PrecticeHall, ISBN-10: 0-13-147139-2, 2009.

**Reference Books**

1. An Introduction to Machine Learning, Miroslov Kubat, Springer, ISBN-10 3030819345, 2021.
2. Machine Learning, 1st Edition, Saika Dutt, Subramanian Chandramouli, Amit Kumar Das, Pearson Education, ISBN-10 9353066697, 2018.
3. Machine Learning: A First Course for Engineers and Scientists, Andreas Lindholm, Niklas Wahlstom, Fredrik Lindsten et al., Cambridge Institution Press, ISBN-10 1108843603, 2022.
4. Handbook of Reinforcement Learning and Control, Kyriakos G. Vamvoudakis, Yan Wa n, et al., ISBN-10 3030609898, Sprimger, 2021.
5. Neural Networks and Deep Learning, Charu C. Aggarwal, Springer, ISBN: 978-3-319-94463-0, 2018.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCCSPRP107 | SIGNAL PROCESSING LAB 1 | LABORATORY1 | 0 | 0 | 2 | 1 |

**Preamble:** To experiment the concepts introduced in the topics : Linear Algebra, Random processes, Advanced Signal Processing and Machine Learning

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO 1 | Apply knowledge of Linear algebra, Random processes,Advanced Signal Processingand Machine Learning in various signal processing applications. | 3 |
| CO 2 | Develop the student's ability on analysing observations of experiments/ simulations,interpreting them and preparing reports | 5 |
| CO 3 | Apply the fundamental principles of linear algebra and random processes | 3 |
| CO 4 | Familiarize the basic operations of filter banks through simulations. | 2 |
| CO 5 | Implement the basic algorithms learned in Machine learning and to Implement a mini project pertaining to an application of Signal Processing in real life | 5 |

**Assessment Pattern**

| Bloom's Category | CIA |
|---|---|
| Apply | 40 |
| Analyse | 30 |
| Evaluate | 15 |
| Create | 15 |

**Mark distribution**

| Total Marks | CIA | ESE |
|---|---|---|
| 100 | 100 | -- |

**Continuous Internal Assessment Pattern:**

| | |
|---|---|
| Pre Processing work | 30 marks |
| Output | 30 marks |
| Internal Test | 30 marks |
| Record | 10 marks |
| **TOTAL** | **40 marks** |

**Tools :**

Numerical Computing Environment – MATLAB or any other equivalent tool.

**Syllabus**

| No | Topics |
|---|---|
| 1 | **Linear Algebra** |
| 1.1 | Row Reduced Echelon Form: To reduce the given mxn matrix into Row reducedEchelon form |
| 1.2 | Gram-Schmidt Orthogonalization: To find orthogonal basis vectors for the givenset of vectors. Also find orthonormal basis. |
| 1.3 | Least SquaresFit to a Sinusoidal function |
| 1.4 | Least Squares fit to a quadratic polynomial |
| 1.5 | Eigen Value Decomposition |
| 1.6 | Singular Value Decomposition |
| 1.7 | Karhunen- Loeve Transform |
| 2 | **Advanced DSP** |
| 2.1 | Sampling rate conversion: To implement Down sampler and Up sampler and study their characteristics |
| 2.2 | Two channel Quadrature Mirror Filterbank: Design and implement a two channel<br>Quadrature Mirror Filterbank |
| 3 | **Random Processes** |
| 3.1 | To generate random variables having the following probability distributions (a) Bernoulli(b) Binomial(c) Geometric(d) Poisson(e)Uniform,(f) Gaussian(g)Exponential (h) Laplacian |
| 3.2 | Central Limit Theorem: To verify the sum of sufficiently large number of Uniformly distributed random variables is approximately Gaussian distributedand to estimate the probability density function of the random variable. |
| 4 | **Machine Learning** |
| 4.1 | Implementation of K Nearest Neighbours Algorithm with decision region plots |
| 4.2 | Implementation of K Means Algorithm with decision region plots |
| 4.3 | Implementation of Perceptron Learning Algorithms with decision region plots |
| 4.4 | Implementation of SVM algorithmfor classification applications |
| 5 | **Implement a mini project pertaining to an application of Signal Processing in real life, make a presentation and submit a report** |

# PROGRAM ELECTIVE I

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCADCT114 | ADVANCED DIGITAL COMMUNICATION | PROGRAM ELECTIVE 1 | 3 | 0 | 0 | 3 |

**Preamble:** Digital communications is a broad term that incorporates all procedures and forms of transmission of data or information. This course imparts mathematical modelling about various modulation schemes, channels and multipath mitigation techniques.

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| **CO 1** | Represent digitally modulated signals in signal space. | An |
| **CO 2** | Design of Optimum receiver for AWGN channel. | E |
| **CO 3** | Design of Equalizers for optimum detection in presence of ISI | E |
| **CO 4** | Analyse Multi Channel and Multi Carrier Systems | An |
| **CO 5** | Evaluate Digital Communication through Fading Multipath Channels and CDMA systems. | E |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 2 | 3 | | 3 | | 3 | |
| **CO 2** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | |
| **CO 3** | 3 | 2 | 2 | 3 | | 3 | | 3 | |
| **CO 4** | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 3 | |
| **CO 5** | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 3 | |
| **CO 6** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| **Understand** | **10** |
| Apply | 20 |
| Analyse | 15 |
| Evaluate | 15 |
| Create | |

**Mark distribution**

| TotalMarks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 Hrs |

**Evaluation of Elective Courses**

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

**Continuous Internal : 40 marks**

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination: 60 marks**

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation),with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

## Syllabus

| Module No | Description | Contact Hours |
|---|---|---|
| 1 | **Characterization of Communication Signals and Systems:** | |
| | Overview of Digital Communication systems. Communication Channels and Mathematical models Representation of band pass signals and systems, Signal Space representation.Representation of digitally modulated signals .Spectral Characteristics of Digitally Modulated Signals. | 9 |
| 2 | **Optimum receiver for AWGN channel:** | |
| | Correlation demodulator, matched filter demodulator, optimum detector. Performance of optimum receiver for memoryless modulation techniques: probability of error for binary modulation and M-ary orthogonal signals,Probability of error ,QPSK, QAM. | 6 |
| 3 | **Communication through Band-Limited Linear Filter channels** | |
| | Optimum receiver for channels with ISI and AWGN. Equalization techniques: Linear equalization, Decision feedback equalization,Adaptive equalization: Algorithms(ZF and LMS) | 9 |
| 4 | **Multi Channel and Multi Carrier Systems** | |
| | Multichannel Digital communication in AWGN channels Multicarrier communication: Discrete implementation of multicarrier modulation. FFT based multi carrier system Spread spectrum principles, Generation of PN sequences, Direct sequence spread spectrum (DSSS), Frequency Hopping Spread Spectrum (FHSS), Synchronization of Spread Spectrum signals. | 9 |
| 5 | **Digital Communication through Fading Multipath Channels** | |
| | Characterization of fading multipath channel Frequency-nonselective slowly fading channel Diversity techniques for Fading Multipath channels Digital signaling over a frequency selective, slowly fading channel. RAKE receiver .Multiple access techniques- CDMA | 9 |

| | | |
|---|---|---|
| | signal and channel models ,Random access Methods | |
| | Total Hours | 45 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Characterization of Communication Signals and Systems:** | |
| 1.1 | Overview of Digital Communication systems. | 1 |
| 1.2 | Communication Channels and Mathematical models | 2 |
| 1.3 | Representation of band pass signals and systems, Signal spacerepresentation. | 2 |
| 1.4 | Representation of digitally modulated signals | 2 |
| 1.5 | Spectral Characteristics of Digitally Modulated Signals. | 2 |
| | | |
| **2** | **Optimum receiver for AWGN channel:** | |
| 2.1 | Correlationdemodulator, matched filter demodulator, optimum detector. | 3 |
| 2.2 | Performance of optimum receiver for memoryless modulationtechniques: probability of error for binary modulationand M-aryorthogonal signals | 3 |
| 2.3 | Probability of error ,QPSK, QAM. | 3 |
| | | |
| 3 | **Communication through Band-Limited Linear Filter channels** | |
| 3.1 | Optimum receiver for channels with ISI and AWGN. | 3 |
| 3.2 | Equalization techniques: Linear equalization, Decision feedback equalization, | 3 |
| 3.3 | Adaptive equalization: Algorithms(ZF and LMS) | 3 |
| 4 | **Multi Channel and Multi Carrier Systems** | |
| 4.1 | Multichannel Digital communication in AWGN channels | 2 |
| 4.2 | Multicarrier communication: Discrete implementation of multicarrier modulation. FFT based multi carrier system | 2 |
| 4.3 | Spread spectrum principles, Generation of PN sequences, | 2 |
| 4.4 | Direct sequence spread spectrum (DSSS), Frequency Hopping Spread Spectrum (FHSS), Synchronization of Spread Spectrum signals. | 3 |
| 5 | **Digital Communication through Fading Multipath Channels** | |

| | | |
|---|---|---|
| 5.1 | Characterisation of fading multipath channel | 1 |
| 5.2 | Frequency-nonselective slowly fading channel | 2 |
| 5.3 | Diversity techniques for Fading Multipath channels | 2 |
| 5.4 | Digital signalling over a frequencyselectiveslowly fading channel. RAKE receiver | 2 |
| 5.5 | Multiple access techniques- CDMA signal and channel models, Random access Methods | 2 |
| | Total Hours | 45 |

**Text Books**

1. John G.Proakis, Digital Communications, 4/e, McGraw-Hill

**Reference Books**

1. Edward. A. Lee and David. G. Messerschmitt, "Digital Communication", Allied Publishers (second edition).
2. Viterbi, A. J., and J. K. Omura. Principles of Digital Communication and Coding. NY: McGraw-Hill, 1979. ISBN: 0070675163.
3. Marvin K Simon, Sami M Hinedi, William C Lindsey - Digital Communication -Techniques –Signal Design & Detection, PHI.
4. Bernard Sklar," Digital Communications: Fundamentals and applications ", Prentice Hall 2001.
5. Andrea Goldsmith," Wireless Communications", Cambridge Institution Press 2005.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCPANT124 | PATTERN ANALYSIS | PROGRAM ELECTIVE 1 | 3 | 0 | 0 | 3 |

**Preamble:** Pattern analysis is the use of machine learning algorithms to identify and categorise patterns. It classifies data based on statistical information or knowledge gained from patterns and their representation. The popular pattern analysis tasks are pattern recognition, classification, clustering and retrival. Students will be able to learn pattern analysis fundamentals, understand the different types of algorithms in pattern analysis, develop in-depth knowledge of pattern analysis tasks such as classification, clustering, matching, retrieval etc.
algorithms.

**Prerequisite:** A sound knowledge of the fundamentals and basics of probabilty, statistics and

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| **CO 1** | Understand and apply the fundamentals, concepts and terminologies in patternanalysis. | U |
| **CO 2** | Understand and analyze the principles of feature extraction and optimization andillustrate the functionalities of the feature extraction and optimization algorithms. | An |
| **CO 3** | Understand and analyse the principles of supervised models for pattern analysis andillustrate the functionalities of the supervised pattern analysis algorithms. | An |
| **CO 4** | Understand and analyse the principles of unsupervised models for pattern analysis andillustrate the functionalities of the unsupervised pattern analysis algorithms. | An |
| **CO 5** | Create and evaluate critically the domain specific applications of pattern analysis. | E |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 3 | | 3 | | | | | 2 |
| **CO 2** | 2 | 2 | | | 2 | | | | 2 |
| **CO 3** | 3 | 2 | | | 2 | 3 | 3 | | 2 |
| **CO 4** | | | | | 2 | 2 | 2 | | 2 |
| **CO 5** | 3 | 3 | | 2 | | | | | 2 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| **Understand** | **10** |
| Apply | 20 |
| Analyse | 20 |
| Evaluate | 10 |
| Create | |

**Mark distribution**

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 3 hours |

**Continuous Internal Assessment: 40 marks**

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

Test paper shall include minimum 80% of the syllabus. include minimum 80% of the syllabus.

**End Semester Examination: 60 marks**

The end semester examination will be conducted by the respective College. There will be twoparts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry7 marks.

**Syllabus**

| Module No | Description | Contact Hours |
|---|---|---|
| 1 | **Introduction to Pattern Analysis** | |
| | Introduction - features, feature vectors and classifiers, Supervised versus unsupervised pattern recognition.<br>Classifiers based on Bayes Decision theory- Review of Probability Theory, Conditional Probability and Bayes rule.<br>Bayesian classification for normal distributions, Bayes classifier, Case I, Case II and Case III.<br>Linear classifiers- Linear and quadratic discriminant functions and decision hyper planes. | 9 |
| 2 | **Feature extraction and optimization** | |
| | Review of Linear Algebra. Linear Transformations-KLT, SVD, ICA, DFT, DCT, DST, Hadamard Transform, Wavelet Transform and transform based features.Feature engineering- Feature extraction-Global and local features, features for shape and characterization. Typical features for object recognition in images, typical featuresfor speech and audio classification. Feature reduction and optimization-Dimensionality reductiontechniques. Principal component analysis. | **10** |
| 3 | **Supervised Models for Pattern Classification** | |
| | K-Nearest-Neighbor Classification, selection criterion for k. The perceptron learning algorithm, classifier using perceptron.<br>Multi layer perceptrons- Multilayer feed forward neural networks, Training neural networks, back propagation, gradient descent algorithm, activation functions and performance analysis of MLFFNN. Introduction to CNN.Support vector machines- SVM for linearly separable and nonlinearly separable patterns. Concept of maximum margin,kernels for SVM, kernel trick. | 8 |
| 4 | **Unsupervised Models for pattern Classification** | |
| | Clustering - Vector Quantization, K-means clustering, Silhouette score.Cluster analysis, Proximity measures, Clustering Algorithms - Sequential algorithms, Hierarchical algorithms – Agglomerative | |

| | | |
|---|---|---|
| | algorithms, Divisive algorithms.<br>Clustering Schemes based on function optimization-<br>Fuzzyclustering algorithms, Probabilistic clustering,<br>Clustering algorithms based on graph theory. | **9** |
| 5 | **Applications of Pattern Analysis** | |
| | Application of pattern analysis in image classification, speech recognition, speaker identification.<br>Multimedia document recognition (MDR), automatic medical diagnosis. Outlier detection, novelty/anomaly detection using pattern analysis.<br>Music and image/video retrieval systems. | 8 |
| | Total Hours | 45 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Introduction to Pattern Analysis** | |
| 1.1 | Introduction - features, feature vectors and classifiers, Supervised<br>versus unsupervised pattern recognition. | 2 |
| 1.2 | Classifiers based on Bayes Decision theory- Review of Probability<br>Theory, Conditional Probability and Bayes rule. | 2 |
| 1.3 | Bayesian classification for normal distributions, Bayes classifier,<br>Case I, Case II and Case III. | 3 |
| 1.4 | Linear classifiers- Linear and quadratic discriminant functions and<br>decision hyper planes. | 2 |
| 2 | **Feature extraction and optimization** | |
| 2.1 | Review of Linear Algebra. Linear Transformations-KLT, SVD, ICA, DFT, DCT, DST, Hadamard Transform, Wavelet Transformand transform based features. | 2 |
| 2.2 | Feature engineering- Feature extraction- Global and local features, features for shape and characterization. | 2 |
| 2.3 | Typical features for object recognition in images, typical featuresfor speech and audio classification. | 2 |
| 2.4 | Feature reduction and optimization- Dimensionality reduction techniques. | 2 |

| | | |
|---|---|---|
| 2.5 | Principal component analysis. | 2 |
| 3 | **Supervised Models for Pattern Classification** | |
| 3.1 | K-Nearest-Neighbor Classification, selection criterion for k. The perceptron learning algorithm, classifier using perceptron. | 2 |
| 3.2 | Multi layer perceptrons- Multilayer feed forward neural networks,Training neural networks, back propagation, gradient descent algorithm, activation functions and performance analysis of MLFFNN. Introduction to CNN. | 3 |
| 3.3 | Support vector machines- SVM for linearly separable and nonlinearly separable patterns. Concept of maximum margin,kernels for SVM, kernel trick. | 3 |
| 4 | **Unsupervised Models for pattern Classification** | |
| 4.1 | Clustering - Vector Quantization, K-means clustering, Silhouette score. | 3 |
| 4.2 | Cluster analysis, Proximity measures, Clustering Algorithms - Sequential algorithms, Hierarchical algorithms - Agglomerative | 3 |
| | algorithms, Divisive algorithms. | |
| 4.3 | Clustering Schemes based on function optimization- Fuzzyclustering algorithms, Probabilistic clustering, | 2 |
| 4.4 | Clustering algorithms based on graph theory. | 3 |
| 5 | **Applications of Pattern Analysis** | |
| 5.1 | Application of pattern analysis in image classification, speech recognition, speaker identification. | 2 |
| 5.2 | Multimedia document recognition (MDR), automatic medical diagnosis. | 2 |
| 5.3 | Outlier detection, novelty/anomaly detection using pattern analysis. | 1 |
| 5.4 | Music and image/video retrieval systems. | 2 |
| | Total Hours | 45 |

**Text Book**s

1. Pattern classification , Richard O. Duda and Hart P.E, and David G Stork, , 2nd Edn., John Wiley & Sons Inc., 2001

2. Neural Networks and Learning Machines, Simon S. Haykin, 3rd Edition, Pearson-Prectice Hall, ISBN-10: 0-13-147139-2, 2009.

3. Pattern Recognition, Sergios Theodoridis, Konstantinos Koutroumbas , Academic Press, 2006.

**Reference Books**

1. Pattern Recognition and Classification- An Introduction, Geoff Dougherty, ISBN: 978-1- 4614-5323-9, Springer, 2013.

2. Advances in Fuzzy Clustering and its Applications, Jose Valente de Olliveira (Editor), Witold Pedrycz (Editor), ISBN: 978-0-470-02760-8, Wiley 2017.

3. Digital Pattern Recognition, King Sun Fu, ISBN: 978-3-642-96303-2, Springer, 1976

4. Pattern Recognition and Image Analysis Earl Gose, Richard Johnsonbaugh, and Steve Jost,, PHI Pvt. Ltd., NewDelhi-1, 1999.

5. Statistical Pattern Recognition, 2nd Edition, Andrew R. Webb, ISBN:9780470845134,John Wiley & Sons, 2002

| CODE | COURSE | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCSSPT134 | SPEECH SIGNAL PROCESSING | PROGRAM ELECTIVE 1 | 3 | 0 | 0 | 3 |

**Preamble:** This course aims to develop in-depth understanding of fundamentals of speech analysis, parametric representations and models of speech and speech processing applications enabling the students to explore into research and development of speech processing systems.

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO 1 | Understand the basic concepts of speech production and apply time domain analysis methods for classification of speech sounds | U |
| CO 2 | Analyse speech segments using frequency domain techniques - STFT and Cepstral analysis | An |
| CO 3 | Apply LPC Analysis to speech signals | A |
| CO 4 | Analyse and apply speech coding techniques for speech compression, storage and transmission | An |
| CO 5 | Understand the fundamentals of speech processing applications | U |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | | 3 | 3 | 3 | | | | 2 |
| CO 2 | 3 | | 3 | 3 | 3 | | | | 2 |
| CO 3 | 3 | | 3 | 3 | 3 | | | | 2 |
| CO 4 | 3 | | 3 | 3 | 3 | | | | 2 |
| CO 5 | 3 | | 3 | 3 | 3 | | | | 2 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 10 |
| Apply | 20 |
| Analyse | 20 |
| Evaluate | 10 |
| Create | |

**Mark distribution**

| TotalMarks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern**

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be twoparts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Note:** The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60%.

Syllabus

| Module No | Description | Contact Hours |
|---|---|---|
| 1 | Acoustic theory of speech production, Excitation, Vocal tract model for speech analysis,Formant structure, Pitch, Articulatory Phonetics, and Acoustic Phonetics,Time domain analysis (Short time energy, short time zero crossing Rate, ACF). | 9 |
| 2 | Filter Banks, STFT,Spectrogram, Formant Estimation & Analysis Cepstral Analysis, MFCC, | 9 |
| 3 | AR model, ARMA model, LPC Analysis - LPC model, Autocorrelation method ,Covariance method, Levinson-Durbin Algorithm, Lattice form Sinusoidal Model, GMM, Hidden Markov Model | 9 |
| 4 | Phase Vocoder, LPC, Sub-band coding,Adaptive Transform Coding, Harmonic Coding,Vector Quantization based Coders, CELP | 9 |
| 5 | Fundamentals of Speech recognition, Speech segmentation. Text-to-speech conversion, speech enhancement Speaker Verification, Language Identification | 9 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **MODULE I** | |
| 1.1 | Acoustic theory of speech production, Excitation, Vocal tract model for speech analysis | 3 |
| 1.2 | Formant structure, Pitch, Articulatory Phonetics, and Acoustic Phonetics | 3 |
| 1.3 | Time domain analysis (Short time energy, short time zero crossing Rate, ACF). | 3 |
| 2 | **MODULE II** | |
| 2.1 | Filter Banks, STFT | 3 |
| 2.2 | Spectrogram, Formant Estimation & Analysis | 3 |
| 2.3 | Cepstral Analysis, MFCC | 3 |

| | | |
|---|---|---|
| 3 | **MODULE III** | |
| 3.1 | AR model, ARMA model, LPC Analysis - LPC model, Autocorrelation method | 3 |
| 3.2 | Covariance method, Levinson-Durbin Algorithm, Lattice form | 3 |
| 3.3 | Sinusoidal Model, GMM, Hidden Markov Model | 3 |
| 4 | **MODULE IV** | |
| 4.1 | Phase Vocoder, LPC, Sub-band coding | 3 |
| 4.2 | Adaptive Transform Coding, Harmonic Coding | 3 |
| 4.3 | Vector Quantization based Coders, CELP | 3 |
| 5 | **MODULE V** | |
| 5.1 | Fundamentals of Speech recognition, Speech segmentation. | 3 |
| 5.2 | Text-to-speech conversion, speech enhancement | 3 |
| 5.3 | Speaker Verification, Language Identification | 3 |

**Reference Books**

1. Thomas F. Quatieri, Discrete-Time Speech Signal Processing: Principles and Practice, Prentice Hall; ISBN: 013242942X; 1st edition
2. Rabiner and Juang, Fundamentals of Speech Recognition, Prentice Hall, ISBN:0130151572.
3. Douglas O'Shaughnessy, Speech Communications: Human & Machine, IEEE Press,Hardcover 2nd edition, 1999; ISBN: 0780334493.
4. Digital Processing of Speech Signals, 1st edition, ISBN: 97881317051314.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCAEPT144 | ADVANCED EMBEDDED PROCESSORS | PROGRAM ELECTIVE 1 | 3 | 0 | 0 | 3 |

**Preamble:** This course is intended to impart thorough knowledge in embedded processors. It also helps to develop skills in designing complex systems using different processor architectures.

**Course Prerequisites:** Basic knowledge in digital electronics and Microprocessors at UG level.

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO 1 | Understand the basics of an embedded system | U |
| CO 2 | Familiarize ARM Architecture | U |
| CO 3 | Understand and analyse the structure and design of an Embedded System | U |
| CO 4 | Analyse Product Enclosure, Design and Development | An |
| CO 5 | Compare standard I/O interfaces and to Design an Embedded System. | An |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | | 2 | 2 | | | | 2 | |
| CO 2 | 3 | | 2 | 2 | 3 | | | 2 | |
| CO 3 | 3 | | 3 | 2 | 2 | | | 2 | |
| CO 4 | 3 | | 3 | 3 | 2 | | | 2 | |
| CO 5 | 3 | | 2 | 3 | 3 | | | 2 | |
| CO 6 | 3 | | 3 | 3 | 3 | 3 | | 2 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 5 |
| Apply | 15 |
| Analyse | 30 |
| Evaluate | 10 |
| Create | |

**Mark distribution**

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

**Continuous Internal Assessment Pattern:**

Continuous Internal Evaluation: 40 marks

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be twoparts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation),with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Note:** The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % fora core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60%.

## Syllabus

| Module No | Description | Contact Hours |
|---|---|---|
| 1 | **Introduction to Embedded systems** | |
| | Embedded system examples, Parts of Embedded System, Typical Processor architecture, Power supply, clock, memory interface, interrupt, I/O ports, Buffers, Programmable Devices, ASIC, etc.Simple interfacing examples, Memory Technologies, EPROM, Flash,OTP, SRAM, DRAM, SDRAM etc | **9** |
| 2 | **ARM architecture** | |
| | ARM organization and Implementation, Memory Hierarchy, ARM Instruction Set and Thumb Instruction set High- Level Language Programming, System Development using ARM,Digital Signal Processing on ARM, Peripheral Programming andsystem design for a specific ARM processor (ARM7/9). | **11** |
| 3 | **Embedded System product Development** | |
| | Embedded System product Development Life cycle (EDLC) Specifications, Component selection, Schematic Design, PCB layout,fabrication and assembly. | 8 |
| 4 | **Product enclosure design and development** | |
| | Concept of firmware, operating system and application programs Power supply Design, External Interfaces. | 8 |
| 5 | **Embedded System Development Environment** | |
| | IDE, Cross compilation, Simulators/Emulators Hardware Debugging. Hardware testing methods like Boundary Scan,In Circuit Testing (ICT) etc.,Serial EEPROM, PWM, Analog to digital converter, Bus architecture like I2C, SPI, UART, AMBA, CAN etc. | 9 |
| | Total Hours | 45 |

**COURSE PLAN**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Introduction to Embedded systems** | |
| 1.1 | Embedded system examples, Parts of Embedded System, Typical Processor architecture, Power supply, clock, memory interface, interrupt, I/O ports, Buffers, Programmable Devices, ASIC, etc | 5 |
| 1.2 | Simple interfacing examples, Memory Technologies, EPROM, Flash, OTP, SRAM, DRAM, SDRAM etc | 4 |
| **2** | **ARM architecture** | |
| 2.1 | ARM organization and Implementation, Memory Hierarchy, ARM Instruction Set and Thumb Instruction set | 4 |
| 2.2 | High- Level Language Programming, System Development usingARM | 4 |
| 2.3 | Digital Signal Processing on ARM, Peripheral Programming andsystem design for a specific ARM processor (ARM7/9). | 3 |
| **3** | **Embedded System product Development** | |
| 3.1 | Embedded System product Development Life cycle (EDLC) | 4 |
| 3.2 | Specifications, Component selection, Schematic Design, PCB layout,fabrication and assembly. | 4 |
| **4** | **Product enclosure design and development** | |
| 4.1 | Concept of firmware, operating system and application programs | 4 |
| 4.2 | Power supply Design, External Interfaces. | 4 |
| **5** | **Embedded System Development Environment** | |
| 5.1 | IDE, Cross compilation, Simulators/Emulators | 3 |
| 5.2 | Hardware Debugging. Hardware testing methods like Boundary Scan,In Circuit Testing (ICT) etc., | 3 |
| 5.3 | Serial EEPROM, PWM, Analog to digital converter, Bus architecture like I2C, SPI, UART, AMBA, CAN etc. | 3 |
| | Total Hours | 45 |

**Text Books**

1. Shibu K.V. Introduction to Embedded Systems, Tata McGraw Hill, 2009.
2. Steve Furber, ARM System-on-chip Architecture, Second Edition PearsonEducation, 2007.

**Reference Books**

1. Van Ess, Currie and Doboli, Laboratory Manual for Introduction to Mixed-Signal,Embedded Design, Alphagraphics, USA
2. William Hohl, ARM Assembly Language Programming, CRC Press, 2009.
3. Andrew Sloss, Dominic Symes, Christ Wright, ARM System Developer's guide –Designing and optimizing software, Elsevier Publishers, 2008.


Passed in 1st BOS dated _____ Passed in 1st Academic Council dated

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCIDET154 | INFORMATION HIDING AND DATA ENCRYPTION | PROGRAM ELECTIVE 1 | 3 | 0 | 0 | 3 |

**Preamble:** The course is designed to provide an insight to various data encryption and information hiding techniques and applying these techniques in various security applications.

The course also aims to develop skills in analysing the strengths and weakness of various techniques used for information security.

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO 1 | Apply various techniques for data encryption and analyse the performance (K3). | A |
| CO 2 | Identify and apply information hiding and digital watermarking techniques for given problems in security systems (K3). | A |
| CO 3 | Analyse publications related to encryption and information hiding in journals and conferences and submit report (K4). | An |
| CO 4 | Choose and solve a research problem in the area of data encryption (K5). | E |
| CO5 | Choose and solve a research problem in the area of information hiding (K5). | E |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | | | | | 2 | | 2 | |
| CO 2 | 3 | | 3 | | | 2 | | 2 | |
| CO 3 | 3 | 3 | 3 | | | 2 | | 2 | |
| CO 4 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | |
| CO5 | | | | | | | | 2 | |

**Assessment Pattern**

| Bloom's Category | End SemesterExamination | Continuous Internal Assessment |
|---|---|---|
| Understand | 10 | |
| Apply | 40 | 10 |
| Analyse | 10 | 15 |
| Evaluate | | 15 |
| Create | | |

**Mark distribution**

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| | | | |


Passed in 1st BOS dated _____ Passed in 1st Academic Council dated _____

| | | | |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment Pattern:**

| | |
|---|---|
| Preparing a review article based on peer reviewedoriginal publications (minimum 10 Publications shall be referred): | 15 marks |
| Course based task/Seminar/Data Collection and interpretation: | 15 marks |
| Test paper, 1 no.: (Test paper shall include minimum 80% of thesyllabus.) | 10 marks |

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practicalknowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry7 marks.

**Syllabus**

| Module No | Description | Contact Hours |
|---|---|---|
| 1 | **Review of Number Theory and Data Encryption Methods:** | |
| | Elementary Number theory,Algebraic Structures- Groups, Rings and Finite Fields,Polynomials over Finite Fields (Fq),Introduction to Complexity theory.Introduction to Cryptography, Classical Cryptography, StreamCiphers ,Public Key Cryptography based on Knapsack problem,AES. Digital Signature, Zero Knowledge Proofs. | 10 |
| 2 | **Information Hiding**: | |
| | Steganography. Objectives, difference, requirements,Types – Fragile, Robust. Parameters and metrics - BER, PSNR,WPSNR, Correlation coefficient, MSE, and Bit per pixel.Information Hiding Approaches LSB, additive and spread spectrum methods. | 8 |
| 3 | **Digital Watermarking and applications of Image Hiding:** | |


Passed in 1st BOS dated _____ Passed in 1st Academic Council dated _____

| | | |
|---|---|---|
| | Digital Watermarking Algorithms<br>Types of Digital Watermarks and Applications<br>Audio Watermarking<br>Applications of Information Hiding: Authentication, annotation, tamper detection and Digital rights management<br>Hiding text and image data, mathematical formulations. | 9 |
| 4 | **Information Hiding in 1D and 2D signals:** | |
| | Information Hiding in 1D signals: Time and transform techniques, hiding in Audio, biomedical signals, HAS Adaptive techniques.<br>Information Hiding in 2D signals: Spatial and transform techniques-hiding in images, ROI images, HVS Adaptive techniques. | 9 |
| 5 | **Information Hiding in video and Steg analysis:** | |
| | Information Hiding in video: Temporal and transform domain techniques, Bandwidth requirements.<br>Steg analysis: Statistical Methods, HVS based methods, SVM method, Detection theoretic approach. | 9 |
| | Total Hours | 45 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Review of Number Theory and Data Encryption Methods:** | |
| 1.1 | Elementary Number theory | 1 |
| 1.2 | Algebraic Structures- Groups, Rings and Finite Fields, Polynomials over Finite Fields ($F_q$) | 2 |
| 1.3 | Introduction to Complexity theory. | 1 |
| 1.4 | Introduction to Cryptography, Classical Cryptography, Stream Ciphers | 2 |
| 1.5 | Public Key Cryptography based on Knapsack problem | 2 |
| 1.6 | AES. Digital Signature, Zero Knowledge Proofs. | 2 |
| 2 | **Information Hiding**: | |
| 2.1 | Steganography. Objectives, difference, requirements | 2 |
| 2.2 | Types – Fragile, Robust. Parameters and metrics - BER, PSNR, | 3 |


Passed in 1st BOS dated _____ Passed in 1st Academic Council dated _____

| | | |
|---|---|---|
| | WPSNR, Correlation coefficient, MSE, and Bit per pixel. | |
| 2.3 | Information Hiding Approaches: LSB, additive and spread spectrum methods. | 3 |
| 3 | **Digital Watermarking and applications of Image Hiding:** | |
| 3.1 | Digital Watermarking Algorithms | 2 |
| 3.2 | Types of Digital Watermarks and Applications | 2 |
| 3.3 | Audio Watermarking | 1 |
| 3.4 | Applications of Information Hiding: Authentication, annotation, tamper detection and Digital rights management | 2 |
| 3.5 | Hiding text and image data, mathematical formulations. | 2 |
| 4 | **Information Hiding in 1D and 2D signals:** | |
| 4.1 | Information Hiding in 1D signals: Time and transform techniques,hiding in Audio, biomedical signals, HAS Adaptive techniques. | 4 |
| 4.2 | Information Hiding in 2D signals: Spatial andtransform techniques-hiding in images, ROI images, HVS Adaptive techniques. | 5 |
| 5 | **Information Hiding in video and Steg analysis:** | |
| 5.1 | Information Hiding in video: Temporal and transform domain,techniques, Bandwidth requirements. | 4 |
| 5.2 | Steg analysis: Statistical Methods, HVS based methods, SVM,method, Detection theoretic approach. | 5 |
| | Total Hours | 45 |

**Reference Books**

1. Neal Koblitz, A Course in Number Theory and Cryptography, 2nd Edition, Springer
2. Stefan Katzenbeisser, Fabien A. P. Petitcolas, Information Hiding Techniques for Steganography and Digital Watermarking, Artech House Publishers, 2000.
3. Neil F Johnson et al Kluwer, Information hiding: Steganography and Watermarking - Attacks and Countermeasures,Springer, 2001.
4. Ingemar J Cox, Digital Watermarking, The Morgan Kaufman Series in Multimedia Information and Systems, 2001
5. Ira S Moskowits, Information Hiding, Proceedings, 4th International Workshop, IH 2001, Pittsburg, USA, April 2001, Eds:2. AVISPA package homepage, http:/www.avispaproject.org/
6. Handbook of Applied Cryptography, AJ Menezes, CRC Press, 2001.


Passed in 1st BOS dated _____ Passed in 1st Academic Council dated _____

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCPMST164 | PROGRAMMING TOOLS FOR MODELING AND SIMULATION | PROGRAM ELECTIVE 1 | 3 | 0 | 0 | 3 |

**Preamble:** This course is about learning the programming languages used in the development of embedded systems. Learners can use the concepts learned in this course for the development of processor based systems.

**Course Prerequisites:** Basic knowledge in programming, and embedded systems. Knowledge on ARM processors or any other processors and their architecture is a requirement.

**Course Outcomes** After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| **CO 1** | To understand the Linux system and command level programming | U |
| **CO 2** | To understand the c programming basics | U |
| **CO 3** | To apply the c programming language in ARM programming | A |
| **CO 4** | To understand the basics of python language and its constructs | U |
| **CO 5** | To apply the python language in embedded applications | A |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | 3 | 3 | 3 | | | | 2 |
| **CO 2** | 3 | | 3 | 3 | 3 | | | | 2 |
| **CO 3** | 3 | | 3 | 3 | 3 | | | | 2 |
| **CO 4** | 3 | | 3 | 3 | 3 | | | | 2 |
| **CO 5** | 3 | | 3 | 3 | 3 | | | | 2 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination (Marks) |
|---|---|
| **Understand** | **10** |
| Apply | 20 |
| Analyse | 20 |
| Evaluate | |
| Create | 10 |


Passed in 1st BOS dated _____ Passed in 1st Academic Council dated _____

**Mark distribution**

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

Evaluation shall only be based on application, analysis or design based questions(for both internal and end semester examinations).

**Continuous Internal Assessment Pattern:**

**Continuous Internal Evaluation: 40 marks**

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

All course based assignments/tasks shall be of programming examples/ programming implementations of embedded systems. Review article can be prepared on embedded application implementations, embedded processors,

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be twoparts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module; having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students).Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Eachquestion can carry7 marks.

**Note:** The marks obtained for the ESE for an elective course shall not exceed20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

## Syllabus

| Module No | Description | Contact Hours |
|---|---|---|
| **1** | Linux: Introduction.<br>Linux : Introduction, distributions, accessing linux System,deskop and command line interface<br>The shell, Shell script and programming, Shell configuration, Linux files, directories and archives.The X window system, Xorg, and Display managers, Gnome, KDE, Linux software management. | 9 |
| 2 | Embedded Programming: Embedded Programming: C programming, Constants, variables and data types, operators and Expressions, I/O operations,Control flow statements (if else, switch, loops), Arrays and strings, Functions, structures and unions,Pointers, file management, Dynamic memory allocation and Linked lists. | 9 |
| **3** | Embedded C Programming using embedded IDE.<br>Embedded C Programming using embedded IDE. ARM I/O programming, LED, LCD, Keypad interfacing,UART,SPI,I2C programming, Timer programming,Interrupt and Exception programming, ADC, DAC, Sensor Interfacing,. | 9 |
| 4 | Python Programming basics :<br>Python Programming basics : variables, Input, Output, Basic operations,String manipulation, Conditional instructions, Loops, functions. | 9 |
| **5** | Python programming-<br>Python programming- Advanced python, Formatting, class, files, exceptions, linux commands, web server, Signal plotting and processing (numpy and matplotlib),Graphics, Computer vision. Programming examples of systems. | 9 |
| | Total Hours | 45 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | Linux: Introduction. | |
| 1.1 | Linux : Introduction, distributions, accessing linux system, deskop and command line interface | 3 |
| 1.2 | The shell, Shell script and programming, Shell configuration, Linux files, directories and archives. | 3 |
| 1.3 | The X window system, Xorg, and Display managers, Gnome, KDE, Linux software management. | 3 |
| 2 | Embedded Programming: | |
| 2.1 | Embedded Programming: C programming, Constants, variables and data types, operators and Expressions, I/O operations, | 3 |
| 2.2 | Control flow statements (if else, switch, loops), Arrays and strings, Functions, structures and unions, | 3 |
| 2.3 | Pointers, file management, Dynamic memory allocation and Linked lists. | 3 |
| 3 | Embedded C Programming using embedded IDE. | |
| 3.1 | Embedded C Programming using embedded IDE. ARM I/O programming, LED, LCD, Keypad interfacing | 3 |
| 3.2 | UART,SPI,I2C programming, Timer programming, | 3 |
| 3.3 | Interrupt and Exception programming, ADC, DAC, Sensor interfacing | 3 |
| 4 | Python Programming basics : | |
| 4.1 | Python Programming basics : variables, Input, Output, Basic operations, | 3 |
| 4.2 | String manipulation, Conditional instructions, Loops, functions, | 3 |
| 5 | Python programming- | |
| 5.1 | Python programming- Advanced python, Formatting, class, files, exceptions | 3 |
| 5.2 | linux commands, web server, Signal plotting and processing (numpy and matplotlib), | 3 |
| 5.3 | Graphics, Computer vision. Programming examples of systems. | 3 |
| | Total Hours | 45 |

**Text Books**

1. E. Balagurusamy, Programming in ANSI C, Tata McGraw-Hill, 6th Edition 2012
2. Muhammad Ali Mazidi, Shujen Chen, Sarmad Naimi, SepehrNaimi, "Freescale ARM Cortex-M Embedded Programming using C language", Mazidi and Naimi,2014
3. Simon Monk, "Raspberry Cook Book Software and Hardware Problems and Solutions", 2nd Edition, O' Reilly Media Inc., 2016.
4. Richard Petersen, "Linux: The Complete Reference", 2017, Sixth Edition, McGraw Hill Education

**Reference Books**

1. David Russell, "Introduction to Embedded systems Using ANSI C and the Arduino development Environment", 2010, 1rd edition, Morgan & Claypool Publishers.
2. E.I. Horvath, E.A. Horvath, "Learning IoT with Python and Raspberry Pi", Learning IoT LLC, 2019.
3. Sarmad Naimi, Muhammad Ali Mazidi, SepehrNaimi, "The STM32F103 Arm Microcontroller and Embedded Systems: Using Assembly and C", MicroDigitalEd, 2020

# PROGRAM ELECTIVE II

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCDPAT115 | DSP PROCESSORS AND ARCHITECTURE | PROGRAM ELECTIVE 2 | 3 | 0 | 0 | 3 |

**Preamble:** The aim of the course is to give an overview of the commonly used DSPalgorithms,

optimisations through various algorithm to architecture mapping which can lead to efficient their applications and various techniques for the algorithmic and architecturelevel Processors,Micro controllers with DSP extensions, DSP Architecture with case studies, the hardware implementations. The course also introduces the basic features in DigitalSignal

latest architectural trends in DSPsand their programming tools.

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO 1 | Analyse the basic resource constraints in a practical DSP system and solve them using various techniques/transformations that map the DSP algorithms to efficient architectures. | An |
| CO 2 | Apply the knowledge of various single core and multicore Digital Signal Processor architectures in identifying the optimal processor for solving real life signal processing problems. | A |
| CO 3 | Evaluate the DSP algorithms implemented in dedicated DSP processors and the micro controllers with DSP extensions | E |
| CO 4 | Create algorithms to solve signal processing problems using the latest hardware platforms. | E |
| CO5 | Create algorithms to solve signal processing problems using the latest software tools. | E |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 1 | | 3 | 3 | 3 | 1 | | | 2 |
| CO 2 | 1 | | 3 | 3 | 3 | 1 | | | 2 |
| CO 3 | 1 | | 3 | 3 | 3 | 1 | | | 2 |
| CO 4 | 2 | | 3 | 3 | 3 | 2 | | | 2 |
| CO5 | | | | | | | | | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| **Understand** | **5** |
| Apply | 20 |
| Analyse | 15 |
| Evaluate | 10 |
| Create | 10 |

**Mark distribution**

| TotalMarks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment Pattern:**

Continuous Internal Evaluation: 40 marks

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination question paper consists of two parts; Part A and Part B. Part Awill contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall beuseful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent should answer any five. Each question can carry 7 marks.

## Syllabus

| Module No | Description | Contact No. |
|---|---|---|
| 1 | **Basics of DSP Algorithm Representation to Architecture Mapping** | |
| | DSP Algorithm representations –Block Diagram, Signal Flow,Graph,Data Flow Graph, Dependence Graph.<br>Introduction to Filter structures- Recursive, Non-recursive and Lattice structures.<br>Fundamentals of DSP algorithm to architecture mapping - Loop bound, Iteration Bound, Critical Path.<br>Algorithms for computing Iteration Bound – Longest Path Matrix ,Algorithm, Minimum Cycle Mean Algorithm. | 8 |
| 2 | **Transformations for Improved DSP Architectures** | |
| | VLSI performance measures - area, power, and speed<br>Pipelining - Pipelining of FIR filters, Concept of Fine Grain Pipelining.Parallel Processing – Designing Parallel FIR systems.Pipelining and Parallel Processing for low power.<br>Folding and Unfolding Transformations and its applications. | 11 |
| 3 | **Single Core DSP Architectures** | |
| 3 | Introduction to General Purpose Processors (GPP), Microcontroller Units (MCU), Digital Signal Processors (DSP) - comparison andApplications.<br>The key features of a Digital Signal Processors – Dedicated hardwareunits, Circular Buffers, Modified bus structures and Memory access schemes.<br>Introduction to Harvard, Super Harvard DSP architectures,<br>Concept of Instruction Level Parallelism, VLIW Architecture and SingleInstruction Multiple Data (SIMD) processor architecture.<br>Case Study 1: Introduction to a popular DSP from Texas Instruments, The TMS320C67xx Series Processor- CPU | **11** |

| | | |
|---|---|---|
| | Architecture - CPU Data Paths and Control - Timers – Multichannel Buffered Serial Ports (McBSPs)- Internal Data/ Program Memory - External Memory Interface.<br>Case Study 2: Introduction to ARM Cortex-M Based Microcontrollers<br>with DSP extensions - ARMv7E-M architecture | |
| **4** | **Homogeneous Multicore DSPs** | |
| 4.1 | Introduction to multicore processors and their applications, A brief comparison between DSP SoCs, Field-Programmable Gate Arrays(FPGAs), Graphic Processors and CPUs. | |
| | Introduction to Multicore DSP Architectures: The TMS320C66xarchitecture:The CPU, Overview of peripherals and memory organization | 5 |
| | | |
| **5** | **Programming the DSPs** | |
| | Introduction to Code Composer Studio (CCS) software developmenttool and the TMS320C6XX EVM kit<br>Introduction to Keil Development tool, CMSIS DSP software libraryand ARM Cortex-M4 development board<br>Introduction to Open MP Application Programming Interface (API)and Open Computing Language (OpenCL).<br>Implementation of simple DSP algorithms<br>Latest architectural trends in digital signal processing:<br>Introduction toHeterogeneous Multicore DSP Architecture and FPGA SoCs. | **10** |
| | Total Hours | 45 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Basics of DSP Algorithm Representation to Architecture Mapping** | |
| 1.1 | DSP Algorithm representations –Block Diagram, Signal Flow Graph, Data Flow Graph, Dependence Graph. | 2 |
| 1.2 | Introduction to Filter structures- Recursive, Non-recursive and | 2 |

| | | |
|---|---|---|
| | Lattice structures. | |
| 1.3 | Fundamentals of DSP algorithm to architecture mapping - Loop bound, Iteration Bound, Critical Path. | 2 |
| 1.4 | Algorithms for computing Iteration Bound – Longest Path Matrix Algorithm, Minimum Cycle Mean Algorithm. | 2 |
| **2** | **Transformations for Improved DSP Architectures** | |
| 2.1 | VLSI performance measures - area, power, and speed | 2 |
| 2.2 | Pipelining - Pipelining of FIR filters, Concept of Fine Grain Pipelining. | 2 |
| 2.3 | Parallel Processing – Designing Parallel FIR systems. | 2 |
| 2.4 | Pipelining and Parallel Processing for low power. | 2 |
| 2.5 | Folding and Unfolding Transformations and its applications. | 3 |
| | | |
| **3** | **Single Core DSP Architectures** | |
| 3.1 | Introduction to General Purpose Processors (GPP), Microcontroller Units (MCU), Digital Signal Processors (DSP) - comparison and Applications. | 2 |
| 3.2 | The key features of a Digital Signal Processors – Dedicated hardware units, Circular Buffers, Modified bus structures and Memory access schemes. | 2 |
| 3.3 | Introduction to Harvard, Super Harvard DSP architectures, Concept of Instruction Level Parallelism, VLIW Architecture and Single Instruction Multiple Data (SIMD) processor architecture. | 1 |
| 3.4 | Case Study 1: Introduction to a popular DSP from Texas Instruments, The TMS320C67xx Series Processor- CPU Architecture - CPU Data Paths and Control - Timers – Multichannel Buffered Serial Ports (McBSPs)- Internal Data/ Program Memory - External Memory Interface. | 3 |
| 3.5 | Case Study 2: Introduction to ARM Cortex-M Based Microcontrollers with DSP extensions - ARMv7E-M architecture | 3 |
| | | |

| | | |
|---|---|---|
| **4** | **Homogeneous Multicore DSPs** | |
| 4.1 | Introduction to multicore processors and their applications, A brief comparison between DSP SoCs, Field-Programmable Gate Arrays (FPGAs), Graphic Processors and CPUs. | 3 |
| 4.2 | Introduction to Multicore DSP Architectures: The TMS320C66xarchitecture:The CPU, Overview of peripherals and memory organization | 2 |
| | | |
| **5** | **Programming the DSPs** | |
| 5.1 | Introduction to Code Composer Studio (CCS) software development tool and the TMS320C6XX EVM kit Introduction to Keil Development tool, CMSIS DSP software libraryand ARM Cortex-M4 development board | 2 |
| 5.2 | Introduction to Open MP Application Programming Interface (API)and Open Computing Language (OpenCL). | 3 |
| 5.3 | Implementation of simple DSP algorithms | 2 |
| 5.4 | Latest architectural trends in digital signal processing: Introduction toHeterogeneous Multicore DSP Architecture and FPGA SoCs. | 3 |
| | Total Hours | 45 |

**Text Books**

1. Keshab K. Parhi, "VLSI Signal Processing Systems, Design and Implementation",John Wiley &Sons,1999
2. NaimDahnoun, “Multicore DSP: from algorithms to real-time implementation on theTMS320C66x SoC”. John Wiley & Sons, 2018.
3. Steven W. Smith, “The Scientist and Engineer’s Guide to Digital Signal Processing”Second Edition, California Technical Publishing , 1999.
4. Reference Link for Overview of Latest Processor Architectures– Digital signal processors (DSPs) | Overview | Processors |TI.com, https://training.ti.com/system/files/docs/c66x-corepac-instruction-set-referenceguide.pdf
5. Joseph Yiu “The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors”, Elsevier, 2014

**Reference Books**

1. Rulph Chassaing, “Digital Signal Processing and Applications with the C6713 andC6416 DSK”, John Wiley & Sons, 2005.
2. Sen M. Kuo, Woon-Seng S. Gan, Digal Signal Processors: Architectures, Implementations, and Applications, Prentice Hall, 2004.
3. Lars Wanhammar, DSP Integrated Circuits, Academic Press, 1999.
4. B Venkataramani, M Bhaskar, “Digital Signal Processors: Architecture, Programming and Applications”, 2nd Ed., Tata McGraw-Hill Education, 2002.
5. A. Kharin, S. Vityazev and V. Vityazev, "Teaching multi-core DSP implementation on EVM C6678 board," 2017 25th European Signal Processing Conference (EUSIPCO), 2017, pp. 2359-2363, doi: 10.23919/EUSIPCO.2017.8081632
6. Donald S. Reay.. “Digital Signal Processing Using the ARM Cortex M4”, (1st. ed.). Wiley Publishing, 2015
7. CemÜnsalan, M. ErkinYücel, H. DenizGürhan, “Digital Signal Processing Using Arm Cortex-M Based Microcontrollers: Theory and Practice”, ARM Education Media, 2018.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCCOOT125 | CODING THEORY | PROGRAM ELECTIVE 2 | 3 | 0 | 0 | 3 |

**Preamble:** This course aims at a rigorous analysis of various error correction codes starting from the earliest Hamming code to the latest polar codes used in 5G

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| **CO 1** | Analyse block codes and various bounds governing their construction | An |
| **CO 2** | Analyse LDPC coding and hard decision/soft decision decoding | An |
| **CO 3** | Illustrate coding and decoding of BCH/RS codes | U |
| **CO 4** | Review convolutional encoding and decoding them using BCJR algorithm | A |
| **CO 5** | Illustrate coding and decoding of Turbo codes and to discuss polar codes and their applications in 5G | U |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 2 | | | | | 3 | |
| **CO 2** | 3 | 2 | 2 | | | | | 3 | |
| **CO 3** | 3 | 3 | 3 | | | | | 3 | |
| **CO 4** | 3 | 2 | 3 | | | | | 3 | |
| **CO 5** | 3 | 3 | 2 | | | | | 3 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| **Understand** | **10** |
| Apply | 10 |
| Analyse | 20 |
| Evaluate | 20 |
| Create | |

**Mark distribution**

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment Pattern:**

Continuous Internal Evaluation: 40 marks

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

**End Semester Examination Pattern:**

There will be two parts; Part A and Part B

- Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions.
- Part B will contain 7 questions with minimum one question from each module of whichstudent should answer any five. Each question can carry 7 marks.

**Syllabus**

| Module No | Description | Contact Hours |
|---|---|---|
| 1 | **Linear Block Codes and Bounds** | |
| 1.1 | Course Overview-Relevance of Error correction schemes in communication systems | 2 |
| 1.2 | Repetition coding, concepts of Code rate, Hamming Distance, Minimum Distance, Error detecting and correcting capability. | 2 |
| 1.3 | Review of Group,ring, fields and vector spaces | 2 |

| | | |
|---|---|---|
| 1.4 | Linear Block codes-Generator and parity check matrices,encoding, standard array and syndrome decoding, Hamming codes | 2 |
| 1.5 | Maximum Distance Separable (MDS) codes | 1 |
| 1.6 | Bounds on size of codes: Hamming bound, Singleton bound, Plotkin bound, Gilbert-Varshamov bound | 2 |
| 2 | **LDPC Codes** | |
| 2.1 | Regular and Irregular Low Density Parity Check Codes-Tanner graph | 2 |
| 2.2 | Message Passing decoding-Hard decision and Soft decision | 2 |
| 2.3 | Message passing decoding in a BEC | 1 |
| 2.4 | Bit flipping algorithm for decoding | 1 |
| 2.5 | Belief Propagation decoding: Sum Product algorithm | 2 |
| 3 | **BCH and RS codes** | |
| 3.1 | Galois Fields -- Irreducible and Primitive Polynomials, Primitive elements, Field extension, Conjugate elements and Minimal Polynomials. Cyclotomiccosets. | 2 |
| 3.2 | BCH Codes - Design, BCH Bound, Decoding BCH codes – Decoding BCH – the general outline, computation of the syndrome, error locator polynomial, Chien Search algorithm, Finding the error locator polynomial. Berlekamp Massey Algorithm. Burst-error correction capability of BCH codes. | 4 |
| 3.3 | Reed Solomon Codes – BCH code viewpoint. Vandermonde matrix view point. MDS property. Generalized Reed-Solomon codes. Application of BCH decoding algorithms to Reed-Solomon decoding. Sudan's algorithm for decoding. Use of RS codes in disks and cloud storage. | 4 |
| 4 | **Convolutional Codes and Turbo codes** | |
| 4.1 | Review of convolutional codes: Encoding, state diagram, trellis diagram | 2 |
| 4.2 | Review of convolutional codes: Viterbi Decoding | 1 |
| 4.3 | Decoding of convolutional codes: BCJR algorithm | 2 |
| 4.4 | Turbo Codes: Turbo encoder, Parallel concatenation decoding | 3 |

**Text Books**

1. Shu Lin, D. J Costello Jr. Error Control Coding: Fundaments and Applications, Prentice Hall

**Reference Books:**

1. Ron M Roth, Introduction to Coding Theory, Cambridge Institution Press

2. T. Richardson, R. Urbanke, Modern Coding Theory, Cambridge Institution Press

3. A. Thangaraj, LDPC and Polar Codes in 5G Standard, NPTEL

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCMSWT135 | MULTIRATE SIGNAL PROCESSING AND WAVELETS | PROGRAM ELECTIVE 2 | 3 | 0 | 0 | 3 |

**Preamble:** Multirate systems play a central role in many areas of signal processing, such as filter bank theory and multiresolution theory. This course imparts a comprehensive knowledge of topics in multirate signal processing and wavelets, some of the standard signal processing techniques such as signal analysis, denoising, and other applications.

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcome | Description | Bloom'S Level |
|---|---|---|
| **CO 1** | Apply sampling rate conversions, decimation and interpolation as part of Signal Processing techniques | A |
| **CO 2** | Design a perfect reconstruction filter bank system | E |
| **CO 3** | Analyze the signal decomposition and reconstruction using tree structured filter banks | An |
| **CO 4** | Design an orthogonal/biorthogonal wavelet system according to the application. | E |
| **CO 5** | Implement the wavelet based decomposition using appropriate filter bank structure | E |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | | | | 3 | | | | 3 | |
| **CO 2** | 3 | | | | | 2 | | 3 | |
| **CO 3** | | | | 3 | | | | 3 | |
| **CO 4** | 3 | | | | | | | 3 | |
| **CO 5** | | | | 3 | | | | 3 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| **Understand** | **10** |
| Apply | 20 |
| Analyse | 20 |
| Evaluate | 10 |
| Create | |

**Mark distribution**

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment Pattern:**

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications<br>(minimum 10 Publications shall be referred): | 15 marks |
| Course based task/Seminar/Data Collection and interpretation: | 15 marks |
| Test paper, 1 no.:<br>(Test paper shall include minimum 80% of the syllabus.) | 10 marks |

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be twoparts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry7 marks.

4. Spectral Audio Signal Processing, Julius O. Smith III, W3K Publishing, 2011.

| Module No | Description | Contact Hours |
|---|---|---|
| 1 | **Multi-rate System Fundamentals:** | |
| | Review of basic multi-rate operations: up sampling and down sampling, time domain and frequency domain analysis, Need for antialiasing and anti-imaging filters.Interpolator and decimator design, Noble identities.Type 1 and Type 2 polyphase decomposition, 2-channel and N- channelpolyphase decompositionEfficient structures for decimation and interpolation filters,efficient structures for fractional sampling rate conversion. | **9** |
| 2 | **Multi-rate Filter Banks** | |

| | | |
|---|---|---|
| | Overview of Maximally decimated filter banks and non-maximally decimated filter bank. Uniform DFT filter banks - design, polyphase implementation.<br>Two-channel critically sampled filter banks<br>Amplitude-Complementary 2-Channel Filter<br>Bank<br>Example - Two channel Haar Filter bank and its polyphase decomposition.<br>Quadrature mirror filter (QMF) bank , Errors in the QMF bank, conditions for perfect reconstruction, polyphase implementation<br>Design of perfect reconstruction M- channel Filter Banks<br>Overview of Uniform and non-uniform tree structured filter banks.<br>Dyadic filter bank. | **11** |
| 3 | **Continuous and Discrete Wavelet Transform** | |
| | Short Time Fourier Transform (STFT), STFT as a bank of filters, Choice of window function and time frequency trade-off.<br>The Uncertainty Principle and Time Frequency Tiling<br>Continuous wavelet transform (CWT) and inverse CWT.<br>Properties of Wavelets Used in CWT, Admissibility condition.<br>Concept of orthogonal and orthonormal basis functions, function spaces. Discrete Wavelet Transform.<br>Haar Scaling Function, Nested Spaces.<br>Haar Wavelet Function, Orthogonality of scaling and translate functions, Normalization of Haar Bases at different Scales, Refinement Relation with respect to normalized bases.<br>Support of a Wavelet System, Daubechies Wavelets. | 9 |
| 4 | **Design of Orthogonal & Biorthogonal wavelets systems** | |
| | Designing Orthogonal Wavelet systems - a direct approach, Frequency domain approach for designing wavelets.<br>Implementation using tree structured QMF bank and equivalentM-channel filter bank.<br>Designing Biorthogonal Wavelet systems: Biorthogonality in Vector Space, Biorthogonal Wavelet Systems.<br>Signal Representation Using Biorthogonal Wavelet System, Biorthogonal Analysis and Biorthogonal Synthesis. | **9** |

| | | |
|---|---|---|
| | Construction of Biorthogonal Wavelet Systems-B-splines Computation of the discrete wavelet transform using Mallat Algorithm and Lifting Scheme | |
| 5 | **Wavelet Packet Analysis and applications of wavelets** | |
| | Wavelet Packet Transform – Signal representation using wavelet packet analysis | 8 |
| | Applications of Wavelets and Wavelet Packets in Signal and Image compression | |
| | Wavelet based signal denoising. | |
| | Total Hours | 45 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Multi-rate System Fundamentals:** | |
| 1.1 | Review of basic multi-rate operations: up sampling and down sampling, time domain and frequency domain analysis, Need for antialiasing and anti-imaging filters. Interpolator and decimator design, Noble identities. | 3 |
| 1.2 | Type 1 and Type 2 polyphase decomposition, 2-channel and N-channelpolyphase decomposition | 3 |
| 1.3 | Efficient structures for decimation and interpolation filters, efficient structures for fractional sampling rate conversion. | 3 |
| 2 | **Multi-rate Filter Banks** | |
| 2.1 | Overview of Maximally decimated filter banks and non-maximally decimated filter bank. Uniform DFT filter banks - design, polyphase implementation.Two-channel critically sampled filter banks Amplitude-Complementary 2-Channel Filter Bank Example - Two channel Haar Filter bank and its polyphase decomposition. | 3 |
| 2.2 | Quadrature mirror filter (QMF) bank , Errors in the QMF bank, conditions for perfect reconstruction, polyphase implementation | 2 |
| 2.3 | Design of perfect reconstruction M- channel Filter Banks | 2 |

| | | |
|---|---|---|
| 2.4 | Overview of Uniform and non-uniform tree structured filter banks. Dyadic filter bank. | 2 |
| 3 | **Continuous and Discrete Wavelet Transform** | |
| 3.1 | Short Time Fourier Transform (STFT), STFT as a bank of filters, Choice of window function and time frequency trade-off. | 2 |
| 3.2 | The Uncertainty Principle and Time Frequency Tiling | 1 |
| 3.3 | Continuous wavelet transform (CWT) and inverse CWT. Properties of Wavelets Used in CWT, Admissibility condition. | 2 |
| 3.4 | Concept of orthogonal and orthonormal basis functions, function spaces. Discrete Wavelet Transform. Haar Scaling Function, Nested Spaces. Haar Wavelet Function, Orthogonality of scaling and translate functions, Normalization of Haar Bases at different Scales, Refinement Relation with respect to normalized bases. Support of a Wavelet System, Daubechies Wavelets. | 4 |
| 4 | **Design of Orthogonal & Biorthogonal wavelets systems** | |
| 4.1 | Designing Orthogonal Wavelet systems - a direct approach, Frequency domain approach for designing wavelets. Implementation using tree structured QMF bank and equivalentM-channel filter bank. | 3 |
| 4.2 | Designing Biorthogonal Wavelet systems: Biorthogonality in Vector Space, Biorthogonal Wavelet Systems. Signal Representation Using Biorthogonal Wavelet System, Biorthogonal Analysis and Biorthogonal Synthesis. Construction of Biorthogonal Wavelet Systems-B-splines | 3 |
| 4.3 | Computation of the discrete wavelet transform using Mallat Algorithm and Lifting Scheme | 3 |
| 5 | **Wavelet Packet Analysis and applications of wavelets** | |
| 5.1 | Wavelet Packet Transform – Signal representation using wavelet packet analysis | 2 |
| 5.2 | Applications of Wavelets and Wavelet Packets in Signal and Image compression | 3 |

| | | |
|---|---|---|
| 5.3 | Wavelet based signal denoising. | 3 |
| | Total Hours | 45 |

**Reference Books**

1.P. P. Vaidyanathan, Multirate Systems and Filter Banks, Pearson Education, 2006.

2. Fredric J Harris, Multirate Signal Processing for Communication Systems, 1st Edition,Pearson Education, 2007

3. Sanjit K. Mitra, Digital Signal Processing: A Computer based Approach, Special Indian Edition,McGraw Hill, 2013.

4. K. P. Soman, K. I. Ramachandran, N. G. Resmi, PHI, Insight into wavelets :From theory topractice

4. G.Strang& T. Nguyen , Wavelets and Filter bank, Wellesly-Cambridge

5. M. Vetterli& J. Kovacevic, Wavelets and sub band coding, Prentice Hall

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCASPT145 | ADAPTIVE SIGNAL PROCESSING | PROGRAM ELECTIVE 2 | 3 | 0 | 0 | 3 |

**Preamble:** This course introduces the design and analysis of signal processing algorithms which can automatically change the system parameters to get a desired output, when a stationary random signal is applied to it.

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| **CO 1** | Analyse stationary random signals and adaptive systems. | An |
| **CO 2** | Analyse performance of the gradient search algorithms. | An |
| **CO 3** | Evaluate the effect of gradient noise in weight vector solution. | E |
| **CO 4** | Analyse LMS algorithms, adaptive recursive filters and Kalman filters. | An |
| **CO 5** | Apply the adaptive systems for applications in system modelling and inverse adaptive modelling. | A |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 1 | | | | | | | 3 | |
| **CO 2** | 2 | | 2 | | 2 | | | 3 | |
| **CO 3** | 2 | | 2 | | 2 | | | 3 | |
| **CO 4** | 2 | | 2 | 3 | 2 | | | 3 | |
| **CO 5** | 2 | | 2 | 3 | 3 | 2 | | 3 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 10 |
| Apply | 40 |
| Analyse | 10 |
| Evaluate | |
| Create | |

**Mark distribution**

| TotalMarks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern**

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 Publications shall be referred): | 15 marks |
| Course based task/Seminar/Data Collection and interpretation: | 15 marks |
| Test paper, 1 no.:<br>(Test paper shall include minimum 80% of the syllabus.) | 10 marks |

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be twoparts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry7 marks.

**Syllabus**

| Module No | Description | Contact No |
|---|---|---|
| 1 | **Review of discrete time stochastic process and auto correlation matrix** | |
| | Univariate and Multivariate random sequences, Gaussian noise<br>Autocorrelation matrix of stationary process and its properties<br>Eigen decomposition, properties of Eigen vectors, whitening | 9 |
| **2** | **Introduction to adaptive systems** | |
| | Introduction to adaptive systems – definitions– characteristics– configurations – applications<br>Adaptive linear combiner – MSE performance function – Wiener-Hopf equation,Searching the MSE performance function – Newton's methodfor searching the performance function, stability and Convergence,Steepest descent algorithm – Stability and convergence –Learning curve | 8 |
| **3** | **Gradient estimation and its effects on adaptation** | |
| | Performance penalty and perturbation<br>Effects on weight vector solution, covariance of weight vector | 9 |

| | | |
|---|---|---|
| | Excess MSE, mis adjustment and time constants | |
| 4 | Adaptive algorithms and structures | |
| | LMS algorithm, Convergence of weight vector and learning Curve Adaptive recursive filters<br>Discrete Kalman Filter, filtering example | 10 |
| 5 | **Applications of adaptive filtering** | |
| | Adaptive modelling of multipath communication channel<br>Adaptive modelling for FIR filter synthesis<br>Adaptive equalization of telephone channels<br>Adapting poles and zeros for IIR digital filter synthesis | 8 |
| | Total Hours | 45 |

**Course Plan**

| Course No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Review of discrete time stochastic process and auto correlation matrix** | |
| 1.1 | Univariate and Multivariate random sequences, Gaussian noise | 3 |
| 1.2 | Autocorrelation matrix of stationary process and its properties | 3 |
| 1.3 | Eigen decomposition, properties of Eigen vectors, whitening | 3 |
| **2** | **Introduction to adaptive systems** | |
| 2.1 | Introduction to adaptive systems – definitions– characteristics–configurations – applications | 2 |
| 2.2 | Adaptive linear combiner – MSE performance function –Wiener-Hopf equation | 2 |
| 2.3 | Searching the MSE performance function – Newton's methodforsearching theperformancefunction, stabilityand convergence | 2 |
| 2.4 | Steepest descent algorithm – Stability and convergence –Learning curve | 2 |
| **3** | **Gradient estimation and its effects on adaptation** | |
| 3.1 | Performance penalty and perturbation | 3 |
| 3.2 | Effects on weight vector solution, covariance of weight vector | 3 |

| | | |
|---|---|---|
| 3.3 | Excess MSE, mis adjustment and time constants | 3 |
| 4 | Adaptive algorithms and structures | |
| 4.1 | LMS algorithm, Convergence of weight vector and learning curve | 3 |
| 4.2 | Adaptive recursive filters | 3 |
| 4.3 | Discrete Kalman Filter, filtering example | 4 |
| 5 | **Applications of adaptive filtering** | |
| 5.1 | Adaptive modelling of multipath communication channel | 2 |
| 5.2 | Adaptive modelling for FIR filter synthesis | 2 |
| 5.3 | Adaptive equalization of telephone channels | 2 |
| 5.4 | Adapting poles and zeros for IIR digital filter synthesis | 2 |
| | Total Hours | 45 |

**Reference Books**

1. Bernard Widrow and Samuel D. Stearns, Adaptive signal processing, Pearsoneducation.
2. Simon Hykins, Adaptive filter theory, Fifth edition, Pearson education.
3. A. Papaulis and U. Pillai, Probability Random Variables and Stochastic Processes,4th Edition, McGraw Hill Education.
4. S. Thomas Alexander, Adaptive Signal Processing – Theory and Applications,SpringerVerlag

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCIOTT155 | INTERNET OF THINGS | PROGRAM ELECTIVE 2 | 3 | 0 | 0 | 3 |

**Preamble:** The core modules of this elective course include introduction to Internet of Things (IoT), IoT protocol and software, IoT point to point communication technologies, IoT security and IoT Platform. This course aims to teach the student to understand the concepts of IoT and its applications.

**Prerequisites:** NIL

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| **CO 1** | Identify the IoT networking components with respect to OSI layer. | U |
| **CO 2** | Understand the communication networks and protocols used in IoT | U |
| **CO 3** | Understand the cloud resources, data analysis and applications. | U |
| **CO 4** | Understand IoT security and threat models analysis. | U |
| **CO 5** | Understand various IoT applications and its variants and to design and develop prototype models for various IoT applications.. | U |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | 3 | 3 | 3 | | | | 2 |
| **CO 2** | 3 | | 3 | 3 | 3 | | | | 2 |
| **CO 3** | 3 | | 3 | 3 | 3 | | | | 2 |
| **CO 4** | 3 | | 3 | 3 | 3 | | | | 2 |
| **CO 5** | 3 | | 3 | 3 | 3 | | | | 2 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| **Understand** | **5** |
| Apply | 20 |
| Analyse | 30 |
| Evaluate | |
| Create | 5 |

**Mark distribution**

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

Evaluation shall only be based on application, analysis or design-based questions (for bothinternal and end semester examinations).

**Continuous Internal Assessment Pattern:**

**Continuous Internal Evaluation: 40 marks**

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module; having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation),with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Note:** The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % fora core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60%.

# SYLLABUS

| Module No | Description | Contact hours |
|---|---|---|
| 1 | **Introduction to IoT:** | |
| | Basics of Networking- network types,layered network models, addressing,TCP/IP Transport layer<br>Emergence of IoT- evolution of IoT,IoT networking components<br>IoT network architecture and design-comparing IoT architectures,simplified IoT architecture.<br>Smart objects: the things in IoT-sensors, actuators and smart objects,sensor networks | 9 |
| 2 | **IoT protocols and Softwares:** | |
| | Connecting smart objects: communications criteria<br>IoT connectivity technologies(IEEE 802.15.4,Zigbee,Sigfox,LoRA,NB-IoT,Wi-Fi,Bluetooth)<br>IoT communication technologies: infrastructure ,protocols(IPv6,6LoWPAN),Dataprotocols(MQTT,CoAp,AMQP,XMPP,SOAP,REST,WebSocket) | 9 |
| 3 | **Introduction to Cloud computation and Big data analytics:** | |
| | cloud computing: introduction, cloud models<br>cloud implementation-cloud simulation,open-source cloud(OpenStack),commercial cloud:AWS<br>introduction to data analytics for IoT, machine learning<br>Big data analytics tools and technology - Hadoop<br>Edge streaming analytics, Network analytics | 9 |
| 4 | **IoT security:** | |

| | | |
|---|---|---|
| | common challenges in Iot security<br>fundamentals of cryptography: cryptographic algorithms and their security services, the lightweight features of cryptographic algorithms<br>Quadruple Trust Model for IoT-A – Threat Analysis and model for IoT-A,Cloud security | 9 |
| 5 | **IoT application and its Variants:** | **8** |
| | Case studies: IoT for smart cities, health care, agriculture, smart meters.<br>M2M, Web of things, Cellular IoT<br>Industrial IoT, Industry 4.0, IoT standards. | |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Introduction to IoT:** | |
| 1.1 | Basics of Networking- network types,layered network models, addressing,TCP/IP Transport layer | 2 |
| 1.2 | Emergence of IoT- evolution of IoT,IoT networking components | 3 |
| 1.3 | IoT network architecture and design-comparing IoT architectures,simplified IoT architecture. | 2 |
| 1.4 | Smart objects: the things in IoT-sensors, actuators and smart objects,sensor networks | 2 |
| 2 | **IoT protocols and Softwares:** | |
| 2.1 | Connecting smart objects: communications criteria | 3 |
| 2.2 | IoT connectivity technologies(IEEE 802.15.4,Zigbee,Sigfox,LoRA,NB-IoT,Wi-Fi,Bluetooth) | 3 |
| 2.3 | IoT communication technologies: infrastructure ,protocols(IPv6,6LoWPAN),Dataprotocols(MQTT,CoAp,AMQP,XMPP ,SOAP,REST,WebSocket) | 3 |
| 3 | **Introduction to Cloud computation and Big data analytics:** | |
| 3.1 | cloud computing: introduction, cloud models | 2 |
| 3.2 | cloud implementation-cloud simulation,open-source cloud(OpenStack),commercial cloud:AWS | 2 |
| 3.3 | introduction to data analytics for IoT, machine learning | 1 |
| 3.4 | Big data analytics tools and technology - Hadoop | 2 |

| | | |
|---|---|---|
| 3.5 | Edge streaming analytics, Network analytics | 2 |
| 4 | **IoT security:** | |
| 4.1 | common challenges in Iot security | 2 |
| 4.2 | fundamentals of cryptography: cryptographic algorithms and their security services, the lightweight features of cryptographic algorithms | 2 |
| 4.3 | Quadruple Trust Model for IoT-A – Threat Analysis and model for IoT-A, | 2 |
| 4.4 | Cloud security | 3 |
| 5 | **IoT application and its Variants:** | |
| 5.1 | Case studies: IoT for smart cities, health care, agriculture, smart meters. | 3 |
| 5.2 | M2M, Web of things, Cellular IoT | 3 |
| 5.3 | Industrial IoT, Industry 4.0, IoT standards. | 2 |
| | Total Hours | 45 |

**Text Books**

1. S.Misra, A. Mukherjee, and A.Roy, 2020. Introduction to IoT. Cambridge Institution Press.
2. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, —IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017.
3. Rajkamal, “Internet of Things : Architecture and Design Principles”, McGraw Hill (India) Private Limited
4. Chuan Kun Wn,”Internet of Things Security: Architectures and Security Measures”,Springer 2021.
5. Alessandro Bassi, Martin Bauer, Martin Fiedler, Thorsten Kramp, Rob van Kranenburg, Sebastian Lange, Stefan Meissner, “Enabling things to talk – Designing IoT solutions with the IoT Architecture Reference Model”, Springer Open, 2016

**Reference Books**

1. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, “From Machine to Machine to Internet of Things”, Elsevier Publications, 2014.
2. LuYan, Yan Zhang, Laurence T. Yang, Huansheng Ning, The Internet of Things: From RFID to the Next-Generation Pervasive Network, Aurbach publications, March,2008.
3. Vijay Madisetti , Arshdeep Bahga, Adrian McEwen (Author), Hakim Cassimally “Internet of Things A Hands-on-Approach” Arshdeep Bahga & Vijay Madisetti, 2014.

4. Asoke K Talukder and Roopa R Yavagal, “Mobile Computing,” Tata McGraw Hill, 2010.
5. Barrie Sosinsky, “Cloud Computing Bible”, Wiley-India, 2010
6. RonaldL. Krutz, Russell Dean Vines,Cloud Security: A Comprehensive Guide to Secure Cloud Computing,Wiley-India, 2010

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 22PCOPTT165 | OPTIMIZATION TECHNIQUES | PROGRAM ELECTIVE 2 | 3 | 0 | 0 | 3 |

**Preamble:** This course aims to enable the students to apply suitable optimization techniques for various applications.

**Prerequisite**: Nil

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| **CO1** | Outline the mathematical building blocks of optimization | U |
| **CO2** | Model and solve linear programming problems | E |
| **CO3** | Apply principles and techniques for solving nonlinear programming models | A |
| **CO4** | Investigate and assess constrained convex optimization problems | An |
| **CO5** | Appreciate prominent heuristic optimization algorithms and to Solve optimization problem through optimization software | E |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | | 2 | 3 | 3 | 1 | | 3 | |
| **CO2** | 3 | 1 | 2 | 3 | 3 | 1 | 1 | 3 | |
| **CO3** | 3 | 1 | 2 | 3 | 3 | 1 | 1 | 3 | |
| **CO4** | 3 | 1 | 2 | 3 | 3 | 1 | 1 | 3 | |
| **CO5** | 3 | | 2 | 3 | 3 | 1 | 1 | 3 | |
| **CO 6** | 3 | 1 | 2 | 3 | 3 | 1 | 1 | 3 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| **Understand** | **10** |
| Apply | 20 |
| Analyze | 20 |
| Evaluate | 10 |
| Create | |

**Mark distribution**

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| **100** | **40** | **60** | **2.5hours** |

**Continuous Internal Assessment Pattern:**

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

Test paper 1 no. (Test paper shall include minimum 80% of syllabus):*10marks*

**End Semester Examination Pattern:**

The end semester examination will be conducted by respective College. There will be two parts; Part Aand Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Note**: *The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, thenthe maximum eligible mark % for an elective course is 40+20 = 60 %.*

**SYLLABUS**

| Module No | Topic | Contact Hours |
|---|---|---|
| 1 | **Mathematical Background:** | |
| | Vector norm, Matrix norm, Inner product, Norm ball | 9 |
| | Interior point, Closure and boundary | |
| | Complement, scaled sets, and sum of sets, Supremum and infimum | |
| | Vector subspace, Function, Continuity of function, | |
| | Derivative, gradient and Hessian | |
| | Convex sets and convex functions | |
| | Introduction to optimization - Optimal problem formulation | |
| | Engineering applications of optimization, Optimization techniques Classification | |
| 2 | **Linear Programming:** | |
| | Linear Programming - Formulation of the problem, Graphical method<br>Simplex method<br>Artificial variable techniques, Duality Principle<br>Dual simplex method | 9 |
| 3 | **Non-linear programming:**<br>**Uni-modal Function**<br>**Elimination Methods: (1) Fibonacci Method**<br>**Elimination Methods: (2) Golden Section Method**<br>**Direct Search Methods: (1) Random Walk**<br>**Direct Search Methods: (2) Grid Search Method**<br>**Indirect Search Method: (1) Steepest Descent Method**<br>**Indirect Search Method: (2) Newton's Method** | 9 |
| 4 | **Convex optimization:** | |
| | Standard form of convex optimization problems<br>Global optimality, An optimality criterion for differentiable convex function<br>Lagrange dual function and conjugate function<br>Lagrange dual problem<br>Karush–Kuhn–Tucker (KKT) optimality conditions | 9 |
| 5 | **Optimization algorithms:** | |
| | Genetic algorithm<br>Neural network-based optimization<br>Ant colony optimization<br>Particle swarm optimization.<br>Optimization Libraries in Python: scipy.optimize, CVXPY, CVXOPT | 9 |
| | Total Hours | 45 |

**Text Books**

1. Chong-Yung-Chi, Wei-Chiang Li, Chia-Hsiang Lin, Convex Optimization for Signal Processing and Communications – From fundamentals to applications, CRC press.
2. Sukanta Nayak, Fundamentals of Optimization Techniques with Algorithms, Academic press.
3. Singiresu S. Rao, Engineering Optimization: Theory and Practice, John Wiley and Sons.

**Reference Books**

1. Igor Griva, ArielaSofer, Stephen G Nash,Linear and Nonlinear Optimization, Second edition, SIAM.
2. Kalyanmoy Deb,Optimization for Engineering: Design Algorithms and Examples, Second edition,Prentice Hall.
3. David G Luenberger, Linear and Nonlinear Programming, Second edition, Addison-Wesley.

| No | Topic | No. Of Lectures |
|---|---|---|
| **1** | **Mathematical Background:** | |
| 1.1 | Vector norm, Matrix norm, Inner product, Norm ball | 1 |
| 1.2 | Interior point, Closure and boundary | 1 |
| 1.3 | Complement, scaled sets, and sum of sets, Supremum and infimum | 1 |
| 1.4 | Vector subspace, Function, Continuity of function, | 1 |
| 1.5 | Derivative, gradient and Hessian | 1 |
| 1.6 | Convex sets and convex functions | 1 |
| 1.7 | Introduction to optimization - Optimal problem formulation | 1 |
| 1.8 | Engineering applications of optimization, Optimization techniques Classification | 2 |
| **2** | **Linear Programming:** | |
| 2.1 | Linear Programming - Formulation of the problem, Graphical method | 2 |
| 2.2 | Simplex method | 2 |
| 2.3 | Artificial variable techniques, Duality Principle | 2 |
| 2.4 | Dual simplex method | 3 |
| **3** | **Non-linear programming:** | |
| 3.1 | Uni-modal Function | 1 |
| 3.2 | Elimination Methods: (1) Fibonacci Method | 1 |
| 3.3 | Elimination Methods: (2) Golden Section Method | 1 |
| 3.4 | Direct Search Methods: (1) Random Walk | 1 |
| 3.5 | Direct Search Methods: (2) Grid Search Method | 1 |
| 3.6 | Indirect Search Method: (1) Steepest Descent Method | 2 |
| 3.7 | Indirect Search Method: (2) Newton's Method | 2 |
| **4** | **Convex optimization:** | |
| 4.1 | Standard form of convex optimization problems | 1 |

| | | |
|---|---|---|
| 4.2 | Global optimality, An optimality criterion for differentiable convex function | 2 |
| 4.3 | Lagrange dual function and conjugate function | 2 |
| 4.4 | Lagrange dual problem | 2 |
| 4.5 | Karush–Kuhn–Tucker (KKT) optimality conditions | 2 |
| **5** | **Optimization algorithms:** | |
| 5.1 | Genetic algorithm | 1 |
| 5.2 | Neural network-based optimization | 2 |
| 5.3 | Ant colony optimization | 2 |
| 5.4 | Particle swarm optimization. | 2 |
| 5.5 | Optimization Libraries in Python: scipy.optimize, CVXPY, CVXOPT | 2 |
| | Total Hours | 45 |

# SEMESTER II

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCFDST201 | FOUNDATIONOF DATA SCIENCE | DISCIPLINE CORE 2 | 3 | 0 | 0 | 3 |

Preamble:None

Course Outcomes:After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO 1 | Understand the basics of machine learning and different types. | U |
| CO 2 | Differentiate regression and classification, Understand the basics ofunsupervised learning and non-metric methods | An |
| CO 3 | Apply statistical methods in non-linear classification and neural networks | A |
| CO 4 | Understand the basics of deep learning networks. | U |
| CO5 | Understand the basics of convolutional neuralnetworks | U |

Mapping of course outcomes with program outcomes (1-3)

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 1 | | 2 | 3 | 3 | 2 | 2 | | 3 |
| CO 2 | 2 | | 2 | 2 | 2 | 2 | 2 | | 3 |
| CO 3 | 1 | | 2 | 3 | 3 | 1 | 1 | | 3 |
| CO 4 | 1 | | 2 | 3 | 3 | 1 | 1 | | 3 |
| CO5 | 1 | | 2 | 3 | 3 | 1 | 1 | | 3 |

Mark distribution

| TotalMarks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

Continuous Internal Assessment: 40marks

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

End Semester Examination Pattern:
Total : 60 marks
Part A: Answer all – 5 questions x 5 marks :
25 marksPart B: Answer 5 of 7: 5 questions x 7
marks : 35 marks

The end semester examination two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students).Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating totheoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus

| Module No | Description | Contact Hours |
|---|---|---|
| | Basics of machine learning, supervised and unsupervised learning, examples,features, feature vector, training set, target vector, test set over-fitting, curse of dimensionality.<br>Evaluation and model selection: ROC curves, evaluation measures,validation set, bias-variance trade-off.confusion matrix, recall, precision, accuracy. | 9 |
| 2 | Regression: linear regression, error functions in regression,multivariate regression, regression applications, bias and variance.Classification : Bayes' decision theory,discriminant functions and decision surfaces,Bayesian classification for normal distributions, classification,applications. | 9 |

| | | |
|---|---|---|
| 3 | Linear discriminant based algorithm: perceptron, perceptronalgorithm,support vector machines. Nonlinear classifiers, the XOR problem,multilayer perceptrons,backpropagation algorithm. | 9 |
| | Unsupervised learning: Clustering, examples, criterion functions for clustering,proximity measures, algorithms for clustering.Ensemble methods: boosting, bagging. Basics of decision trees, random forest, examples. | 9 |
| 5 | Introduction to deep learning networks,deep feedforward networks,basics of convolutional neural networks (CNN),CNN basic structure, Hyper-parameter tuning, Regularization - Dropouts,Initialization, CNN examples | 9 |
| | | 45 |

Course Plan

| No | Topic | No of lecture hours |
|---|---|---|
| 1 | | |
| 1.1 | Basics of machine learning, supervised and unsupervisedlearning,examples, | 2 |
| 1.2 | features, feature vector, training set, target vector, test set | 1 |
| 1.3 | over-fitting, curse of dimensionality. | 1 |
| 1.4 | Evaluation and model selection: ROC curves, evaluation measures, | 2 |
| 1.5 | validation set, bias-variance trade-off. | 2 |
| 1.6 | confusion matrix, recall, precision, accuracy. | 2 |
| 2.1 | Regression: linear regression, error functions in regression | 1 |
| 2.2 | multivariate regression, regression applications, bias and variance. | 2 |

| | | |
|---|---|---|
| 2.3 | Classification : Bayes' decision theory, | 2 |
| 2.4 | discriminant functions and decision surfaces, | 2 |
| 2.5 | Bayesian classification for normal distributions, classificationapplications. | 2 |
| 3.1 | Linear discriminant based algorithm: perceptron, perceptronalgorithm, | 1 |
| 3.2 | support vector machines. | 2 |
| 3.3 | Nonlinear classifiers, the XOR problem, | 2 |
| 3.4 | multilayer perceptrons, | 2 |
| 3.5 | backpropagation algorithm. | 2 |
| 4.1 | Unsupervised learning: | 1 |
| 4.2 | Clustering, examples, criterion functions for clustering, | 2 |
| 4.3 | proximity measures, algorithms for clustering. | 2 |
| 4.4 | Ensemble methods: boosting, bagging. | 2 |
| 4.5 | Basics of decision trees, random forest, examples. | 2 |
| 5.1 | Introduction to deep learning networks, | 1 |
| 5.2 | deep feedforward networks, | 2 |
| 5.3 | basics of convolutional neural networks (CNN) | 2 |
| 5.4 | CNN basic structure, Hyper-parameter tuning, Regularization -Dropouts, | 2 |
| 5.5 | Initialization, CNN examples | 2 |
| | | 45 |

Text Books

1. Bishop, C. M. "Pattern Recognition and Machine Learning"Springer, NewYork, 2006.

Reference Books

2. Theodoridis, S. and Koutroumbas, K. "Pattern Recognition". Academic Press,San Diego, 2003.
3. Hastie, T., Tibshirani, R. and Friedman, J. "The Elements of StatisticalLearning". Springer.
4. Duda, R.O., Hart, P.E., and Stork, D.G. "Pattern Classification". Wiley, NewYork,
5. Ian Goodfellow, Yoshua Bengio, Aaron Courville. "Deep Learning"MITPress, 2016

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCEDT202 | ESTIMATION AND DETECTIONTHEORY | PROGRAM CORE 3 | 3 | 0 | 0 | 3 |

Preamble:This course introduces the basics of estimation and detection theory,with a focus on classical and Bayesian estimators, estimation bounds,hypothesis testing, and detectors of signals in noise.

Course Outcomes: After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO 1 | Recognize, describe and evaluate two broad areas of statistical inferencenamely, estimation and detection. | E |
| CO 2 | Compute the performance limits of unbiased estimators and compare theperformance of a given estimator to these bounds | An |
| CO 3 | Analyse the performances ofclassical and Bayesian estimation techniques,when applied for solving parameter estimation problems fromnoisy data. | An |
| CO 4 | Apply optimal hypothesis tests and analyse the performance of these testsfor signal detection from noisy data. | A |
| CO 5 | Relate real world applications to different types of inference problems andidentify appropriate tools for approaching these problems and communicating them via presentations/reports/publications . | An |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 2 | | 3 | 3 | | | | 3 | |
| CO 2 | 2 | | 3 | 3 | | | | 3 | |
| CO 3 | 2 | | 3 | 3 | 2 | 2 | | 3 | |
| CO4 | 2 | | 3 | 3 | 2 | 2 | | 3 | |
| CO 5 | 3 | | 3 | 3 | 2 | 2 | 2 | 3 | |

Assessment Pattern

| Bloom'sCategory | End Semester Examination |
|---|---|
| Understand | 5 |
| Apply | 25 |
| Analyse | 15 |
| Evaluate | 15 |
| Create | |

Mark distribution

| TotalMarks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment Pattern:**

Evaluation shall only be based on application, analysis or design based questions(for both internal and end semester examinations).

Continuous Internal Assessment: 40marks

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

The project shall be done individually. Group projects not permitted. Test papershall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

The end semester examination will be conducted by the Institution. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be

useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Syllabus and Course Plan

| Module No | Description | Contact Hours |
|---|---|---|
| | Review of LinearAlgebra and Random Processes,Estimation in Signal Processing ;Minimum varianceunbiasedestimation: Minimum variance criterion; existence of minimum variance unbiased estimator; generalization to vector parameters<br>Cramer-Rao lower bound: scalar parameters; signal inwhite Gaussian noise; vector parameters; transformations; general Gaussian case; wide-sense stationary Gaussian processes; Examples from radar, sonar, and speech processing<br>Linear models: definition and properties; curve fitting; Fourier analysis; system identification; general linearmodels, | 9 |
| 2 | General minimum variance unbiased estimation and Best linearunbiased estimators | |
| | General minimum variance unbiased estimation: sufficient statistic; Finding minimum variance unbiased estimators; complete statistics; generalizations,Best linear unbiased estimators: definition; finding | 8 |

| | | |
|---|---|---|
| | The BLUE; example of source localization; generalization to vector parameters | |
| 3 | Maximum likelihood estimators, Linear Least Squares Approach and Bayesian Estimators | |
| | Maximum likelihood estimators: definition; finding the MLE; properties; transformed parameters; vector parameters; examples Linear Least Squares, Approach for Gaussian linear models, Bayesian estimators: priors; posteriors; linear models; Bayes Risks, Minimum Mean Square Error, Estimator, Maximum A-Posteriori estimator.<br>State estimation: Kalman Filters | 10 |
| 4 | Basics of Statistical Detection Theory | |
| 4 | Simple hypothesis testing; Neyman-Pearson detectors, Minimum probability of error, Minimum Bayes risk detectors; receiver operating characteristics; Multiple hypothesis testing, Composite hypothesis testing : Generalized Likelihood Ratio Test- Detection of signals with Unknown Amplitude. | 9 |
| 5 | Detection of signals in noise | |
| | Detection of known signals in noise: Matched filter ;performance of matched filter; generalized matched filter; Minimum distance detector; examples from communications, radar/sonar, and pattern recognition<br>Detection of random signals: energy detector; estimator-correlator; canonical form of detector; performance analysis; examples. | 8 |
| | | 45 |

Course Plan

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | Parameter Estimation: Minimum variance unbiased estimation, Cramer-Rao lowerBound and Linear Models | |
| 1.1 | Review of Linear Algebra and Random Processes, Estimation in Signal Processing;Minimum variance unbiased estimation: Minimum variance criterion;existence of minimum variance unbiased estimator; generalization to vector parameters | 3 |
| 1.2 | Cramer-Rao lower bound: scalar parameters; signal in white Gaussian noise; vector parameters;transformations; general Gaussian case;wide-sensestationary Gaussian processes;Examples from radar, sonar, and speech processing | 3 |
| 1.3 | Linear models: definition and properties; curve fitting; Fourier analysis; system identification; general linearmodels | 3 |
| 2 | General minimum variance unbiased estimation and Best linearunbiased estimators | |
| 2.1 | General minimum variance unbiased estimation:sufficientstatistic;Finding minimum variance unbiased estimators; complete statistics; generalizations | 4 |
| 2.2 | Best linear unbiased estimators: definition; finding theBLUE;example ofsourcelocalization; generalization tovectorparameters | 4 |
| 3 | Maximum likelihood estimators,Linear Least Squares Approach andBayesian Estimators | |
| 3.1 | Maximum likelihood estimators: definition; finding the MLE; properties; transformed parameters; vector | 2 |

| | | |
|---|---|---|
| | parameters; examples | |
| 3.2 | Linear Least Squares Approach for Gaussian linearmodels | 1 |
| 3.2 | Bayesian estimators: priors; posteriors;linear models;Bayes Risks,Minimum Mean Square Error Estimator,<br>Maximum A-Posteriori estimator. | 4 |
| 3.3 | State estimation: Kalman Filters | 3 |
| 4 | Basics of Statistical Detection Theory | |
| 4.1 | Simple hypothesis testing;Neyman-Pearson detectors, Minimum probability of error | 3 |
| 4.2 | Minimum Bayes risk detectors; receiver operatingcharacteristics; Multiple hypothesis testing, | 3 |
| 4.3 | Composite hypothesis testing : Generalized Likelihood Ratio Test- Detection of signals with Unknown Amplitude. | 3 |
| 5 | Detection of signals in noise | |
| 5.1 | Detection of known signals in noise: Matched filter ;performance of matched filter; generalized matched filter; Minimum distance detector; examples from | 4 |
| | communications, radar/sonar, and pattern recognition | |
| 5.2 | Detection of random signals: energy detector; estimator-correlator; canonical form of detector;performance analysis; examples. | 4 |
| | | 45 |

Text Books

1. S.M. Kay, Fundamentals of Statistical Signal Processing: Detection Theory,Prentice Hall, 1998

2. S.M. Kay, Fundamentals of Statistical Signal Processing: Estimation Theory,Prentice Hall, 1993

Reference Books

1. H.L. Van Trees, Detection, Estimation and Modulation Theory, Part I,Wiley,1968.

2. H.V. Poor, An introduction to Signal Detection and Estimation, 2nd edition,Springer, 1994.

3. L.L. Scharf, Statistical Signal Processing, Detection and Estimation Theory,Addison-Wesley,1990

| COURSE CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCMIPP206 | MINI PROJECT | PROJECT | 0 | 0 | 4 | 2 |

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem solving skills.

The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs.The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Evaluation Committee - Programme Coordinator, One Senior Professor and Guide.

| Sl. No | Type of evaluations | Mark | Evaluation criteria |
|---|---|---|---|
| 1 | Interim evaluation 1 | 20 | |
| 2 | Interim evaluation 2 | 20 | |
| 3 | Final evaluation bya Committee | 35 | Will be evaluating the level of completion and demonstration of functionality/specifications, clarity of presentation,oral examination, work |

| | | | |
|---|---|---|---|
| | | | knowledge and involvement. |
| 4 | Report | 15 | the committee will be evaluating for the technical content,adequacyof references, templates followed and permittedplagiarism level( not more than 25% ) |
| 5 | Supervisor/Guide | 10 | |
| | Total Marks | 100 | |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCSPRP207 | SIGNAL PROCESSING LABII | LABORATORY 2 | 0 | 0 | 2 | 1 |

Preamble:This labis envisaged as a specialization lab for the streams: Signal Processing,Communication Engineering & Signal Processing, and SignalProcessing and Embedded Systems

Course Outcomes:After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO 1 | Apply knowledge of Advanced Signal Processing, in various signal processing applications. | A |
| CO 2 | Develop the student's ability on analysing observations of experiments/simulations, interpreting them and preparing reports | E |
| CO 3 | Implement the fundamental principlesand algorithmslearned inSignalProcessing/Communication Engineering/ Embedded systems | E |
| CO4 | Apply knowledge of Image Processing, in various signal processing applications. | A |
| CO5 | Apply knowledge of Deeplearning, Communication Engineering and Embedded systems in various signal processing applications. | A |

Assessment Pattern

| Bloom's Category | CIA |
|---|---|
| Apply | 50 |
| Analyse | 30 |
| Evaluate | 10 |
| Create | 10 |

Mark distribution

| Total Marks | CIA | ESE |
|---|---|---|
| 100 | 100 | -- |

## Continuous Internal Assessment Pattern:

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

Tools :
Numerical Computing Environment – MATLAB or any other equivalent tool.

Based on the specialization of the streams, experiments must be chosen mandatorilyfrom ANYONE of the sets listed below:

## Syllabus

| No | Topics |
|---|---|
| Set I | Speech, Image and Deep Learning Lab |
| 1 | Image processing fundamentals-Simulation and Display of an Image, Negative of an Image- Implementation of Relationships between PixelsGeometric transformations- Image rotation, scaling, and translation |
| 2 | Apply 2 D DFT, DCT and DWT transform for an image and compare theresults |
| 4 | Image enhancement-Point/spatial/transform operations<br>Enhance an image using image arithmetic and logical operations--- Graylevel slicing/Sharpening/histogram equalization/Filtering/homomorphic filtering |
| 5 | Colour image processing --Wavelet-based Image Processing. |
| 6 | Image Segmentation |
| 7 | Edge detection-basic edge detection methods- parametric and non-parametric approaches<br>Morphological operations -dilation, erosion. |
| 8 | Object recognition in an imageTemplate matching/ clustering |

| | |
|---|---|
| 9 | Feature extraction from speech<br>Implement the steps for the extraction of MFCC/rhythmic features from agivenaudio file<br>Visualization of spectrogram/Mel-spectrogram---narrow-band and wide-band spectrogram |
| 10 | Implement the steps to extract LPC coefficient from the given speech file |
| 11 | Implement the steps to extract formants using homographic filtering |
| 12 | Pattern classification using machine learning/Deep learning, Implementationof KNN, K-Means Clustering, Implementation of LogisticRegression, SVM (*speech or image data)*<br>Deep learning architectures using TensorFlow/Keras*(speech or image data)* |
| Sec II. | Communication Engineering |
| 1 | Simulation of probability Distributions- Continuous and Discrete.<br>-Illustration of Central Limit theorem. |
| 2 | Simulation of PAM and PCM systems and performance evaluation. |
| 3 | Implementation of digital modulation schemes-BASK,BFSK, BPSK. PlotBER vs$E_b/N_0$ in AWGN channel. |
| 4 | Implementationand performance comparison of QPSK , DPSK, MSK&GMSK. |
| 5 | Plotting Eye pattern and Constellation diagram of various digitalmodulation schemes |
| 6 | Implementation of Matched filter, Correlation receiver. |
| 7 | Communication over fading Channels-Rayleigh fading & Rician fading |
| 8 | Simulation of RAKE receiver. |
| 9 | Spread spectrum communication systems-Develop simulation models for Direct sequence Spread spectrum systems and Frequency Hopping spreadspectrum systems. |

| | |
|---|---|
| 10. | Simulation of OFDM system. |
| Set III. | Embedded Systems |
| A | *FPGA based experiments:* |
| 1 | Design entry using Verilog/ VHDL examples for circuit description. |
| 2 | Sequential and concurrent statements. |
| 3 | Structural and behavioral descriptions,principles of operation andlimitation of HDL simulators. |
| 4 | Examples of sequential and combinational logic design and simulation. |
| 5 | Test vector generation. |
| 6 | Synthesis principles,logical effort, standard cell-based design andsynthesis, interpretation synthesis scripts, constraint introduction and library preparation and generation. |
| 7 | FPGA programming |
| 8 | I/O interfacing |
| 9 | Analog interfacing |
| 10 | Real time application development. |
| B | *Microcontroller based Experiments*: |
| 1 | Design with ARM Processors: I/O programming, ADC/DAC,Timers,Interrupts. |
| 2 | Study of one type of Real Time Operating Systems (RTOS) |

# PROGRAM ELECTIVE III

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCWSNT213 | WIRELESS SENSOR NETWORKS | PROGRAM ELECTIVE3 | 3 | 0 | 0 | 3 |

Preamble:The core modules of this elective course include introduction to wireless sensor networks, localisation and synchronisation techniques, wireless MAC protocols, routing in wireless sensor networks and fundamentals of networksecurity.This course aims to teach the student to understand the concepts ofwireless sensor networks.
Course prerequisites:None

Course Outcomes:After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO 1 | Evaluate the performance of schedule based and random Medium Access Control protocols for power consumption, fairness, channel utilization andcontrol packet overhead. | E |
| CO 2 | Evaluate the performance of Geographic routing protocols for powerconsumption, scalability and latency parameters. | E |
| CO 3 | Relate the performance of transport control protocols for congestiondetection and avoidance, reliability and control packet overhead parameters. | An |
| CO4 | Understand about the routing challenges in WSN. | U |
| CO5 | Classify the security issues in wireless network. | An |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 1 | | | 3 | 3 | 3 | | | | 3 |
| CO 2 | | | 3 | 3 | 3 | | | | 3 |
| CO 3 | | | 3 | 3 | 3 | | | | 3 |
| CO 4 | | | 3 | 3 | 3 | | | | 3 |
| CO 5 | | | 3 | 3 | 3 | | | | 3 |

Assessment Pattern

| Bloom's Category | End Semester Examination (Marks) |
|---|---|
| Understand | 10 |
| Apply | 20 |
| Analyse | 20 |
| Evaluate | 10 |
| Create | |

Mark distribution

| TotalMarks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

Evaluation shall only be based on application, analysis or design-based questions(for both internal and end semester examinations).

Continuous Internal Assessment Pattern:

Continuous Internal Evaluation: 40 marks

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. Therewill be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module; having 5 marks for each question (such questions shall

be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overallachievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note:The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if theaverage end semester mark % for a core course is 40, then the maximum eligiblemark %for an elective course is 40+20 = 60.

## SYLLABUS

| Module No | Description | Contact Hours |
|---|---|---|
| 1 | Fundamentals of sensor networks: | |
| | Introduction wireless sensornetworks,Wireless Sensornodes- Sensing and sensors challenges and constraints. Node architecture-sensing subsystem, processor subsystem Communication interfaces-prototypes, Application of Wirelesssensors,Introduction of Tiny OS Programming | 9 |
| 2 | Communication characteristics and deployment mechanisms: | |
| | Basics of time synchronization-Time synchronization protocols,Localization- Ranging Techniques- Range based Localization-Range Free Localization- Event driven Localization | 9 |
| 3 | MAC Layer: | |

| | | |
|---|---|---|
| | Overview-Wireless Mac Protocols-Characteristics of MAC protocols in Sensor networks,Contention freeMAC Protocols- characteristics- Traffic Adaptive Medium Access-Y-MAC, Low energy Adaptive Clustering Low energy Adaptive Clustering - Contention based MAC Protocols Power Aware Multi-Access with signalling, Sensor MAC-Timeout MAC-Data gathering MAC | 9 |
| 4 | Routing in wireless sensor networks: | |
| | Design Issues in WSN routing- Data Dissemination and Gathering Routing Challenges in WSN - Flooding-Flat Based Routing SAR, Directed Diffusion, Hierarchical Routing- LEACH, PEGASIS - Query Based Routing- Negotiation Based Routing- Geographical Based Routing | 9 |
| 5 | Middleware and security issues: | |
| | WSN middleware principles-Middleware architecture-Existing middleware,Operating systems for wireless sensor networks-performance,and traffic management. Fundamentals of network security-challenges and attacks | 9 |
| | | 45 |

Course Plan

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | Fundamentals of sensor networks: | |
| 1.1 | Introduction wireless sensor networks,Wireless Sensornodes- Sensing and sensors challenges and constraints. | 3 |
| 1.2 | Node architecture-sensing subsystem, processor subsystem | 3 |
| 1.3 | Communication interfaces- prototypes, Application of Wirelesssensors,Introduction of Tiny OS | 3 |

| | | |
|---|---|---|
| | Programming | |
| 2 | Communication characteristics and deployment mechanisms: | |
| 2.1 | Basics of time synchronization-Time synchronization protocols | 3 |
| 2.2 | Localization- Ranging Techniques- Range based Localization- | 3 |
| 2.3 | Range Free Localization- Event driven Localization | 3 |
| 3 | MAC Layer: | |
| 3.1 | Overview-Wireless Mac Protocols-Characteristics of MACprotocols in Sensor networks | 3 |
| 3.2 | Contention free MAC Protocols-characteristics- Traffic Adaptive MediumAccess-Y-MAC, Low energy AdaptiveClustering | 3 |
| 3.3 | Low energy Adaptive Clustering - Contention based MAC Protocols Power Aware Multi-Access with signalling, SensorMAC-Timeout MAC-Data gathering MAC | 3 |
| 4 | Routing in wireless sensor networks: | |
| 4.1 | Design Issues in WSN routing- Data Dissemination andGathering | 3 |
| 4.2 | Routing Challenges in WSN - Flooding-Flat Based Routing,SAR, Directed Diffusion, | 3 |
| 4.3 | Hierarchical Routing- LEACH, PEGASIS - Query Based Routing- Negotiation Based Routing-Geographical Based Routing | 3 |
| 5 | Middleware and security issues: | |
| 5.1 | WSNmiddleware principles-Middleware architecture-Existingmiddleware | 3 |
| 5.2 | Operating systems for wireless sensor networks-performance and traffic management. | 3 |
| 5.3 | Fundamentals of network security-challenges and attacks | 3 |

| | | |
|---|---|---|
| | | 45 |

Text Books

1. DargieWaltenegus, Poellabauer Christian (2011): Fundamentals of Wireless Sensor Networks, Theory and Practice: Wiley Series on wireless Communication and Mobile Computing.
2. SohrabyKazem, Manoli Daniel (2010): Wireless Sensor networks- Technology, Protocols and Applications, New Jersey: Wiley Inter Science Publications.

Reference Books

1. Krishnamachari Bhaskar (2005): Networking Wireless Sensors, Cambridge: Cambridge Institution Press.
2. Raghavendra C.S., Sivalingam Krishna M., Taiebznati (2004): Wireless Sensor Networks: Springer Science.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCIPCT223 | IMAGE PROCESSING AND COMPUTER VISION | PROGRAM ELECTIVE3 | 3 | 0 | 0 | 3 |

Preamble: Image processing is a method to perform certain operations on animage, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. Computer vision is a field of artificial intelligence (AI) that enables computers and systems to derive meaningful information from digital images, videos and other visual inputs — and take actions ormake recommendations based on that information. Students will beable to learn image processing fundamentals, understand the different types of algorithms in image processing and computer vision, develop in-depth knowledge of image and video processing tasks such as image representation, image transforms,image enhancement, Image restoration, image segmentation and image compression.

Prerequisite:A sound knowledge of the fundamentals and basics of digital signal processing techniques.

Course Outcomes:After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO1 | Understand and apply the fundamentals, concepts and terminologies inimage processing and computer vision. | U |
| CO2 | Understand and analyse the principles of image restoration and segmentationand illustrate the methods and algorithms for image restoration and segmentation. | An |
| CO3 | Understand and analyse the principles of image compression and video processing and illustrate the methods and algorithms for image compressionand video processing. | An |
| CO4 | Analyze and evaluate the performance of depth estimation and multi-cameraviews. for computer vision. | E |
| CO5 | Evaluate critically the techniques for motion analysis and optical flow incomputer vision. | E |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | | 2 | | | | | |
| CO2 | 2 | 2 | | | 3 | | | | |
| CO3 | 3 | 2 | | | 2 | 2 | 3 | | |
| CO4 | | | | | 2 | 2 | 2 | | |
| CO5 | 3 | 2 | | 3 | | | | | |

| Bloom's Category | End SemesterExamination |
|---|---|
| Understand | 10 |
| Apply | 20 |
| Analyse | 20 |
| Evaluate | 10 |
| Create | |

Mark distribution

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

Continuous Internal Evaluation: 40 marks

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

Test paper shall include minimum 80% of the syllabus. include minimum 80% of thesyllabus.

End Semester Examination: 60 marks

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus

| Module No | Description | Contact Hours |
|---|---|---|
| 1 | Image Representation | |
| | Image Representation: Gray scale and colour Images, image sampling and quantization. Two dimensional orthogonal transforms: DFT, WHT, Haar transform, KLT, DCT. Image representation using SIFT, GIST and HOG features. Image enhancement - filters in spatial and frequency domains, histogram-based processing, homomorphic filtering. | 9 |
| 2 | Image Resoration and Segmentaton | |
| | Image Restoration: Degradation Models, PSF, circulant and block-circulant matrices, deconvolution, restoration using inverse filtering. Wiener filtering and maximum entropy-based methods Image Segmentation: Pixel classification, Bi- level thresholding, Multi- level thresholding. Edge detection, edge | 9 |

| | | |
|---|---|---|
| | sharpening, edge profiles, edge operators, LoG, DoG. Hough transform. | |
| 3 | Image Compression and video Processing | |
| | Fundamental Concepts ofImageCompression: Compression models- Information theoretic perspective -Fundamental coding theorem. Lossless Compression: Huffman Coding- Arithmeticcoding – Bit,plane coding - Run length coding.Lossy compression: | 8 |
| | Transform coding - Image compression standards.Video Processing: Representation of Digital Video, Spatio-temporal sampling; Motion Estimation; Video Filtering; Video Compression, Video coding standards. | 3 |
| 4 | Depth estimation and Multi-camera views | |
| | Depth estimation and Multi-camera views: Perspective,Binocular Stereopsis.Camera and Epipolar Geometry;Homography, Rectification.DLT, RANSAC, 3-D reconstruction framework.Auto-calibration. | 9 |
| 5 | Motion Analysis | |
| | Motion Analysis: Background Subtraction and Modeling.Optical Flow, KLT, Spatio-Temporal Analysis, DynamicStereo. Motion parameter estimation. Light at Surfaces: Phong Model, Shape from Texture, color,motion and edges. | 9 |
| | | 45 |

Course Plan

| No | Topic | No. of Lectures [40Hrs] |
|---|---|---|
| 1 | Image Representation | |
| 1.1 | Image Representation: Gray scale and colour Images, imagesampling and quantization. | 2 |
| 1.2 | Two dimensional orthogonal transforms: DFT, WHT,Haartransform, KLT, DCT. | 2 |
| 1.3 | Image representation using SIFT, GIST and HOG features. | 2 |
| 1.4 | Image enhancement - filters in spatial and frequency domains, histogram- based processing, homomorphicfiltering. | 3 |
| 2 | Image Resoration and Segmentaton | |
| 2.1 | Image Restoration: Degradation Models, PSF, circulant and block-circulant matrices, deconvolution, restoration usinginverse filtering. | 2 |
| 2.2 | Wiener filtering and maximum entropy-based methods. | 2 |
| 2.3 | Image Segmentation: Pixel classification, Bi-levelthresholding, Multi- level thresholding. | 3 |
| 2.4 | Edge detection, edge sharpening, edge profiles, edgeoperators, LoG, DoG. Hough transform. | 2 |
| 3 | Image Compression and video Processing | |
| 3.1 | Fundamental Concepts of ImagCompression: Compression models- Information theoretic perspective -Fundamental coding theorem. | 2 |

| | | |
|---|---|---|
| 3.2 | Lossless Compression: Huffman Coding- Arithmeticcoding – Bit,plane coding - Run length coding. | 3 |
| 3.3 | standards. | 3 |
| 3.4 | Video Processing: Representation of Digital Video, Spatio-temporal sampling; Motion Estimation; Video Filtering; Video Compression, Video coding standards. | 3 |
| 4 | Depth estimation and Multi-camera views | |
| 4.1 | Depth estimation and Multi-camera views: Perspective,Binocular Stereopsis. | 3 |
| 4.2 | Camera and Epipolar Geometry; Homography,Rectification. | |
| 4.3 | DLT, RANSAC, 3-D reconstruction framework. | 3 |
| 4.4 | Auto-calibration. | 3 |
| 5 | Motion Analysis | |
| 5.1 | Motion Analysis: Background Subtraction and Modeling. | 2 |
| 5.2 | Optical Flow, KLT, Spatio-Temporal Analysis, DynamicStereo. | 2 |
| 5.3 | Motion parameter estimation. | 3 |
| 5.4 | Light at Surfaces: Phong Model, Shape from Texture, color,motion and edges. | 3 |
| | | 45 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCASPT233 | ARRAY SIGNAL PROCESSING | PROGRAM ELECTIVE3 | 3 | 0 | 0 | 3 |

Preamble:This course aims to introduce the concept of sensor arrays and spatial signals to perform beam-forming in the context of direction of arrival estimation innoisy and interference environments.

Course Outcomes:After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO 1 | Understand the concept of spatial signals and spatial frequency. | U |
| CO 2 | Understand the concept of sensor arrays and beam-forming. | U |
| CO 3 | Understand the different methods of direction of arrival estimation. | U |
| CO 4 | Understand the impact of noise and interference in DoA estimation. | U |
| CO 5 | Understand the concept of spatial smoothing. | U |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 11 | | | 1 | 1 | | | | | 2 |
| CO 21 | | | 1 | 1 | 1 | 1 | | | 2 |
| CO 31 | 1 | | 1 | 1 | 1 | 1 | 1 | | 2 |
| CO 41 | 1 | | 1 | 1 | 1 | 1 | 1 | | 2 |
| CO 51 | 1 | | 1 | 1 | 1 | | | | 2 |

Assessment Pattern

| Bloom's Category | End SemesterExamination |
|---|---|
| Understand | 10 |
| Apply | 20 |
| Analyse | 20 |
| Evaluate | 10 |

Mark distribution

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

Continuous Internal Assessment Pattern:

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

(Shall include minimum of 80% of the syllabus)1 no.:10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (suchquestions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | Signals in space and time | |
| | Spatial and Temporal Characteristics | 9 |
| | Spatial Frequency or Wavenumber, Noise and Interferences | |
| | Wave fields - Far field and Near field signals | |
| | Spatial Frequency | |
| 2 | Spatial Frequency Transform, Spatial Spectrum. | 8 |
| | Spatial Domain Filtering, Beam-forming, Spatially whitesignal | |
| | Spatial sampling, Nyquist criterion. Aliasing in spatialfrequency domain | |
| 3 | Arrays and Spatial Filter | |
| | Sensor arrays - linear arrays, planar and random arrays. | 9 |
| | Uniform linear array, Uniformly weighted linear array,Delay Sum Beam-former, Beam Pattern Parameters. | |
| | Array Steering, Null Steering. Array Performance Measures – Directivity, Array gain vs. Spatially white Noise. | |
| 4 | Optimum Waveform Estimation | |
| | Optimum Beam-formers – MVDR or Capon Beam-former,MPDR Beam-former. | 9 |
| | MMSE Beam-former, Maximum SNR Beam-former | |
| | Discrete Interference-Plane wave interfering Signal | |
| 5 | Direction of Arrival Estimation | |
| | Parameter Estimation-Maximum Likelihood (ML)Estimation, Cramer-Rao Bounds. Non-parametric methods (Subspace | 9 |

| | | |
|---|---|---|
| | Methods) –ESPRIT, MUSIC, Root MUSIC, Min--Norm Techniques. | |
| | Spatial Smoothing – Forward Smoothing and Backward Smoothing | |
| | Total Hours | 45 |

Course Plan

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | Signals in space and time | |
| 1.1 | Spatial and Temporal Characteristics | 3 |
| 1.2 | Spatial Frequency or Wavenumber, Noise and Interferences | 3 |
| 1.3 | Wave fields - Far field and Near field signals | 3 |
| | Spatial Frequency | |
| 2.1 | Spatial Frequency Transform, Spatial Spectrum. | 2 |
| 2.2 | Spatial Domain Filtering, Beam-forming, Spatially whitesignal | 3 |
| 2.3 | Spatial sampling, Nyquist criterion. Aliasing in spatialfrequency domain | 3 |
| 3 | Arrays and Spatial Filter | |
| 3.1 | Sensor arrays - linear arrays, planar and random arrays. | 2 |
| 3.2 | Uniform linear array, Uniformly weighted linear array,Delay Sum Beam-former, Beam Pattern Parameters. | 4 |
| 3.3 | Array Steering, Null Steering. Array Performance Measures – Directivity, Array gain vs. Spatially white Noise. | 3 |
| 4 | Optimum Waveform Estimation | |
| 4.1 | Optimum Beam-formers – MVDR or Capon Beam-former,MPDR Beam-former. | 3 |
| 4.2 | MMSE Beam-former, Maximum SNR Beam-former | 3 |
| 4.3 | Discrete Interference-Plane wave interfering Signal | 3 |
| 5 | Direction of Arrival Estimation | |

| | | |
|---|---|---|
| 5.1 | Parameter Estimation-Maximum Likelihood (ML)Estimation, Cramer-Rao Bounds. | 3 |
| 95.2 | Non-parametric methods (Subspace Methods) –ESPRIT,MUSIC, Root MUSIC, Min--Norm Techniques. | 4 |
| 5.3 | Spatial Smoothing – Forward Smoothing andBackwardSmoothing | 2 |
| | Total Hours | 45 |

Text Book

1.1. Harry L. Van Trees, "Optimum Array Processing- Part IV of Detection, Estimation, and Modulation Theory", Wiley.

Reference Books

1. Dan E. Dugeon and Don H. Johnson. (1993). Array SignalProcessing:Concepts and Techniques. Prentice Hall.
2. Petre Stoica and Randolph L. Moses. (2005, 1997) Spectral AnalysisofSignals. Prentice Hall.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCEMNT243 | EMBEDDED NETWORKS | PROGRAM ELECTIVE3 | 3 | 0 | 0 | 3 |

Preamble:This course focuses into the aspects of networking and then to the wireless concept. The aim of this course is to teach the student to understandabout different embedded communication protocols, CAN and USB bus, embedded ethernet and wireless embedded networking and their applications.

Course prerequisites :None

Course Outcomes: After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO 1 | Understand the Serial and Parallel Communication Protocol inEmbedded networking | U |
| CO2 | Apply USB in serial communication applications. | A |
| CO3 | Apply CAN protocols in network applications. | A |
| CO4 | Build an internet network using ethernet protocol. | An |
| CO5 | Implement Wireless sensor networks. | E |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 1 | | | | 3 | 3 | 2 | | | |
| CO 2 | | | 3 | 3 | 3 | | | | |
| CO 3 | | | 3 | 3 | 3 | | | | |
| CO 4 | | | 3 | 3 | 3 | 2 | | | |
| CO 5 | | | 3 | 3 | 3 | 2 | | | |

Assessment Pattern

| Bloom's Category | End Semester Examination |
|---|---|
| | |
| Apply | |
| Analyse | |
| Evaluate | |
| Create | |

ark distribution

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

Evaluation shall only be based on application, analysis or design-based questions (forboth internal and end semester examinations).

Continuous Internal Assessment Pattern:

Continuous Internal Assessment: 40 marks

| | |
|---|---|
| Preparing a review article based on peer reviewed originalpublications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of thesyllabus.) | 10 marks |
| TOTAL | 40 marks |

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B.
Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the

testing of overallachievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note:The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %

.SYLLABUS

| Module No | | |
|---|---|---|
| I | Embedded communication protocols: Embedded Networking, Introduction, Serial/Parallel Communication – PC Parallel port programming: ISA/PCI Busprotocols<br>Serial communication protocols: RS232 standard, RS485 standard, Synchronous Serial Protocols - Serial Peripheral Interface (SPI), Inter Integrated Circuits (I2C), Firewire. | 10 |
| 2 | USB bus: Introduction, USB bus, Speed Identification on the bus – USB States.USB bus communication: Packets –Data flow types –Enumeration –Descriptors | 6 |
| 3 | CAN Bus: Introduction, Frames –Bit stuffing –Types of errors – Nominal Bit Timing – PIC microcontroller CAN Interface – A simple application with CAN. | 8 |
| 4 | Ethernet: Elements of a network – Inside Ethernet – Building a Network:Hardware options – Cables, Connections and network speed.<br>Design choices: Selecting components –Ethernet Controllers – Using the internetinlocal and internet communications – Inside the Internet protocol. | 8 |

| | | |
|---|---|---|
| 5 | Wireless embedded networking: Wireless sensor networks, Introduction – Applications – Network Topology – Localization – Time Synchronization - Energyefficient MACprotocols –SMAC – Energy efficient and robust routing – Data Centric routing. | 8 |

Course Plan

| Sl. No | Topic | No. of Lectures |
|---|---|---|
| 1 | Em bedded communication protocols | |
| 1.1 | Introduction, Embedded Networking | 2 |
| 1.2 | Serial/Parallel Communication – PC Parallel port programming - ISA/PCI Bus | 2 |
| 1.3 | Serial communication protocols – RS232 standard – RS485standard – Synchronous Serial Protocols | 3 |
| 1.4 | Serial Peripheral Interface (SPI), Inter Integrated Circuits (I2C)protocols, Firewire | 3 |
| 2 | USB Bus | |
| 2.1 | USB bus, Introduction, USB bus, Speed Identification on thebus – USB States | 3 |
| 2.2 | USB bus communication: Packets Data flow types –Enumeration –Descriptors | 3 |
| 3 | CAN Bus | |
| 3.1 | Introduction, Frames –Bit stuffing | 2 |
| 3.2 | Types of errors – Nominal Bit Timing | 2 |
| 3.3 | PIC microcontroller CAN Interface | 2 |
| 3.4 | A simple application with CAN. | 3 |
| 4 | Embedded Ethernet | |
| 4.1 | Elements of a network – Inside Ethernet | 2 |
| 4.2 | Building a Network: Hardware options – Cables, Connectionsand network speed | 2 |
| 4.3 | Design choices: Selecting components –Ethernet Controllers Using the internet in local and internet communications – Insidethe Internet protocol | 5 |
| 5 | Wireless Embedded Networking | |

| | | |
|---|---|---|
| 5.1 | Wireless sensor networks, Introduction – Applications | 3 |
| 5.2 | Network Topology – Localization – Time Synchronization | 3 |
| 5.3 | Energy efficient MAC protocols –SMAC – Energy efficient androbust routing – Data Centric routing | 3 |
| | | 45 |

Text Books

1. Frank Vahid, Tony Givargis"Embedded Systems Design: A Unified Hardware/Software Introduction", John & Wiley Publications, 2002.
2. Jan Axelson, "USB Complete The Developer's Guide" Fifth Edition, Lakeview Research.
3. BhaskarKrishnamachari, "Networking Wireless Sensors", Cambridge press 2005.
4. Marco Di Natalem, Haibo Zeng, Paolo Giusto, ArkadebGhosal, "Understanding and Using the Controller Area Network Communication Protocol - Theory and Practice", Springer 2012

Reference Books

1. Dogan Ibrahim, "Advanced PIC microcontroller projects in C", Elsevier 2008.
2. Jan Axelson,"Embedded Ethernet and Internet Complete", Penrampublications, 2003.
3. Glaf P.Feiffer, Andrew Ayre and Christian Keyold, "Embedded Networking withCAN and CAN open", Embedded System Academy 2005.
4. Don Anderson, "USB System Architecture", Mindshare, Inc.
5. Jan Axelson, "Parallel Port Complete: Programming, interfacing and using thePC"s parallel printer port", Penram publications, 1996.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCSCTT253 | SIGNAL COMPRESSION TECHNIQUES | PROGRAM ELECTIVE3 | 3 | 0 | 0 | 3 |

Preamble:This course gives a comprehensive knowledge of the essentials of SignalCompression Techniques.

Pre-requisites: Nil

Course Outcomes:After the completion of the course the student will be able to:

| Course Outcome | Description | Bloom's level |
|---|---|---|
| CO1 | Differentiate between lossless and lossy compression/ coding techniques. | U |
| CO2 | Explain the concept of rate distortion theory and quantization theory. | U |
| CO3 | Understand different types of transforms | U |
| CO4 | Distinguish between different data compression standards | An |
| CO 5 | Understand various audio compression techniques, Video compressionTechniques and standards | U |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 1 | | | 1 | 2 | 3 | | | | 2 |
| CO 2 | | | | 1 | 2 | | | | 2 |
| CO 3 | | | | 3 | | | | | 2 |
| CO 4 | | | 3 | 2 | 1 | | | | 2 |
| CO 5 | | | | 2 | 1 | | | | 0 |

Assessment Pattern

| Bloom's Category | End SemesterExamination |
|---|---|
| Understand | 10 |
| Apply | 20 |
| Analyse | 20 |
| Evaluate | 10 |

Mark distribution

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

Continuous Internal Assessment Pattern: Elective courses

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

Continuous Internal Assessment: 40

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

Test paper shallinclude minimum 80% of the syllabus

End Semester Examination Pattern: End Semester Examination: 60 marks

The end semester examination will be conducted by the respective College.There will be two parts; Part A and Part B.
Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.
Part B will contain 7 questions (such questions shall be useful in the testing of overallachievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note:The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses.
ESE marks awarded to a student for each elective course shall be normalizedaccordingly. For example if the average end semester mark % for a core course is 40,then the maximum eligible mark % for an elective course is 40+20 = 60 %.

| No. | Topic | No. of Lectures |
|---|---|---|
| 1. | Compression Techniques | 9 |
| | Lossless and Lossy Compression | 1 |
| | Huffman Coding - Optimality of Huffman codes | 1 |
| | Extended Huffman coding | 1 |
| | Adaptive Huffman coding | 1 |
| | Arithmetic coding | 1 |
| | Run Length coding, | 1 |
| | Lempel-Ziv coding, | 1 |
| | Burrows Wheeler Transform. | 2 |
| 2. | Rate distortion theory, quantization techniques | 9 |
| | Rate distortion function R(D) | 1 |
| | Properties of R(D) | 1 |
| | Calculation of R(D) for the binary source | 1 |
| | Rate distortion theorem - Converse of the Rate distortiontheorem | 1 |
| | | 1 |

| | | |
|---|---|---|
| | Quantization – Uniform & Non-uniform | 1 |
| | Optimal and adaptive quantization | 1 |
| | Vector quantization,<br>Optimality conditions for VQ | 2 |
| 3 | Transforms for Compression,Coding | 9 |
| | Mathematical Preliminaries for Transforms,<br>Karhunen Loeve Transform<br>Discrete Cosine and Sine Transforms<br>Discrete Walsh Transform Discrete Hadamard Transform<br>Discrete Walsh Hadamard Transform<br>Wavelet Based Compression<br>Transform coding<br>Subband coding | |
| 4. | Data Compression and Image compression<br><br>standards | 9 |
| 4.1<br>4.2<br>4.3<br>4.4<br>4.5<br>4.6<br>4.7<br>4.8 | Zip and Gzip<br>PCM, G.711,G.729<br>ADPCM G.726<br>SBC CODEC<br>LD-CELP<br>G.722<br>G.723.1<br>JPEG 2000 standards, JBIG | |
| 5. | Audio compression techniques,<br>Video compression Techniques, Standards | 9 |
| | Need for audio compression<br>MPEG audio encoding<br>MPEG audio decoding<br>AC standard<br>Dolby AC3<br>Need for video compression, Motion Compensation<br>H.261<br>H.264 | |
| | Total Hours | 45 |

Course Plan

| No. | Topic | No. of Lectures |
|---|---|---|
| 1. | Compression Techniques | 9 |
| 1.1 | Lossless and Lossy Compression | 1 |
| 1.2 | Huffman Coding - Optimality of Huffman codes | 1 |
| 1.3 | Extended Huffman coding | 1 |
| 1.4 | Adaptive Huffman coding | 1 |
| 1.5 | Arithmetic coding | 1 |

| | | |
|---|---|---|
| 1.6 | Run Length coding, | 1 |
| 1.7 | Lempel-Ziv coding, | 1 |
| 1.8 | Burrows Wheeler Transform. | 2 |
| 2. | Rate distortion theory, quantization techniques | 9 |
| 2.1 | Rate distortion function R(D) | 1 |
| 2.2 | Properties of R(D) | 1 |
| 2.3 | Calculation of R(D) for the binary source | 1 |
| 2.4 | Rate distortion theorem - Converse of the Rate distortiontheorem | 1 |
| 2.5 | Quantization – Uniform & Non-uniform | 1 |
| 2.6 | Optimal and adaptive quantization | 1 |
| 2.7 | Vector quantization, | 1 |
| 2.8 | Optimality conditions for VQ | 2 |
| 3 | Transforms for Compression,Coding | 9 |
| 3.1 | Mathematical Preliminaries for Transforms, | 1 |
| 3.2 | Karhunen Loeve Transform | 1 |
| 3.3 | Discrete Cosine and Sine Transforms | 1 |
| 3.4 | Discrete Walsh Transform Discrete Hadamard Transform | 1 |
| 3.5 | Discrete Walsh Hadamard Transform | 2 |
| 3.6 | Wavelet Based Compression | 1 |
| 3.7 | Transform coding | 1 |
| 3.8 | Subband coding | 1 |
| 4. | Data Compression and Image compression standards | 9 |
| 4.1 | Zip and Gzip | 1 |
| 4.2 | PCM, G.711,G.729 | 1 |
| 4.3 | ADPCM G.726 | 1 |
| 4.4 | SBC CODEC | 1 |
| 4.5 | LD-CELP | 1 |
| 4.6 | G.722 | 1 |
| 4.7 | G.723.1 | 1 |
| 4.8 | JPEG 2000 standards, JBIG | 2 |
| 5. | Audio compression techniques, Video compression Techniques, Standards | 9 |
| 5.1 | Need for audio compression | 1 |
| 5.2 | MPEG audio encoding | 1 |
| 5.3 | MPEG audio decoding | 1 |
| 5.4 | AC standard | 1 |
| 5.5 | Dolby AC3 | 1 |
| 5.6 | Need for video compression, Motion Compensation | 1 |
| 5.7 | H.261 | 1 |
| 5.8 | H.264 | 2 |
| | Total Hours | 45 |

Text books

1. Khalid Sayood, "Introduction to Data Compression", MorganKaufmannPublishers., Second Edn, 2005.
2. David Salomon, "Data Compression: The Complete Reference",SpringerPublications, 4th Edn., 2006.
3. Thomas M. Cover, Joy A. Thomas, "Elements of Information Theory,"JohnWiley & Sons, Inc., 1991.

Reference books

1. Toby Berger, "Rate Distortion Theory: A Mathematical Basis forDataCompression", Prentice Hall, Inc., 1971.
2. K.R.Rao, P.C.Yip, "The Transform and Data Compression Handbook",CRCPress., 2001.
3. R.G.Gallager, "Information Theory and Reliable Communication", JohnWiley& Sons, Inc., 1968.
4. Ali N. Akansu, Richard A. Haddad, "Multiresolution Signal Decomposition:Transforms, Subbands and Wavelets", Academic Press.,1992
5. Martin Vetterli, Jelena Kovacevic, "Wavelets and Subband Coding",PrenticeHall Inc., 1995.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCFOCT263 | FIBER OPTIC COMMUNICATION SYSTEMS | PROGRAM ELECTIVE 3 | 3 | 0 | 0 | 3 |

Preamble: Development of fiber optics together with microelectronics is a major breakthrough in information revolution. In fiber optic communication lightis the carrier and the optical fiber is communication channel. This course analyses characteristics of different optical devices, optical fiber and optical networks.

Course Outcomes:After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO1 | Analyse of different optical fiber parameters and nonlinear effects | An |
| CO2 | Evaluate variousOptical sources and modulators | E |
| CO3 | Evaluate the performance of different optical detectors. | E |
| CO4 | Design a Fibre Optic communication link. | E |
| CO5 | Analyse optical multiplexing and Optical Wireless CommunicationChannels | An |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 3 | | 3 | | | |
| CO 2 | 3 | 2 | | 3 | 3 | 3 | 2 | | |
| CO 3 | 2 | 2 | | 3 | | 3 | | | |
| CO 4 | 2 | 2 | | 3 | 3 | 3 | 2 | | |
| CO 5 | 2 | 2 | | 3 | 3 | 3 | 2 | | |

Assessment Pattern

| Bloom'sCategory | End Semester Examination |
|---|---|
| Understand | 10 |
| Apply | 5 |
| Analyse | 20 |
| Evaluate | 25 |
| Create | |

Mark distribution

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design based questions(for both internal and end semester examinations).

Continuous Internal Assessment: 40 marks

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

Test paper shall include minimum 80% of the syllabus.End Semester

Examination: 60 marks

The end semester examination will be conducted by the

respective College.There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overallachievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if theaverage end semester mark % for a core course is 40, then the maximum eligible mark % foran elective course is 40+20 = 60 %.

# Syllabus

| No | Topic | No. of Hours |
|---|---|---|
| 1 | Overview of Optical Communication System : | |
| | Evolution of Fibre-Optic Communications, Light wave System Components.<br>Optical Fibers-Types, Wave propagation, Fiber Modes, Dispersion in fibers, GVD, PMD , Fiber Losses Nonlinear Effects- Self Phase Modulation Cross Phase Modulation, Four Wave Mixing, Stimulated Raman and Brillouin Scattering. Fiber Fibers ,Design-Plastic Optical Fibers, Photonic Crystal | 9 |
| | | |
| 2 | Optical Transmitters and Receivers- | |
| | LEDs and SemiconductorLasers- structure and characteristics, VCSEL, Optical Signal Generation-DirectModulation, External Modulation, MZM, Advanced Modulation Formats ,Optical Receivers- PIN and APD Detectors, Receiverdesign,Sources of Noise, SNR,<br>Coherent Detection , Homodyne and Heterodyne detection, SNR Performance Evaluation of an OOK link- BER, Q, Receiver Sensitivity. | 10 |
| 3 | Lightwave System Design | |
| | Point-to-Point Links, Link Budget(Power & Rise time)<br>Loss Management-Compensation of Fiber Losses, OpticalAmplifiers- EDFA and RAMAN Amplifiers, Optical Signal- To-Noise Ratio.<br>Dispersion Management-Dispersion-Compensating Fibers,Fiber Bragg Gratings, Dispersion-Equalizing Filters Control of Nonlinear Effects-Solitons in Optical Fibers | 8 |
| | | |
| 4 | Introduction to Multiplexing and Communication channels | |

| | | |
|---|---|---|
| | WDM Light wave Systems, Architecture,WDM Components, DWDM , Applications ,Subcarrier Multiplexing-Analog and Digital SCM Systems, -Radio over Fibre Systems, OFDM. Indoor Optical Wireless Communication Channels– Infrared Optical Wireless Communications, Visible Light Communications | 9 |
| | | |
| 5 | Optical Networks – | |
| | SDH/SONET Layers, Frame Structure, Physical Layer, topologies, Access Networks Optical Transport Network, OTN hierarchy. Frame Structure, Multiplexing WDM Network Elements, Optical Line terminals. Optical add/Drop multiplexers, Optical crossconnects Storage-area networks, Photonic Packet Switching Optical Time Division Multiplexing and Synchronization | 10 |
| | Total Hours | 45 |

Course Plan

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | Overview of Optical Communication System : | |
| 1.1 | Evolution of Fibre-Optic Communications, Light wave System Components. | 1 |
| 1.2 | Optical Fibers-Types, Wave propagation, Fiber Modes, Dispersion in fibers, GVD, PMD , Fiber Losses | 3 |
| 1.3 | Nonlinear Effects- Self Phase Modulation Cross Phase Modulation, Four Wave Mixing, Stimulated Raman and Brillouin Scattering. | 2 |
| 1.4 | Fiber Design Plastic Optical Fibers, Crystal Fiber - Photonic s | 3 |
| | | |
| 2 | Optical Transmitters and Receivers- | |
| 2.1 | LEDs and SemiconductorLasers- structure and characteristics, VCSEL | 2 |
| 2.2 | Optical Signal Generation-Direct Modulation, External Modulation, MZM, Advanced Modulation Formats | 2 |

| | | |
|---|---|---|
| 2.3 | Optical Receivers- PIN and APD Detectors, Receiverdesign,Sources of Noise, SNR, | 2 |
| 2.4 | Coherent Detection , Homodyne and Heterodyne detection,SNR | 2 |
| 2.5 | Performance Evaluation of an OOK link- BER, Q, Receiver Sensitivity | 2 |
| | | |
| 3 | Lightwave System Design | |
| 3.1 | Point-to-Point Links, Link Budget(Power & Rise time) | 2 |
| 3.2 | Loss Management-Compensation of Fiber Losses, OpticalAmplifiers- EDFA and RAMAN Amplifiers,Optical Signal-To-Noise Ratio. | 2 |
| 3.3 | Dispersion Management-Dispersion-Compensating Fibers,Fiber Bragg Gratings, Dispersion-Equalizing Filters | 3 |
| 3.4 | Control of Nonlinear Effects-Solitons in Optical Fibers | 1 |
| | | |
| 4 | Introduction to Multiplexing and Communication channels | |
| 4.1 | WDM Light wave Systems, Architecture,WDMComponents, DWDM , Applications | 4 |
| 4.2 | Subcarrier Multiplexing-Analog and Digital SCM Systems, - Radio over Fibre Systems, OFDM. | 3 |
| 4.3 | Indoor Optical Wireless Communication Channels –Infrared Optical Wireless Communications, Visible Light Communications | 2 |
| | | |
| 5 | Optical Networks – | |
| 5.1 | SDH/SONET Layers, Frame Structure, Physical Layer, topologies, Access Networks | 3 |
| 5.2 | Optical Transport Network, OTN hierarchy. Frame Structure, Multiplexing | 3 |
| 5.3 | WDM Network Elements, Optical Line terminals. Opticaladd/Drop multiplexers, Optical crossconnects | 2 |
| 5.4 | Storage-area networks, Photonic Packet Switching Optical Time Division Multiplexing and Synchronization | 2 |
| | Total Hours | 45 |

Reference Books

1. Fiber Optic Communication- GP Agrawal(Wiley 4th ed)
2. Rajiv Ramaswami and Kumar N Sivarajan- Optical networks, A practicalperspective (Morgan kaufmann , 2nd 2001)
3. R.G.Hunsperger , Integrated optics Theory and technology (Springer series inOptical Sciences “, 5th edition 2002)
4. Advanced Optical and Wireless Communications Systems,IvanB.Djordjevic(Springer)
5. G.G Keiser , Optical Fiber Communication (TMH,4th Ed)
6. John M.Senior ,OpticalFiber Communications Principles and practicePHI,1992 .

# PROGRAM ELECTIVE-IV

Electronics and Communication Engineering-EC3

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCWMCT214 | WIRELESS AND MOBILE COMMUNICATION | PROGRAM ELECTIVE4 | 3 | 0 | 0 | 3 |

Preamble:This course introduces the important aspects in Wireless & Mobile Communication. The evolution of different generations of mobile systems, access and diversity techniques are dealt in the course. The course gives an overview fromRF channel modelling to next generation networks.

Course Outcomes:After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO1 | Analyse the characteristics of wireless channels. | An |
| CO2 | Apply the diversity concepts for wireless communication. | A |
| CO3 | Evaluate different multiple access techniques. | E |
| CO4 | Evaluate the challenges in mobile communication systems. | E |
| CO5 | Analyse the new trends in wireless & mobile communicationsnetworks. | An |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 1 | | | 3 | 2 | 2 | 2 | | 3 | 2 |
| CO 2 | | | 3 | 2 | 2 | 2 | | 3 | 2 |
| CO 3 | | | 3 | 3 | 2 | 2 | | 3 | 2 |
| CO 4 | | | 2 | 3 | 3 | 2 | | 2 | 22 |
| CO 5 | | | 2 | 2 | 3 | 3 | | 3 | |

Assessment Pattern

| Bloom's Category | End SemesterExamination |
|---|---|
| Understand | 10 |
| Apply | 20 |
| Analyse | 30 |
| Evaluate | 30 |
| Create | 10 |

Mark distribution

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

Continuous Internal Assessment Pattern:

| Evaluation Method | Marks |
|---|---|
| Preparing a review article based on peer reviewed Originalpublications (minimum 10 Publications shall be referred) | 15 |
| Course based task/ Seminar/ Data Collection and interpretation | 15 |
| Test paper, 1 no.<br>(Test paper shall include minimum 80% of the syllabus.) | 10 |
| Total | 40 |

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. Therewill be two parts; Part A and Part B.

*Part A*

Answer all questions. Each question carries 5 marks.

This section will have 5 numerical/ short answer questions with 1 question fromeach module.

*Part B*

Answer any five. Each question carries 7 marks.

This section will have 7 long answer questions, with minimum one question fromeach module.

Note:The marks obtained for the ESE for an elective course shall not exceed 20%over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if theaverage end semester mark % for a core course is 40, then the maximum eligiblemark % for an elective course is 40+20 = 60 %.

# Syllabus

| No | Topic | Hours |
|---|---|---|
| 1 | Channel Models | (8) |
| | Shannon's capacity - bandwidth and power-limitedregimes.<br>Free space propagation model - factors affecting pathloss.<br>Parameters of mobile multipath channels-time dispersion parameters, coherence bandwidth- Dopplerspread and coherence time.<br>Types of small-scale fading-fading effects due to multipath time delay spread - flat fading- frequency selective fading,<br>Fading effects due to Doppler spread-fast fading slow fading.<br>Narrow band and wideband fading models.<br>Physical modelling of wireless channels - time and frequency coherence<br>Statistical channel models - power delay profile. | |
| | | |
| | Diversity Techniques | (8) |
| 2 | Independent fading paths - receiver diversity – selection,combing -threshold combing - maximal-ratio combing -equal gain combing,Transmitter diversity - channel known at transmitter -channel unknown at transmitter - Rake receiver,The Alamouti scheme-transmit & receive diversity-MIMOsystems.<br>MIMO applications in wireless system - MIMO-OFDM. | |
| | | |
| 3 | Multi - Access Methods | (9) |

| | | |
|---|---|---|
| | TDMA/FDMA: A case study of GSM. CDMA: Direct sequence spread spectrum - Frequency hopping systems.Anti-jamming - Pseudo Random (PN) sequence -Maximal length sequences - Gold sequences - Generation of PN sequences. Power control in CDMA.Data transmission using multiple carriers – Discrete implementation of multicarrier modulation - OFDM – Advantages ,Mitigation of subcarrier fading - Timing and frequencyoffset in OFDM- PAPR reduction of OFDM signals. | 9 |
| | | |
| 4 | Cellular Communication | (9) |
| | Overview of cellular systems and evolution 1G to 3G.Cellular concepts,Frequency reuse, Co-channel and Adjacent channel Interference.<br>Improving coverage &capacity in Cellular Systems - Cellsplitting, Sectoring. Hand over - Hard and soft hand off strategies.Fundamentals of 4G - Advantages and Applications of 4G - Architecture and representative protocols. | |
| | | |
| 5 | Emerging Connectivity | (8) |
| | Introduction to 5G - Architecture - Quality of Service -Radio Network requirements,<br>Security - Specifications – Standardization - B5G<br>Introduction to 6G- requirements - spectrum- key enablers- Key Performance Indicators<br>Introduction to Vehicle to-Vehicle communications. | 9 |
| | Total Hours | 45 |

Course Plan

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | Channel Models | (8) |
| 1.1 | Shannon's capacity - bandwidth and power-limited regimes. | 1 |
| 1.2 | Free space propagation model - factors affecting pathloss. | 1 |
| 1.3 | Parameters of mobile multipath channels-time dispersion parameters, coherence bandwidth- Dopplerspread and coherence time. | 1 |
| 1.4 | Types of small-scale fading-fading effects due to multipath time delay spread - flat fading- frequency selective fading, | 1 |
| 1.5 | Fading effects due to Doppler spread-fast fading slow fading. | 1 |
| 1.6 | Narrow band and wideband fading models. | 1 |
| 1.7 | Physical modelling of wireless channels - time and frequency coherence | 1 |
| 1.8 | Statistical channel models - power delay profile. | 2Mu |
| | | |
| | Diversity Techniques | (8) |
| 2.1 | Independent fading paths - receiver diversity - selection combing -threshold combing - maximal-ratio combing - equal gain combing | 2 |
| 2.2 | Transmitter diversity - channel known at transmitter - channel unknown at transmitter - Rake receiver | 2 |
| 2.3 | The Alamouti scheme-transmit & receive diversity-MIMO systems. | 2 |
| 2.4 | MIMO applications in wireless system - MIMO-OFDM. | 2 |
| | | |
| 3 | Multi - Access Methods | (9) |
| 3.1 | TDMA/FDMA: A case study of GSM. CDMA: Direct sequence spread spectrum - Frequency hopping systems. | 2 |
| 3.2 | Anti-jamming - Pseudo Random (PN) sequence -Maximal length sequences - Gold sequences - Generation of PN sequences. Power control in CDMA. | 2 |
| 3.3 | Data transmission using multiple carriers - Discrete implementation of multicarrier modulation - OFDM - Advantages | 2 |

| | | |
|---|---|---|
| 3.4 | Mitigation of subcarrier fading - Timing and frequency offset in OFDM- PAPR reduction of OFDM signals. | 3 |
| | | |
| 4 | Cellular Communication | (9) |
| 4.1 | Overview of cellular systems and evolution 1G to 3G. Cellular concepts | 2 |
| 4.2 | Frequency reuse, Co-channel and Adjacent channel Interference. | 2 |
| 4.3 | Improving coverage &capacity in Cellular Systems - Cellsplitting, Sectoring. Hand over - Hard and soft handoff strategies. | 2 |
| 4.4 | Fundamentals of 4G - Advantages and Applications of4G - Architecture and representative protocols. | 3 |
| | | |
| 5 | Emerging Connectivity | (8) |
| 5.1 | Introduction to 5G - Architecture - Quality of Service - Radio Network requirements, | 2 |
| 5.2 | Security - Specifications – Standardization - B5G | 2 |
| 5.3 | Introduction to 6G- requirements - spectrum- key enablers- Key Performance Indicators | 2 |
| 5.4 | Introduction to Vehicle to-Vehicle communications. | 3 |
| | Total Hours | 45 |

Text Books

1. Andrea Goldsmith, Wireless Communications, Cambridge Institution press.
2. A.J.Viterbi, CDMA-Principles of Spread Spectrum, Addison Wesley.4.
3. Shinsuke Hara and Ramjee Prasad, Multicarrier Techniques for4GMobileCommunications, Artech House.
4. AngelikiAlexiou, 5G Wireless

Technologies, IET.Reference Books

1. Simon Haykin and Michael Moher, Modern Wireless Communications,Pearson Education.
2. Jonathan Rodriguez, Fundamentals of 5G Mobile Networks, Wiley.
3. Paulo Sergio Rufino Henrique and Ramjee Prasad, 6G: The Road to theFutureWireless Technologies 2030, River Publishers.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCBSPT224 | BIOMEDICALSIGNAL PROCESSING | PROGRAM ELECTIVE4 | 3 | 0 | 0 | 3 |

Preamble:The course introduces the fundamental concepts, principles and application of biomedical signal processing and design. This course goes deeper into the various aspects of artifact removal in biosignals, cardio vascular applications, neurological applications and model based spectral analysis.

Course Outcomes:After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO1 | Analyze biomedical signals properties and effects of noise in biomedicalinstruments | An |
| CO2 | Create a model of bio medical signal | E |
| CO3 | Analyse ECG signals for Cardio vascular applications | An |
| CO4 | Analyse EEG signals for Neurological applications | An |
| CO5 | Analyse model based spectral analysis | An |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | 3 | 3 | 3 | | | 3 | |
| CO2 | | | 3 | 3 | 3 | | | 3 | |
| CO3 | | | 3 | 3 | 3 | | | 3 | |
| CO4 | | | 3 | 3 | 3 | | | 3 | |
| CO5 | | | 3 | 3 | 3 | | | 3 | |

Assessment Pattern

| Bloom's Category | End SemesterExamination |
|---|---|
| Understand | 10 |
| Apply | 10 |
| Analyse | 20 |
| Evaluate | 10 |
| Create | 10 |

Mark distribution

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

## Assessment Pattern

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (suchquestions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | Review of Biomedical Signal | |
| | Fourier Transform and Time Frequency Analysis - (Wavelet) of biomedical signals- Processing of Random &Stochastic signals - Introduction to Biomedical Signals - Examples ofBiomedical signals - ECG, EEG, EMG etc,Tasks in Biomedical Signal Processing - Computer AidedDiagnosis. Origin of bio-potentials ,Properties and effects of noise in biomedical instruments,- Filtering in biomedical instruments | 9 |
| 2 | Concurrent, coupled and correlated processes | |
| | Concurrent, coupled and correlated processes - illustration with case studies,Adaptive and optimal filtering,Modelling of Biomedical signals - Detection of biomedicalsignals in noise - removal of artifacts of one signal embedded in another - Maternal-Fetal ECG – Muscle - contraction interference. Event detection - casestudies with ECG & EEG | 8 |
| 3 | Cardio vascular applications : | |
| | Basic ECG - Electrical Activity of the heart ECG data acquisition – ECG parameters & theirestimation - Use of multiscale analysis for ECG parameters estimation,Noise & Artifacts - ECG Signal Processing: Baseline Wandering, Power line interference, Muscle noise filtering QRS detection - Arrhythmia analysis | 9 |
| 4 | Neurological Applications: | |
| | The electroencephalogram - EEG rhythms & waveform - categorization of EEG activity - recording techniques EEG applications- Epilepsy, sleep disorders Brain computer interface. Modelling EEG- linear, | 9 |

| | | |
|---|---|---|
| | stochastic models - Non linear modelling of EEG<br>Artifacts in EEG & their characteristics and processing - Model based spectral analysis | |
| 5 | Model based spectral analysis | |
| | EEG segmentation | 9 |
| | Joint Time- Frequency analysis correlation analysis of EEG channels | |
| | coherence analysis of EEG channels | |
| | Independent component Analysis - Cocktail party problem applied to EEG signals | |
| | Total Hours | 45 |

Course Plan

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | Review of Biomedical Signal | |
| 1.1 | Fourier Transform and Time Frequency Analysis - (Wavelet) of biomedical signals- Processing of Random& Stochastic signals - | 2hrs |
| 1.2 | Introduction to Biomedical Signals - ExamplesofBiomedical signals - ECG, EEG, EMG etc | 2hrs |
| 1.3 | Tasks in Biomedical Signal Processing - Computer AidedDiagnosis. Origin of bio-potentials | 2hrs |
| 1.4 | Properties and effects of noise in biomedical instruments<br>- Filtering in biomedical instruments | 3hrs |
| 2 | Concurrent, coupled and correlated processes | |
| 2.1 | Concurrent, coupled and correlated processes -illustration with case studies | 2hrs |
| 2.2 | Adaptive and optimal filtering | 3hrs |
| 2.3 | Modelling of Biomedical signals - Detection of biomedicalsignals in noise - removal of artifacts of one signal embedded in another - Maternal-Fetal ECG – Muscle - contraction interference. Event detection - casestudies with ECG & EEG | 3hrs |
| 3Ca | dio vascular applications : | |
| 3.1 | Basic ECG - Electrical Activity of the heart | 3hrs |
| 3.2 | ECG data acquisition – ECG parameters & theirestimation - Use of multiscale analysis forECG parameters estimation | 3hrs |

| | | |
|---|---|---|
| 3.3 | Noise & Artifacts - ECG Signal Processing: Baseline Wandering, Power line interference, Muscle noise filtering | 2hrs |
| 3.4 | QRS detection - Arrhythmia analysis | 1hrs |
| 4Ne | rological Applications: | |
| 4.1 | The electroencephalogram - EEG rhythms & waveform -categorization of EEG activity - recording techniques | 2hrs |
| 4.2 | EEG applications- Epilepsy, sleep disorders | 2hrs |
| 4.3 | Brain computer interface. Modelling EEG- linear,stochastic models - Non linear modelling of EEG | 2hrs |
| 4.4 | Artifacts in EEG & their characteristics and processing -Model based spectral analysis | 3hrs |
| 5Mo | el based spectral analysis | |
| 5.1 | EEG segmentation | 2hrs |
| 5.2 | Joint Time- Frequency analysis correlation analysis ofEEG channels | 2hrs |
| 5.3 | coherence analysis of EEG channels | 2hrs |
| 5.4 | Independent component Analysis - Cocktail partyproblem applied to EEG signals | 3hrs |
| | Total Hours | 45 |

Reference Books

1. Bruce, Eugene N. "Biomedical signal processing and signal modeling: Wileyseries in telecommunications and signal processing." (2001).

2.Sörnmo, Leif, and Pablo Laguna.*Bioelectrical signal processing in cardiacandneurological applications*. Vol. 8. Academic press, 2005.

3.Rangayyan, “Biomedical Signal Analysis”, Wiley 2002.

4.D.C.Reddy , “ Biomedical Signal Processing: Principles and techniques”, TataMcGraw Hill, New Delhi, 2005.

5.Enderle, John, and Joseph Bronzino, eds.*Introduction to biomedical engineering*.Academic press, 2012.

6. Sanei, Saeid, and Jonathon A. Chambers.*EEG signal processing*. John Wiley&Sons, 2013.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCAUPT234 | AUDIO PROCESSING | PROGRAM ELECTIVE4 | 3 | 0 | 0 | 3 |

Preamble:This course aims to develop in-depth understanding of fundamentals of hearing mechanism, cochlear signal processing, auditory filters, critical band structure, psychoacoustic analysis, spatial audio perception & rendering and audio compression algorithms, enabling them to apply that in the research anddevelopment of audio processing applications.

Course Outcomes:After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO 1 | Explain the hearing mechanism, cochlear signal processing, auditoryfilter banks, hearing aids and cochlear implants | U |
| CO 2 | Apply the knowledge of critical band structure, masking phenomenonandpsycho acoustic analysis in developing audio processing applications | A |
| CO 3 | Explain the various audio compression methods and audio codingstandards like MPEG2-AAC | U |
| CO 4 | Apply the knowledge of spacial audio perception and room acoustics inthe development of spatial audio systems | A |
| CO 5 | Analyse the quality of audio signals using objective and subjective methods and explain audio processing techniques for music applications | An |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 1 | | | 3 | 3 | 3 | | | | 2 |
| CO 2 | | | 3 | 3 | 3 | | | | 2 |
| CO 3 | | | 3 | 3 | 3 | | | | 2 |
| CO 4 | | | 3 | 3 | 3 | | | 2 | 3 |
| CO 5 | | | 3 | 3 | 3 | | | 2 | 3 |

Assessment Pattern

| Bloom's Category | End SemesterExamination |
|---|---|
| Understand | 10 |
| Apply | 30 |
| Analyse | 20 |
| Evaluate | 10 |
| Create | |

Mark distribution

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

Continuous Internal Assessment Pattern:

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

Test paper (Shall include minimum of 80% of the syllabus)1 no.:10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (suchquestions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating totheoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

# Syllabus

| Module No | Topic | No. of Lectures |
|---|---|---|
| 1 | Basic anatomy of hearing System-Outer ear, middle ear andinner ear, Cochlea and signal processing in cochlea<br>Auditory Filter Banks, Gamma-tone filters, Bark Scale, Melfrequency scale<br>Hearing aids, Cochlear implants | 6 |
| | | |
| 2 | Absolute Threshold of Hearing, Critical Band Structure,Simultaneous Masking, Temporal Masking,MPEG psycho-acoustic model | 9 |
| | | |
| 3 | Redundancy removal and perceptual irrelevancy removal,<br>Sub-band coding<br>MDCT, Transform coding, Pre-echo and pre-echosuppression<br>MPEG2-AAC coding standard, Lossless coding methods. | 9 |
| 4 | | |
| | Sound localization and space perception, Head relatedtransfer functions<br>Stereo and multi-channel audio, Mid- Side Stereo, Intensity Stereo, Binaural Cue Coding, Spatial audio standards<br>Room acoustics: Sound propagation in rooms, Modeling the influence of short and long term reverberation, Modeling roomimpulse responses and head related impulse responses. | 9 |
| 5 | MODULE V | |

| | | |
|---|---|---|
| | Music Transcription, automatically deriving notes, beats,and chords from music signals.<br>Music Information Retrieval, audio-based genre classification, artist/style identification, and similarityestimation.<br>Objective analysis methods- PEAQ,<br>Subjective analysismethods - MOS score, MUSHRA score | 9 |
| | | 45 |

Course Plan

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | | |
| 1.1 | Basic anatomy of hearing System-Outer ear, middle ear andinner ear, Cochlea and signal processing in cochlea | 2 |
| 1.2 | Auditory Filter Banks, Gamma-tone filters, Bark Scale, Melfrequency scale | 2 |
| 1.3 | Hearing aids, Cochlear implants | 2 |
| 2 | | |
| 2.1 | Absolute Threshold of Hearing, Critical Band Structure | 3 |
| 2.2 | Simultaneous Masking, Temporal Masking | 3 |
| 2.3 | MPEG psycho-acoustic model | 3 |
| 3 | | |
| 3.1 | Redundancy removal and perceptual irrelevancy removal, | 3 |
| | Sub-band coding | |
| 3.2 | MDCT, Transform coding, Pre-echo and pre-echosuppression | 3 |
| 3.3 | MPEG2-AAC coding standard, Lossless coding methods. | 3 |
| 4 | | |

| | | |
|---|---|---|
| 4.1 | Sound localization and space perception, Head relatedtransfer functions | 3 |
| 4.2 | Stereo and multi-channel audio, Mid- Side Stereo, IntensityStereo, Binaural Cue Coding, Spatial audio standards | 3 |
| 4.3 | Room acoustics: Sound propagation in rooms, Modeling the influence of short and long term reverberation, Modeling roomimpulse responses and head related impulse responses. | 3 |
| 5 | | |
| 5.1 | Music Transcription, automatically deriving notes, beats,and chords from music signals. | 3 |
| 5.2 | Music Information Retrieval, audio-based genre classification, artist/style identification, and similarityestimation. | 3 |
| 5.3 | Objective analysis methods- PEAQ, Subjective analysismethods - MOS score, MUSHRA score | 3 |
| | | 45 |

Reference Books

1. Audio Signal Processing and Coding, Andreas Spanias, Ted PainterandVenkittaramAtti, Wiley-Inter Science publication, 2006
2. Speech and Audio Signal Processing: Processing and Perception of Speechand Music, 2nd Edition, Ben Gold, Nelson Morgan, Dan Ellis, ISBN: 978-0-470-19536-9
3. Spatial Audio (Music Technology Series), 1st Edition, Francis Rumsey,ISBN:0240516230

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCDEPT244 | DEEP LEARNING | PROGRAM ELECTIVE4 | 3 | 0 | 0 | 3 |

Preamble:This course provides an introduction to key concept in deep learning andequip students with knowledge required to develop best deep learningsolutionsfor real world problems in domains such as computer vision, naturallanguage processing etc.

Course Outcomes:The COs shown are only indicative. For each course, there canbe 4 to 6 COs.

After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO1 | Demonstrate the uses and limitations of fully connected neural networks | An |
| CO 2 | Compare different CNN networks for classification and detection in terms ofarchitecture, performance and computational requirements | An |
| CO3 | Develop a convolutional neural network for a real-world application | An |
| CO4 | Apply regularization and optimization techniques in CNN training | A |
| CO5 | Demonstrate the use of RNNS and LSTM for analysing sequential data | An |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 13 | | | | | | | | 3 | |
| CO 23 | | | | | | | | 3 | |
| CO 33 | | | 3 | 3 | 3 | | | 3 | |
| CO 43 | | | | | | | | 3 | |
| CO 53 | | | | | | | | 3 | |
| CO 63 | | | 3 | 3 | | | | 3 | |

Assessment Pattern

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 20 |
| Apply | 20 |
| Analyse | 20 |
| Evaluate | |
| Create | |

Mark distribution

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

Continuous Internal Evaluation Pattern:

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

End Semester Examination Pattern:

60 Marks
Part A: 5×5
MarksPart B: 5×7
Marks

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | Introduction to Machine Learning | |
| 1.1 | Introduction: Supervised Vs. Unsupervised Learning,Classification Vs. Regression,Machine Learning Vs. Deep Learning | 1 |
| 1.2 | Machine Learning System Design: Data-driven Approach, Datasets: Training, Testing and Validation Sets, Over fitting and Under fitting, Hyper parameters, K-nearestneighbour classification | 3 |
| 1.3 | Linear classification: Loss function, Multiclass SVM, Softmax classifier. Optimization, Numeric andAnalytic gradients. | 4 |
| 2 | Neural Networks | |
| 2.1 | Deep feedforward networks/ Multilayer perception: Perceptron, activation functions, Example: Learning XOR, Architecture of deep neural network | 2 |
| 2.2 | Back propagation, Gradient-Based Learning. | 2 |
| 2.3 | Convolutional Neural Networks: Convolution, Pooling Layers, spatialarrangement, layer patterns, layer sizing patterns. | 3 |
| 3Tra | ning Neural Networks | |
| 3.1 | Initialization, batch normalization, Hyper parameter optimization. | 2 |
| 3.2 | Optimization algorithms: SGD, Momentum, Adagrad, RMS Prop, Adam | 2 |
| 3.3 | Regularization methods: L1 and L2 regularization, Early stopping, drop outs, ensembles, data augmentation, Updaterules, transfer learning | 2 |
| 4 | CNN architectures | |
| 4.1 | AlexNet, VGG Net, ResNet, Inception Net | 3 |
| 4.2 | Object Detection: RCNN, Fast RCNN, Faster RCNN, YOLO, Mask RCNN | 3 |
| 4.3 | Recurrent Neural Networks: RNN, Bidirectional RNN, LSTM, GRU | 3 |
| 5At | ntion Models, Transformers and Generative Models | |
| 5.1 | Attention: Multimodal attention, Self-Attention | 3 |
| 5.2 | Transformers: BERT and vision transformer | 3 |
| 5.3 | Autoencoders, Variational auto encoders, Generative Adversarial Network | 4 |

## Reference Books

1. Ian Goodfellow, YoshuaBengio, and Aaron Courville.

Deep learning.MITpress,2016.
2. Francois Chollet. Deep learning with Python. Simon and Schuster, 2021.
3. Ivan Vasilev. Advanced Deep Learning with Python: Design and implementadvanced next-generation AI solutions using TensorFlow and PyTorch. PacktPublishing Ltd, 2019.
4. C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006
5. Michael A Nielsen. Neural networks and deep learning. Determination press,2015.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCSPAT254 | SIGNAL PROCESSINGFOR AUTOMATION | PROGRAM ELECTIVE4 | 3 | 0 | 0 | 3 |

Preamble:This course aims to impart knowledge on thesignal processing and its applications in the field of vehicle automation, process control automation, robotics,andthe audio video processing.

Course Out Comes: After the completion of the course the student will be able to:

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO1 | Understand the general principles of automation, sensors and transducers | U |
| CO 2 | Understand the automotive Protocols and apply the signal processing application in vehicle automation | U |
| CO3 | Apply the Signal Processing methods in Process control and Automation | A |
| CO 4 | Understand the fundamentals of robot and apply the Signal Processing methods in robotics | U |
| CO5 | Understand the principles of audio and video signal processing | U |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|
| CO1 3 | 1 | | 3 | | 3 | 3 | | | |
| CO2 3 | 2 | | 3 | 3 | 3 | 3 | 1 | | 3 |
| CO3 3 | 2 | | 3 | 3 | 3 | 3 | 1 | | 3 |
| CO4 3 | 2 | | 2 | 2 | 2 | 3 | | | 3 |
| CO5 2 | | | 1 | | 1 | 1 | | | 3 |

Assessment Pattern:

| Bloom's Category | CIA | End Semester Examination |
|---|---|---|
| Undersatand | 10 | 10 |
| Apply | 10 | 20 |
| Analyse | 10 | 20 |
| Evaluate | 10 | 10 |
| Create | | |

Mark distribution:

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 Hours |

Continuous Internal Evaluation Pattern:

Evaluation shall only be based on application, analysis or design based questions(forboth internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

| | |
|---|---|
| Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus.) | 10 marks |
| **TOTAL** | **40 marks** |

Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

The end semester examination will be conducted by the College. There will be twoparts;Part A and Part B. Part A contain 5 numerical questions (such questions shallbe useful inthe testing of knowledge, skills, comprehension, application, analysis,synthesis, evaluation and understanding of the students), with 1 questionfrom eachmodule, having5 marks for each question. Students shall answer all questions. PartB contains 7 questions(such questions shall be useful in the

testing of overallachievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solvingand quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 7 marks. Total duration ofthe examination will be 150 minutes.

Syllabus and Course Plan

| Module No | Topi c | No. of hours |
|---|---|---|
| 1 | Introduction to automation (8) | |
| | Introduction to automation and automated systems, Overview ofexpert system, Expert system Architecture | 9 |
| | Fundamentals of sensors, Sensor classification | |
| | Sensor parameters Selection of sensors. Interfacing of Sensors and Signal Conditioning: Change of BIOS and level of signals, | |
| | Smart Transducers: Smart Sensors, Components of SmartSensors, General Architecture of Smart Sensors, | |
| | Evolution of Smart Sensors, Advantages of Smart Sensors.1 | |
| 2 | Signal Processing in Vehicle Automation (8) | |
| | Overview of automotive subsystems | 9 |
| | Basic principles and types of automotive Sensors and Transducers-. | |
| | Introduction to autonomous vehicles architecture | |
| | Introduction to Automotive Protocols: | |
| | Automotive Protocols: LIN, CAN, FlexRay, Test, Calibration and Diagnostics tools for networking of electronic systems like ECU Software and Testing Tools, ECU Calibration Tools | |
| | OSAR Architecture | |
| 3 | Signal Processing in Process control and Automation (10) | |
| | Introduction to Process Modeling: hierarchies. | 10 |

| | | |
|---|---|---|
| | Theoretical model: transfer function, state space models, and time series models. | |
| | concept of feedback & feed forward control, cascade control, selective control loops, ratio control, feed forward and ratio, split range, selective, override, auctioneering, adaptive and inferential controls. Statistical process control, supervisory control, direct digital control, distributed control | |
| 3.5<br>3.6 | Introduction to Automatic Control:<br>PC based automation. SCADA in process automation. Time Delay Systems and Inverse Response Systems<br>Special Control Structures, Introduction to Sequence Control, PLC, RLL, Sequence Control. Scan Cycle. | |
| 4 | Signal Processing in Robotics (8) | |
| | Introduction to robotics, Basic components of robotic system. | 9 |
| | Sensing - Pre-processing – Noise reduction | |
| | Enhancement of details and Signal Conversion in robotic | |
| | Introduction to computer vision, Point operators, Linear Filters,<br>More neighborhood operators | |
| | Introduction to machine vision system | |
| | Overview of SLAM, Different Approaches to SLAM. | |
| | Introduction to Robot Operating system(ROS). | |
| 5 | Signal Processing in Audio Video Processing (7) | |
| | Overview ofAnalog video, digital video | 9 |
| | Time-varying image formation models: three dimensional motion<br>models, | |
| | Geometric image formation, photometric image formation | |
| | Sampling of video signals, filtering operations. | |
| | Vocoder- Voice excited channel vocoder, Voice excited and error<br>signal excited LPC vocoders. | |
| | Adaptive predictive coding of speech, Auditory Modeling. | |

| | | |
|---|---|---|
| | Speech recognition and pattern matching techniques | |
| | | |
| No | Topic | No. of Hours |
| 1 | Introduction to automation (8) | |
| 1.1 | Introduction to automation and automated systems, Overview ofexpert system, Expert system Architecture | 2 |
| 1.2F | ndamentals of sensors, Sensor classification | 1 |
| 1.3 | Sensor parameters Selection of sensors. Interfacing of SensorsandSignal Conditioning: Change of BIOS and level of signals, | 2 |
| 1.4 | Smart Transducers: Smart Sensors, Components of SmartSensors, General Architecture of Smart Sensors, | 2 |
| 1.5 | Evolution of Smart Sensors, Advantages of Smart Sensors.1 | |
| 2 | Signal Processing in Vehicle Automation (8) | |
| 2.1 | Overview of automotive subsystems | 1 |
| 2.2 | Basic principles and types of automotive Sensors and Transducers-. | 1 |
| 2.3 | Introduction to autonomous vehicles architecture | 1 |
| 2.4In | Introduction to Automotive Protocols: | 1 |
| 2.5 | Automotive Protocols: LIN, CAN, FlexRay, Test, Calibration and Diagnostics tools for networking of electronic systems like ECU Software and Testing Tools, ECU Calibration Tools | 3 |
| 2.6 | ATOSAR Architecture | 1 |
| 3 | Signal Processing in Process control and Automation (10) | |
| 3.1 | Introduction to Process Modeling: hierarchies. | 1 |
| 3.2 | Theoretical model: transfer function, state space models, and time series models. | 2 |

| | | |
|---|---|---|
| 3.3 | concept of feedback & feed forward control, cascade control, selective control loops, ratio control, feed forward and ratio, splitrange, selective, override, auctioneering, adaptive and inferential controls. Statistical process control, supervisory control, direct digital control, distributed control | 2 |
| 3.4 | Introduction to Automatic Control: | 1 |
| 3.5 | PC based automation. SCADA in process automation. Time DelaySystems and Inverse Response Systems | 2 |
| 3.6 | Special Control Structures, Introduction to Sequence Control,PLC, RLL, Sequence Control. Scan Cycle. | 2 |
| 4 | Signal Processing in Robotics (8) | |
| 4.1 | Introduction to robotics, Basic components of robotic system. | 1 |
| 4.2 | Sensing - Pre-processing – Noise reduction | 1 |
| 4.3 | Enhancement of details and Signal Conversion in robotic | 1 |
| 4.4 | Introduction to computer vision, Point operators, Linear Filters,<br>More neighborhood operators | 2 |
| 4.5 | Introduction to machine vision system | 1 |
| 4.6 | Overview of SLAM, Different Approaches to SLAM. | 1 |
| 4.7 | Introduction to Robot Operating system(ROS). | 2 |
| 5 | Signal Processing in Audio Video Processing (7) | |
| 5.1 | Overview ofAnalog video, digital video | 1 |
| 5.2 | Time-varying image formation models: three dimensional motion<br>models, | 1 |
| 53 | Geometric image formation, photometric image formation | 1 |
| 5.4 | Sampling of video signals, filtering operations. | 1 |
| 5.5 | Vocoder- Voice excited channel vocoder, Voice excited and error<br>signal excited LPC vocoders. | 1 |
| 5.6 | Adaptive predictive coding of speech, Auditory Modeling. | 2 |
| 5.7 | Speech recognition and pattern matching techniques | 2 |

Text Books

1. "Anatomy of Automation" – Amber G.H & P.S. Amber, PrenticeHall
2. NikolayKirianaki, Sergey Yurish, Nestor Shpak, VadimDeynega, Data Acquisitionand Signal Processing for Smart Sensors, John Wiley & Sons Ltd, 2002.
3. Tao Zhang, Luca Delgrossi, "Vehicle Safety Communications: Protocols, Securityand Privacy", Wiley Publication.
4. Robert Bosch," Automotive Hand Book", Fifth edition, SAE Publications.
5. Groover. M.P. Industrial Robotics, technology, programming and application Mc-Graw Hill 2012.

6. S. R.Deb, "Robotics technology and flexible automation", Tata McGraw Hillpublishing company limited, 1994.
7. Bob Connel, Process Instrumentation Applications Manual, McGrawHill, 1996. 8.Ranjan Parekh,Fundamentals of image, audio, and video processing using matlab®:with applications to pattern recognition,CRC Press (Taylor and Francis2021 :
9.Nelson Morgan and Ben Gold, Speech and Audio Signal Processing: Processing andPerception Speech and Music, July 1999, John Wiley & Sons

Reference Books

1. Smart Sensors, Measurement and Instrumentation by SubhasChandraMukhopadhyay, Springer Book Series.
2. Randy Frank , Understanding Smart Sensors , Second Edition, Artech Housesensors library, 2000.
3. Ronald K. Jurgen, "Automotive Electronics Handbook", Mc -Graw Hill..
3. S. K. Saha, "Introduction to Robotics", Tata McGraw-Hill Publishing CompanyLtd.(2008).
4. Peter Corke, Robotics, Vision and Control: Fundamental Algorithms, SpringerTracts in Advanced Robotics,Volume 118, Second Edition, 2016
5. Seborg, D.E., T.F. Edgar, and D.A. Mellichamp, Process Dynamics andControl,John Wiley , 2004

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 24PCESRT264 | EMBEDDED SYSTEMS AND RTOS | PROGRAM ELECTIVE 4 | 3 | 0 | 0 | 3 |

Preamble: The objective of the course is to impart the concepts and architecture of Embedded systems, Realtime systems and Real-time Operating Systems and to make the students capable of designing Real-Time Embedded Systems. To achieve this, the architecture and programming of Industry popular 32-bit Microcontroller, ARM Cortex is covered in detail.

Course prerequisites: Nil

Course Outcomes: After the completion of the course the student will be able to

| Course Outcome | Description | Bloom's Level |
|---|---|---|
| CO 1 | To do hardware/software co-design for embedded systems and to develop skills in analysis, approach, optimization, and implementation of embedded systems. | An |
| CO2 | To familiarize with ARM cortex Microcontroller architecture. | U |
| CO 3 | Apply embedded program optimization skills in designing embedded systems. | A |
| CO4 | To learn implementation aspects of real time systems. | U |
| CO5 | Apply RTOS concepts in solving multi-tasking embedded applications | A |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|
| CO 13 | | | 3 | 3 | 2 | | | | |
| CO 23 | | | 2 | 2 | | | | | |
| CO 33 | | | 3 | 3 | 3 | | | | |
| CO 43 | 3 | | 2 | 3 | 2 | | | | |
| CO 53 | | | 2 | 3 | 2 | | | | |

Assessment Pattern

| Bloom's Category | End Semester Examination (%) |
|---|---|
| Understand | 10 |
| Apply | 20 |
| Analyse | 20 |
| Evaluate | 10 |
| Create | |

Mark distribution

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

Evaluation shall only be based on application, analysis or design-based questions (forboth internal and end semester examinations).

Continuous Internal Assessment Pattern:

Continuous Internal Evaluation: 40 marks

| | |
|---|---|
| Preparing a review article based on peer reviewed Originalpublications (minimum 10 publications shall be referred) | 15 marks |
| Course based task/Seminar/Data collection and interpretation | 15 marks |
| Test paper, 1 no. (Test paper shall include minimum 80% of thesyllabus.) | 10 marks |
| TOTAL | 40 marks |

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students).

Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overallachievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note:The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if theaverage end semester mark % for a core course is 40, then the maximum eligiblemark % for an elective course is 40+20 = 60 %.

| | Topics | |
|---|---|---|
| 1 | Module 1 (8 Hours)<br><br>Introduction to embedded system design:Complexsystems and microprocessors– Embedded system design process – Design example: Model train controller- Design methodologies- Design flows – Requirement Analysis –Specifications-System analysis and architecture design – Quality Assurance techniques - Designing with computing platforms – consumer electronicsarchitecture – platform-level performance analysis. | 9 |
| 2 | Module 2 (8 Hours)<br><br>ARM processor and peripherals:ARM Architecture Versions – ARM Architecture –Instruction Set – Stacks and Subroutines – Features of the LPC 214X Family –Peripherals – The Timer Unit – Pulse Width Modulation Unit – UART – BlockDiagram of ARM9 and ARM Cortex M3 MCU. | 9 |

| | | |
|---|---|---|
| 3 | Module 3 (8 Hours)<br><br>Embedded programming:Components for embedded programs- Models of programs- Assembly, linking and loading – compilation techniques- Program levelperformance analysis – Software performance optimization – Program levelenergyand power analysis and optimization – Analysis and optimization of program size-Program validation and testing. | 9 |
| 4 | Module 4 (8 Hours)<br><br>Real time systems: Structure of a Real Time System — Estimating program run times – Task Assignment and Scheduling – Fault Tolerance Techniques – Reliability,Evaluation – Clock Synchronisation. | 8 |
| 5 | Processes and operating systems: Introduction – Multiple tasks and multiple processes – Multirate systems- Pre-emptive real time operating systems- Priority based scheduling- Inter process communication mechanisms – Evaluating operating system performance- power optimization strategies for processes – Example Real time operating systems-POSIX-Windows CE. – Distributed embedded systems – MPSoCs and shared memory multiprocessors. – Design Example – Audio player, Engine control unit – Video accelerator. | 9 |

Course Plan

| Sl. No | Topic | No. of Lectures |
|---|---|---|
| 1 | Introduction to embedded system design | |
| 1.1 | Complex systems and micro processors | 1 |
| 1.2 | Embedded system design process –Design example: Model train controller- Design methodologies- Design flows – Requirement Analysis – Specifications- System analysis and architecture design – Quality Assurance techniques | 5 |
| 1.3 | Designing with computing platforms – consumer electronics architecture –platform-level performance analysis | 2 |
| 2 | ARM processor and peripherals | |
| 2.1 | ARM Architecture Versions – ARM Architecture - Instruction Set – Stacks and Subroutines | 4 |
| 2.2 | Features of the LPC 214X Family – Peripherals – The Timer Unit – Pulse Width Modulation Unit – UART | 2 |
| 2.3 | Block Diagram of ARM9 and ARM Cortex M3 MCU. | 2 |
| 3 | Embedded programming | |
| 3.1 | Components for embedded programs- Models of programs- Assembly, linking and loading – compilation techniques | 3 |
| 3.2 | Program level performance analysis – Software performance optimization – Program level energy and power analysis and optimization | 2 |
| 3.3 | Analysis and optimization of program size- Program validation and testing | 3 |
| 4 | Real time systems | |
| 4.1 | Structure of a Real Time System | 1 |

| | | |
|---|---|---|
| 4.2 | Estimating program run times – Task Assignment and Scheduling | 3 |
| 4.3 | Fault Tolerance Techniques – Reliability, Evaluation | 2 |
| 4.4 | Clock Synchronisation. | 2 |
| 5Processes and operating systems | | |
| 5.1 | Multiple tasks and multiple processes – Multirate systems- Pre-emptive real time operating systems | 1 |
| 5.2 | Priority based scheduling- Inter process communication mechanisms | 1 |
| 5.3 | Evaluating operating system performance- power optimization strategies for processes | 2 |
| 5.4 | Example Real time operating systems-POSIX-Windows CE | 1 |
| 5.5 | Distributed embedded systems – MPSoCs and shared memory multiprocessors. | 1 |
| 5.6 | Design Example – Audio player, Engine control unit – Video accelerator. | 2 |

1. Marilyn Wolf (2012): "Computers as Components - Principles of Embedded Computing System Design", 3rd Edition: Morgan Kaufmann Publisher (Animprint from Elsevier).
2. Simon David. E (2007): "An Embedded Software Primer", 1st Edition,FifthImpression: Addison Wesley Professional.
3. Prasad K.V.K.K. (2005): "Embedded Real-Time Systems: Concepts, Design&Programming", Dream Tech Press.

Reference Books

1. Lyla B.Das (2013): "Embedded Systems: An Integrated Approach",PearsonEducation.
2. Valvano Jonathan W (2012): "Embedded Microcomputer Systems RealTimeInterfacing", 3rd Edition: Cengage Learning.
3. Buhr Raymond J.A., Bailey Donald L (1999): "An Introduction to Real-TimeSystems- From Design to Networking with C/C++", Prentice Hall.
4. Krishna C.M., Shin Kang G. (1997): "Real-Time Systems", InternationalEditions, Noida: Mc Graw Hill.
5. Iyer Sriram V, Gupta Pankaj (2004): "Embedded Real

# INTERDISCIPLINARY ELECTIVE

| Code | Course name | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 24PAAUET215 | Automotive Electronics | Interdisciplinary Elective | 3 | 0 | 0 | 3 |

**Preamble:** This purpose of this course is to provide an awareness of Automotive Electronics. As an outcome of the course the students will be aware of the technical details of Electronics Engineering in Automotive industry, the current trends and challenges.

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO1 | understand the fundamentals of vehicle electronic systems and integration of electronic components in vehicle system architecture. | U |
| CO2 | explain the various communication technologies on board vehicles. | A |
| CO3 | explain the working of various control algorithms implemented in vehicles for the purpose of automation. | A |
| CO4 | apply the knowledge of electronics for safety and security in vehicle automation. | A |
| CO5 | understand the emerging trends in automotive electronics. | U |

**Mapping of course outcomes with program outcomes**

| CO'S | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| CO 1 | 2 | 1 | 1 | 1 | 1 | 2 | |
| CO 2 | 2 | 1 | 1 | 1 | 1 | 2 | |
| CO 3 | 2 | 1 | 1 | 1 | 1 | 2 | |
| CO 4 | 2 | 1 | 1 | 1 | 1 | 2 | |
| CO 5 | 2 | 1 | 1 | 1 | 1 | 2 | |

1-Low; 2-Medium; 3- Strong

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 10 |
| Apply | 30 |
| Analyze | 20 |

**Mark Distribution**:

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment (CIA) Pattern:**

Preparing a review article based on peer-reviewed original publications (minimum10 publications shall be referred): 15 marks
Course-based task/Seminar/Data collection and interpretation: 15marks (Group projects not permitted)
Test paper, 1 No.: 10 marks
Test paper shall include a minimum of 80% of the syllabus.

**End Semester Examination (ESE) Pattern:**

1. End Semester Examination: 60 marks
2. The question paper will have Part A and Part B.
3. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions.
4. Part B will contain 7 questions with a minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Syllabus**

| Module | Description | Contact Hours |
|---|---|---|
| 1 | **Module 1: Introduction to Automotive Electronics** Overview of vehicle electronic systems, Integration of electronic components and systems in vehicles, Vehicle System Architecture – Sensors – Actuators – Embedded processors and micro-controllers, Introduction to Electronic Instrumentation for sensors: temperature, distance, velocity, speedometer, anti-collision. limitations, topologies and processing for sensors, DA/AD converters, Interfacing ADC/DAC to peripherals and sensors | 9 |
| 2 | **Module 2: Automotive Communications Systems:** Introduction to communications standards, Introduction to networks, safety critical issues and reliability, Communication protocols for automotive applications, CAN-protocol layers, content based addressing, Hardware- basic CAN module, Basic block level working principle of LIN, MOST, Bluetooth & FlexRay, Telematics for automotive applications, GPRS, GPS in automotive environment | 9 |
| 3 | **Module 3: Automotive Control and Power Systems:** ECU – Electronic Engine Control, Electronic control methods (analog and digital), Stability algorithms for control-cruise control, traction control, Actuator limiting, wind-up and gain scheduling. Energy management strategies: regenerative braking, start-stop, torque boost, Sensing and control systems, Automotive Diagnostics- OBD – Onboard Diagnostics | 9 |
| 4 | **Module 4: Automotive Safety Systems and ADAS:** Introduction to safety systems, Passive system electronics: Airbag and sensors, Active systems electronics: Anti-lock braking system (ABS), Electronic Stability Program (ESP), Anti-slip regulation (ASR), Driver Assistance Systems**:** Advanced active systems electronics: ACC , Active safety system applications: lane detection, blind spot, crash avoidance control electronics, Basics of ADAS, Power Steering, Automatic climate control. | 9 |
| 5 | **Module 5: Advancements in automotive electronics:** Introduction to Autonomous driving-system architecture overview, Navigation systems – VANET, vision intelligence, computational intelligence, smart traffic systems, | 9 |

| | | |
|---|---|---|
| | security, EV- classification, benefits and challenges, Basic concepts and challenges of Hybrid vehicles, fuel cell powered vehicles. | |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Module I** | |
| 1.1 | Overview of vehicle electronic systems, Integration of electronic components and systems in vehicles, Vehicle System Architecture | 2 |
| 1.2 | Sensors – Actuators – Embedded processors and micro-controllers | 2 |
| 1.3 | Introduction to Electronic Instrumentation for sensors: temperature, distance, velocity, speedometer, anti-collision. | 2 |
| 1.4 | limitations, topologies and processing for sensors | 2 |
| 1.5 | DA/AD converters, Interfacing ADC/DAC to peripherals and sensors | 1 |
| 2 | **Module II** | |
| 2.1 | Introduction to communications standards, Introduction to networks, safety critical issues and reliability | 2 |
| 2.2 | Communication protocols for automotive applications, | 3 |
| 2.3 | CAN- protocol layers, content-based addressing, Hardware- basic CAN module, | 2 |
| 2.4 | Basic block level working principle of LIN, MOST, Bluetooth & Flex Ray | 1 |
| 2.5 | Telematics for automotive applications, GPRS, GPS in automotive environment | 1 |
| 3 | **Module III** | |
| 3.1 | ECU – Electronic Engine Control, Electronic control methods (analog and digital), | 1 |
| 3.2 | Stability algorithms for control-cruise control, traction control | 2 |
| 3.3 | Actuator limiting, wind-up and gain scheduling. | 2 |
| 3.4 | Energy management strategies: regenerative braking, start-stop, torque boost, | 3 |
| 3.5 | Sensing and control systems, Automotive Diagnostics- OBD – Onboard diagnostics | 1 |
| 4 | **Module IV** | |
| 4.1 | Introduction to safety systems, Passive system electronics: Airbag and sensors, | 3 |
| 4.2 | Active systems electronics: Anti lock braking system (ABS), Electronic Stability Program (ESP), | 3 |
| 4.3 | Anti-slip regulation (ASR), Driver Assistance Systems: Advanced active systems electronics: ACC | 1 |
| 4.4 | Active safety system applications: lane detection, blind spot, crash avoidance control electronics | 1 |
| 4.5 | Basics of ADAS, Power Steering, Automatic climate control | 1 |
| 5 | **Module V** | |
| 5.1 | Introduction to Autonomous driving-system architecture overview, | 3 |
| 5.2 | Navigation systems –VANET, vision intelligence, | 2 |

| | | |
|---|---|---|
| 5.3 | computational intelligence, smart traffic systems, security, | 2 |
| 5.4 | EV- classification, benefits and challenges, Basic concepts and challenges of Hybrid vehicles, fuel cell powered vehicles. | 2 |

**Text Books**

1. William B.Ribbens, "Understanding Automotive Electronics", 6thEdition, Elsevier Publishing.
2. Robert Bosch Gmbh (Ed.) Bosch Automotive Electrics and Automotive Electronics
3. Systems and Components, Networking and Hybrid Drive, 5th edition, Springer Vieweg, John Wiley Sons.

**Reference Books**

1. Hybrid & Electric Vehicles -A CRC Press FREEBOOK
2. Creating Autonomous Vehicle Systems -SYNTHESIS LECTURES ON COMPUTER SCIENCE MORGAN & CLAYPOOL PUBLISHERS
3. A Progressive Review: Emerging Technologies for ADAS Driven Solutions- Jaswanth Nidamanuri , Chinmayi Nibhanupudi, Rolf Assfalg, and Hrishikesh Venkataraman, IEEE TRANSACTIONS ON INTELLIGENT VEHICLES, VOL. 7, NO. 2, JUNE 2022
4. Hillier's Fundamentals of Motor Vehicle Technology5th Edition Book 3,V.A.W. Hillier & David R. Rogers

| Code | Course name | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 24PAMAST225 | MEMS and SENSORS | Interdisciplinary Elective | 3 | 0 | 0 | 3 |

**Preamble: Nil**

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO1 | Identify structural and sacrificial materials for MEMS | U |
| CO2 | explain the fabrication steps in designing of various MEMS devices. | A |
| CO3 | apply principles for the design of Sensor and actuators | A |
| CO4 | apply MEMS for different applications in various fields of engineering | A |
| CO 5 | Understand the various advancement in the field of MEMS | U |

**Mapping of course outcomes with program outcomes**

| CO'S | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| CO 1 | 2 | 1 | 1 | 1 | 1 | 2 | |
| CO 2 | 2 | 1 | 1 | 1 | 1 | 2 | |
| CO 3 | 2 | 1 | 1 | 1 | 1 | 2 | |
| CO 4 | 2 | 1 | 1 | 1 | 1 | 2 | |
| CO 5 | 2 | 1 | 1 | 1 | 1 | 1 | |

1-Low; 2-Medium; 3- Strong

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 10 |
| Apply | 30 |
| Analyze | 20 |

**Mark Distribution**:

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment (CIA) Pattern:**

Preparing a review article based on peer-reviewed original publications (minimum10 publications shall be referred): 15 marks
Course-based task/Seminar/Data collection and interpretation: 15marks (Group projects not permitted)
Test paper, 1 No.: 10 marks
Test paper shall include a minimum of 80% of the syllabus.

**End Semester Examination (ESE) Pattern:**

1. End Semester Examination: 60 marks
2. The question paper will have Part A and Part B.
3. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions.
4. Part B will contain 7 questions with a minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Syllabus**

| Module | Description | Contact Hours |
|---|---|---|
| 1 | **Module I Introduction:** Introduction to MEMS and Microsystems, MEMS Classification, MEMS versus Microelectronics, Applications of MEMS in Various Industries, Some Examples of Microsensors, Micro actuators, and Microsystems, Materials for MEMS, Laws of Scaling in miniaturization | 9 |
| 2 | **Module II MEMS Fabrication:** Structure of Silicon, Single Crystal Growth Techniques, Photolithography, Oxidation, Diffusion, Ion Implantation, Physical Vapor Deposition, Chemical Vapor Deposition, Bulk Micromachining: Overview of Etching, Isotropic and Anisotropic Etching, Wet Etchants, Etch Stop Techniques, Dry Etching, Surface Micromachining, LIGA, SLIGA, Wafer Bonding, Electroplating | 9 |
| 3 | **Module III Microsensors and Micro actuators:** Basic Modeling Elements in Mechanical, Electrical and Thermal Systems, Types of Beams: Cantilevers, Bridges, Fixed- Guided beams, Electrostatic sensing and Actuation: Parallel plate capacitor, Applications of parallel plate capacitors: Inertial sensor, Pressure sensor, Flow sensor, Parallel plate Actuators, Piezoresistive Sensors: Origin and Expressions of Piezo resistivity, Piezoresistive Sensor Materials, Applications of Piezoresistive Sensors, Piezoelectric Sensing and Actuation, Thermal Sensing and Actuation: Sensors and Actuators based on Thermal Expansion, Thermocouples, Thermo resistors, Shape Memory Alloy, Applications: Inertial sensors, Flow sensors, Infrared sensors | 9 |
| 4 | **Module IV Layout, Simulation Tools, Packaging and Characterization techniques**: Introduction of layout, Simulation Tools, General considerations in Packaging , Bonding techniques for MEMS and Various Characterization Techniques for MEMS Devices | 9 |
| 5 | **Module V Advances in MEMS:** RF-MEMS: MEMS devices for RF Applications: RF MEMS Switches and their applications, High-Q Capacitors and Inductors and Their Applications in RF Circuits, Overview of Optical MEMS , Chemical-Bio MEMS and Nanoelectromechanical Systems | 9 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Module I** | |
| 1.1 | Introduction to MEMS and Microsystems, MEMS Classification, MEMS versus Microelectronics, | 2 |
| 1.2 | Applications of MEMS in Various Industries, Some Examples of Microsensors, Micro actuators, and Microsystems | 3 |
| 1.3 | Materials for MEMS, | 2 |
| 1.4 | Laws of Scaling in miniaturization | 2 |
| 2 | **Module II** | |
| 2.1 | Structure of Silicon, Single Crystal Growth Techniques, Photolithography, Oxidation | 2 |
| 2.2 | Diffusion, Ion Implantation, Physical Vapor Deposition, Chemical Vapor Deposition, | 2 |
| 2.3 | Bulk Micromachining: Overview of Etching, Isotropic and Anisotropic Etching, | 2 |
| 2.4 | Wet Etchants, Etch Stop Techniques, Dry Etching, Surface Micromachining LIGA, SLIGA, Wafer Bonding, Electroplating | 3 |
| 3 | **Module III** | |
| 3.1 | Microsensors and Micro actuators: Basic Modeling Elements in Mechanical, Electrical and Thermal Systems | 1 |
| 3.2 | Types of Beams: Fixed-Free (Cantilevers), Fixed-Fixed (Bridges), Fixed-Guided beams, | 2 |
| 3.3 | Electrostatic sensing and Actuation: Parallel plate capacitor, Applications of parallel plate capacitors: Inertial sensor, Pressure sensor, Flow sensor, Parallel plate Actuators, | 2 |
| 3.4 | Piezoresistive Sensors: Origin and Expressions of Piezo resistivity, Piezoresistive Sensor Materials, | 2 |
| 3.5 | Applications of Piezoresistive Sensors, Piezoelectric Sensing and Actuation, Thermal Sensing and Actuation: Sensors and Actuators based on Thermal Expansion, | 1 |
| 3.6 | Thermocouples, Thermo resistors, Shape Memory Alloy, Applications: Inertial sensors, Flow sensors, Infrared sensors | 1 |
| 4 | **Module IV** | |
| 4.1 | Introduction of layout, Simulation Tools, | 3 |
| 4.2 | General considerations in Packaging and bonding techniques in MEMS | 3 |
| 4.3 | Various Characterization Techniques for MEMS Devices | 3 |
| 5 | **Module V** | |
| 5.1 | Advances in MEMS: RF-MEMS: MEMS devices for RF Applications: | 3 |
| 5.2 | RF MEMS Switches and their applications, | 3 |
| 5.3 | High-Q Capacitors and Inductors and Their Applications in RF Circuits, Overview of Optical MEMS , Chemical-Bio MEMS and Nanoelectromechanical | 3 |

| | | |
|---|---|---|
| | Systems | |

**Text Books**

1. MEMS and Microsystems design and manufacture by Tai-Ran Hsu, Tata McGraw Hill.
2. MEMS by N. P. Mahalik, Tata McGraw Hill.
3. Foundations of MEMS by Chang Liu, Pearson Prentice Hall.

**Reference Books**

1. Sensors and Transducers by M. J. Usher, McMillian Hampshire.
2. Analysis and Design Principles of MEMS Devices by Minhang Bao, Elsevier.
3. Fundamentals of Microfabrication by M. Madou, CRC Press.
4. Microsensors by R.S. Muller, Howe, Senturia and Smith, IEEE Press.
5. Semiconductor Sensors by S. M. Sze, Willy Inderscience Publications.

| Code | Course name | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 24PANMDT235 | Nano materials for Drug Delivery | Interdisciplinary Elective | 3 | 0 | 0 | 3 |

**Preamble:** To inspire the students with interest to investigate role of new nanomaterials and devices drug delivery.

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO1 | understand the concepts of nano materials for drug delivery | U |
| CO2 | explain the use of nano materials for drug delivery | A |
| CO3 | explain the use of nanodevices for drug targeting | A |
| CO4 | explain the various drug delivery methods | A |
| CO 5 | Explain the various Active and passive nanocarriers | A |

**Mapping of course outcomes with program outcomes**

| CO'S | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| CO 1 | | | 3 | | | | |
| CO 2 | | | 3 | | | | |
| CO 3 | | | 3 | | | | |
| CO 4 | | | 3 | | | | |
| CO 5 | | | 3 | | | | |

1-Low; 2-Medium; 3- Strong

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 10 |
| Apply | 30 |
| Analyze | 20 |

**Mark Distribution**:

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment (CIA) Pattern:**

Preparing a review article based on peer-reviewed original publications (minimum10 publications shall be referred): 15 marks
Course-based task/Seminar/Data collection and interpretation: 15marks (Group projects not permitted)
Test paper, 1 No.: 10 marks
Test paper shall include a minimum of 80% of the syllabus.

**End Semester Examination (ESE) Pattern:**

1. End Semester Examination: 60 marks
2. The question paper will have Part A and Part B.
3. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions.
4. Part B will contain 7 questions with a minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Syllabus**

| Module | Description | Contact Hours |
|---|---|---|
| 1 | **Module I Nanomedicines:** Basic concepts in the design, specification and desired features of nanomedicine and general process steps involved in their preparation Nanomedicines for various disease conditions: infectious diseases, neurological diseases, pulmonary disorders, cardiovascular diseases, cancer: nano-chemotherapy, - radiation therapy, - immunotherapy, -nuclear medicine therapy, -photodynamic therapy, - photothermal and RF hyperthermia therapy, scintillation therapy, gene-therapy: DNA, RNA delivery. Theranostic nanomedicines: Basic concept, multifunctional nanomedicines for theranosis | 9 |
| 2 | **Module II Drug Delivery Systems:** AdministrationRoutes: Oral Drug Delivery, Features of Gastrointestinal tract (GI), Targeting of drugs in the GI tract. Design and fabrication of oral systems - Dissolution controlled, diffusion controlled, osmotic controlled, chemically controlled release, Intravenous Drug Delivery - Factors controlling pharmacokinetics of IV formulations, Concept of opsonization | 9 |
| 3 | **Module III Drug Delivery Devices:** Transdermal Drug Delivery, Structure of human skin and theoretical advantages of the transdermal route, Transdermal penetration of drugs, adhesion, bioactivity. Intranasal Drug Delivery - Nasal physiology and intranasal. Drug Administration, Nasal drug delivery devices, Ocular Drug Delivery devices; Miscellaneous Drug Delivery | 9 |
| 4 | **Module IV Advanced Drug Delivery:** Concept of Drug Targeting; Prodrug and Bioconjugation; Nanoscale Drug Delivery Systems - Advantages of nanodrug delivery – Improvements in pharmacokinetics, bioavailability, biodistribution; Concepts of controlled and sustained drug delivery, How nanoparticles pass barriers; Surface modification of nanoparticulate carriers. Nanocarriers for drug delivery - Lipid based pharmaceutical nanoparticles – Liposomes, Solid Lipid Nanoparticles, Nanostructured Lipid Carriers, Cubosomes and Hexosomes, | 9 |

| | | |
|---|---|---|
| | Polymeric Micelles, DNA- Based Nanomaterials, Dendrimers, Polymeric nanoparticles, Inorganic nanoparticles, Hydrogels for controlled drug delivery. | |
| 5 | **Module V Active and passive nanocarriers:** Concept of targeting, Site Specific Drug delivery utilizing Monoclonal Antibodies, Peptides, Other Biomolecules, Stimuli- Responsive Target Strategies; Implants; Protein and Peptide Drug Delivery; Delivery of Nucleic Acids Delivery of Vaccines; Aptamers in Advanced Drug Delivery; Biomimetic Self-Assembling Nanoparticles Nanotechnology Challenges; Regulatory Considerations and Clinical Issues in Advanced Drug Delivery | 9 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Module I** | |
| 1.1 | Basic concepts in the design, specification and desired features of nanomedicine and general process steps involved in their preparation | 2 |
| 1.2 | Nanomedicines for various disease conditions: infectious diseases, neurological diseases, pulmonary disorders, cardiovascular diseases | 2 |
| 1.3 | cancer: nano-chemotherapy, - radiation therapy, - immunotherapy, -nuclear medicine therapy | 2 |
| 1.4 | photodynamic therapy, - photothermal and RF hyperthermia therapy, scintillation therapy, gene-therapy: DNA, RNA delivery. | 2 |
| 1.5 | Theranostic nanomedicines: Basic concept, multifunctional nanomedicines for theranosis | 1 |
| 2 | **Module II** | |
| 2.1 | Administration Routes: Oral Drug Delivery, Features of Gastrointestinal tract (GI), Targeting of drugs in the GI tract. | 2 |
| 2.2 | Design and fabrication of oral systems - Dissolution controlled, diffusion controlled, | 2 |
| 2.3 | osmotic controlled, chemically controlled release, Intravenous Drug Delivery | 2 |
| 2.4 | Factors controlling pharmacokinetics of IV formulations, Concept of opsonization | 3 |
| 3 | **Module III** | |
| 3.1 | Transdermal Drug Delivery, Structure of human skin and theoretical advantages of the transdermal route | 1 |
| 3.2 | Transdermal penetration of drugs, adhesion, bioactivity. Intranasal Drug Delivery | 2 |
| 3.3 | Nasal physiology and intranasal. Drug Administration | 2 |
| 3.4 | Nasal drug delivery devices, Ocular Drug Delivery devices | 2 |
| 3.5 | Miscellaneous Drug Delivery | 1 |
| 4 | **Module IV** | |
| 4.1 | Concept of Drug Targeting; Prodrug and Bioconjugation; Nanoscale Drug Delivery Systems - Advantages of nanodrug delivery | 2 |

| | | |
|---|---|---|
| 4.2 | Improvements in pharmacokinetics, bioavailability, biodistribution; Concepts of controlled and sustained drug delivery | 2 |
| 4.3 | How nanoparticles pass barriers; Surface modification of nanoparticulate carriers. Nanocarriers for drug delivery - Lipid based pharmaceutical nanoparticles | 2 |
| 4.4 | Liposomes, Solid Lipid Nanoparticles, Nanostructured Lipid Carriers, Cubosomes and Hexosomes, Polymeric Micelles | 1 |
| 4.5 | DNA- Based Nanomaterials, Dendrimers, Polymeric nanoparticles, Inorganic nanoparticles, Hydrogels for controlled drug delivery. | 2 |
| 5 | **Module V** | |
| 5.1 | Concept of targeting, Site Specific Drug delivery utilizing Monoclonal Antibodies, Peptides, Other Biomolecules | 1 |
| 5.2 | Stimuli- Responsive Target Strategies; Implants; Protein and Peptide Drug Delivery; | 2 |
| 5.3 | Delivery of Nucleic Acids Delivery of Vaccines; Aptamers in Advanced Drug Delivery; | 3 |
| 5.4 | Biomimetic Self-Assembling Nanoparticles Nanotechnology Challenges; Regulatory Considerations and Clinical Issues in Advanced Drug Delivery | 3 |

**Text Books**

1. Drug Delivery Systems, Pieter Stroeve and MortezaMahmoudi, World Scientific Series: From
2. Biomaterials towards Medical Devices, Vol I, 2018.
3. Nanoparticulates as Drug Carriers, Vladimir Torchillin, Imperial College Press, 2006
4. Drug Delivery Systems, Third Edition, Vasant V Ranade, John B. Cannon, by CRC Press, 2011

# SEMESTER-III

## MOOC COURSES

The MOOC course shall be considered only if it is conducted by the agencies namely AICTE/NPTEL/SWAYAM or NITTTR. The MOOC course should have a minimum duration of 8 weeks and the content of the syllabus shall be enough for at least 40 hours of teaching. The course should have a proctored/offline end semesterexamination. The students can do the MOOC according to their convenience, but shall complete it by third semester. The list of MOOC courses will be provided by theconcerned BoS if at least 70% of the course content match with the area/stream of study. The course shall not be considered if its content has more than 50% of overlapwith a core/elective course in the concerned discipline or with an open elective.

MOOC Course to be successfully completed before the commencement of fourthsemester (starting from semester 1). A credit of 2 will be awarded to all students whoever successfully completes the MOOC course as per the evaluation pattern of the respective agency conducting the MOOC.

| Code | Course name | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 24PAAUCT301 | Academic Writing | Audit Course | 3 | 0 | 0 | 0 |

**Preamble:** Learning academic writing sharpens minds, teaches students how to communicate, and develops their thinking capacities and ability to understand others. Writing is thinking, and every student deserves to be a strong thinker. It can also make them think more carefully about what they write. Showing work to others can help to foster a better culture of learning and sharing among students. It also gives students a sense of how they are contributing to the body of work that makes up an academic subject.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs.After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO1 | understand the principles of scientific/ academic writing. | U |
| CO2 | analyze the technique of scientific writing from the reader's perspective. | An |
| CO3 | apply the concepts of setting expectations and laying the progression tracks. | A |
| CO4 | understand the merits of a title, abstract, introduction, conclusion and structuring of a research paper. | U |
| CO5 | justify the need using a project proposal or a technical report. | A |

**Mapping of course outcomes with program outcomes**

| CO'S | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| CO 1 | | 3 | 1 | | | | |
| CO 2 | | 3 | 1 | | | | |
| CO 3 | | 3 | 1 | | | 2 | |
| CO 4 | | 3 | 1 | | | | |
| CO 5 | | 3 | 2 | 2 | | 2 | |

1-Low; 2-Medium; 3- Strong

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 30 |
| Analyze | 20 |
| Evaluate | 10 |

**Mark Distribution**:

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment (CIA) Pattern:**

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination (ESE) Pattern:**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Vive. Each question can carry 12 marks.

**Syllabus**

| Module | Description | Contact Hours |
|---|---|---|
| 1 | **Module I Fundamentals of Academic writing from a reader's perspective:** acronyms, synonyms, pronouns, disconnected phrases, background ghettos, abusive detailing, cryptic captions, long sentences : all that take their toll on readers' memory. | 6 |
| 2 | **Fluid reading & reading energy consumption:** setting expectations and laying Progression tracks; Reading energy consumption | 6 |
| 3 | **How to write**: the Title, abstract, introduction; Structure the writing with headings & subheadings | 6 |
| 4 | **Visuals:** Resources, Skills, and Methods; Conclusion; References; Bibliography; Grammar in technical writing | 6 |
| 5 | **Techniques of writing:** An extended abstract, a project proposal, a research paper, a technical report. | 6 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Module I** | |
| 1.1 | The Reading tool-kit to reduce memory required; reduce reading time | 2 |
| 1.2 | Acronyms, Pronouns, Synonyms; Background, broken couple, words overflow | 2 |
| 1.3 | Sustain attention: Keep the story moving forward; Twists, shouts, pause to clarify, recreate suspense | 2 |
| 1.4 | Keep the reader motivated: Fuel and meet Expectations; Bridge knowledge gap: ground level; Title words; Just In Time to local background | 1 |
| 2 | **Module II** | |
| 2.1 | Setting expectations of the reader from Grammar, from theme | 2 |
| 2.2 | Progression tracks for fluid reading: Topic & stress; topic and non topic based progression tracks; pause in progression | 2 |
| 2.3 | Detection of sentence fluidity problems: No expectations/ Betrayed expectations | 2 |
| 2.4 | Controlling reading energy consumption: the energy bill; Energy fuelling stations: Pause | 1 |
| 3 | **Module III** | |
| 3.1 | Title: Face of the paper: Techniques, Qualities & Purpose of title; Metrics | 2 |
| 3.2 | Abstract: Heart of the paper: 4 parts; coherence; tense of verbs, precision; purpose & qualities of the abstract; Metrics | 2 |
| 3.3 | Structure: Headings & sub-headings: Skeleton of the paper: principles for a good structure; Syntactic rules; Quality & Purpose of structures; Metrics | 3 |
| 3.4 | Introduction: Hands of the paper: Start, finish; scope, definitions; answers key reader questions; As a personal active story; Traps, qualities; Metrics | 2 |
| 4 | **Module IV** | |
| 4.1 | Visuals as the voice of your paper: principles; purpose & qualities of visuals; metrics | 2 |
| 4.2 | Conclusion: contents; purpose, quality; metrics; Abstracts Vs. Conclusion; examples, counter-examples | 2 |
| 4.3 | References, Bibliography: Styles, punctuation marks, quotes, citations | 2 |
| 4.4 | Grammar in Technical writing: Articles, Syntax, Main and subordinate clauses; Active & passive voices; some commonly made mistakes in technical writing. | 3 |
| 5 | **Module V** | |
| 5.1 | Extended abstract: abstract and keywords, introduction and objective, method, findings and argument, conclusion and suggestions and references. | 3 |
| 5.2 | Project Proposal:Types, executive summary, background including status, objectives, solution, milestones, deliverables, timelines, resources, budgeting, conclusion | 2 |

| | | |
|---|---|---|
| 5.3 | Research paper: writing an overview article: provide a comprehensive foundation on a topic; explain the current state of knowledge; identify gaps in existing studies for potential future research; highlight the main methodologies and research techniques | 2 |
| 5.4 | Writing Technical Reports: Title page; Summary; Table of contents; Introduction; Body; Figures, tables, equations and formulae; Conclusion; Recommendations. | 2 |

**Reference Books**

1. SCIENTIFIC WRITING 2.0 A Reader and Writer's Guide: Jean-Luc Lebrun, World ScientiVic Publishing Co. Pte. Ltd., 2011
2. How to Write and Publish a ScientiVic Paper: Barbara Gastel and Robert A. Day, Greenwood publishers, 2016
3. Grammar, Punctuation, and Capitalisation; a handbook for technical writers and editors. www.sti.nasa.gov/publish/sp7084.pdf www.sti.nasa.gov/sp7084/contents.html
4. Everything You Wanted to Know About Making Tables and Figures. http://abacus.bates.edu/%7Eganderso/biology/resources/writing/HTWtableVigs.html

| Code | Course name | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 24PAAUCT301 | Academic Writing | Audit Course | 3 | 0 | 0 | 0 |

**Preamble:** This course is designed in a way to provide a general view on typically used advanced classes of engineering materials including metals, polymers, ceramics, and composites.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs.After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO1 | Analyse the requirement and find appropriate solution for use of materials. | An |
| CO2 | Differentiate the properties of polymers, ceramics and composite materials. | U |
| CO3 | Understand the basic concepts and properties of functional materials. | U |
| CO4 | Explain smart and shape memory materials for various applications. | A |
| CO5 | Explain materials used for high temperature, energy production and storage applications. | A |

**Mapping of course outcomes with program outcomes**

| CO'S | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| CO 1 | 2 | | | | 2 | 2 | |
| CO 2 | 2 | | | | 2 | 2 | |
| CO 3 | 2 | | | | 2 | 2 | |
| CO 4 | 2 | | | | 2 | 2 | |
| CO 5 | 2 | | | | 2 | 2 | |

1-Low; 2-Medium; 3- Strong

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 10 |
| Apply | 30 |
| Analyze | 20 |

**Mark Distribution**:

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment (C I A) Pattern:**

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination (ESE) Pattern:**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Vive. Each question can carry 12 marks.

**Syllabus**

| Module | Description | Contact Hours |
|---|---|---|
| 1 | Requirements / needs of advanced materials. Classification of materials, Importance of materials selection, Criteria for selection of materials; motivation for selection, cost basis and service requirements. Relationship between materials selection and processing. | 6 |
| 2 | Classification of non-metallic materials. Polymer, Ceramics: Properties, processing and applications. Nano Composites - Polymer nanocomposites (PNCs), Processing and characterization techniques – properties and potential applications. | 6 |
| 3 | Functionally graded materials (FGMs), Potential Applications of FGMs, classification of FGMs, processing techniques. limitations of FGMs | 6 |
| 4 | Smart Materials: Introduction, smart material types – pyro electric sensors, piezoelectric materials, electro strictors and magneto strictors, shape memory alloys – associated energy stimulus and response forms, applications. | 6 |
| 5 | High Temperature Materials: super alloys – main classes, high temperature properties of superalloys, applications. Energy Materials: materials for batteries. | 6 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Module I** | |
| 1.1 | Benefits of advanced materials, classification of materials, importance of materials selection | 1 |
| 1.2 | Selection of materials for different properties, strength, toughness, fatigue and creep | 1 |
| 1.3 | Selection for surface durability, corrosion and wear resistance | 2 |
| 1.4 | Relationship between materials selection and processing | 2 |
| 2 | **Module II** | |
| 2.1 | Rubber: properties, processing and applications. | 1 |
| 2.2 | Plastics: thermosetting and thermoplastics, applications and properties. | 1 |
| 2.3 | Ceramics: properties and applications. | 2 |
| 2.4 | Introduction to nano composites, classification | 1 |
| 2.5 | Processing and characterization techniques applicable to polymer nanocomposites. | 1 |
| 3 | **Module III** | |
| 3.1 | General concept, Potential Applications of FGMs Classification of FGMs | 2 |
| 3.2 | FGMs processing techniques: powder metallurgy route, melt-processing route | 2 |
| 3.3 | Limitations of FGMs | 2 |
| 4 | **Module IV** | |
| 4.1 | Introduction to smart materials, types | 1 |
| 4.2 | Pyroelectric sensors-material class, stimulus, detection capabilities and uses | 2 |
| 4.3 | Piezoelectric materials- material class, stimulus, sensing and actuating applications | 1 |
| 4.4 | Electro strictors and magneto strictors - material class, stimulus, micro positioning capabilities and applications | 1 |
| 4.5 | Shape memory alloys (SMAs) - material class, stimulus, temperature sensing and high strain responses, applications | 1 |
| 5 | **Module V** | |
| 5.1 | Characteristics of high-temperature materials, superalloys as high-temperature materials super alloys - properties and applications | 2 |
| 5.2 | Introduction to lithium-ion battery (LIBs), operating mechanisms and applications | 2 |
| 5.3 | Introduction to Zn-based battery system, types and existing challenges | 2 |

**Reference Books**

1. DeGarmo et al, “Materials and Processes in Manufacturing”, 10th Edition, Wiley, 2008.
2. R.E. Smallman and A.H.W. Ngan, Physical Metallurgy and Advanced Materials, Seventh Edition, Butterworth-Heinemann, 2007
3. Vijayamohanan K. Pillai and Meera Parthasarathy, “Functional Materials: A chemist’s perspective”, Universities Press Hyderabad (2012).
4. M.V. Gandhi, B.S. Thompson: Smart Materials and Structures, Chapman & Hall, 1992.
5. G. W. Meetham and M. H. Van de Voorde, Materials for High Temperature Engineering Applications (Engineering Materials) Springer; 1 edition (May 19, 2000)
6. Inderjit Chopra, Jayant Sirohi, “Smart Structures Theory”, Cambridge University Press, 2013

| Code | Course name | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 24PAAUCT303 | Forensic Engineering | Audit Course | 3 | 0 | 0 | 0 |

**Preamble:** This course explores various aspects of Forensic Engineering and different methods , tools and procedures used by Engineers to investigate and analyze . The students will learn to develop their awareness in Forensic Engineering.

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO1 | Identify the fundamental aspects of forensic Engineering | U |
| CO2 | Apply forensic Engineering in Practical work flow and Investigation | A |
| CO3 | Apply methods and analysis in Forensic Investigation | A |
| CO4 | Develop practical strategies and standards of Investigation | A |
| CO5 | Understand the awareness in criminal cases and create Engineering expertise in court room on forensic Engineering | U |

**Mapping of course outcomes with program outcomes**

| CO'S | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| CO 1 | 2 | 2 | 3 | 3 | 3 | 3 | |
| CO 2 | 2 | 2 | 3 | 3 | 3 | 3 | 1 |
| CO 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| CO 4 | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| CO 5 | 3 | 3 | 3 | 3 | 3 | 3 | |

1-Low; 2-Medium; 3- Strong

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 20 |
| Apply | 40 |

**Mark Distribution**:

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment (C I A) Pattern:**

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination (ESE) Pattern:**
The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Viva. Each question can carry 12 marks.

**Syllabus**

| Module | Description | Contact Hours |
|---|---|---|
| 1 | **Module 01: Introduction to Forensic Engineering:** Forensic Engineering-Definition, Investigation Pyramid, Eyewitness, Information, Role in Legal System, Scientific Method-Applying scientific methods in Forensic Engineering-Engineer as expert Witness-Scientific methods and legal system, Qualification of Forensic Engineer-Technical- Knowledge- Oral-written- Communication- other skills-Personality Characteristics, Ethics and professional responsibilities. | 6 |
| 2 | **Module 2: Forensic Engineering Workflow and Investigation Methods:** Forensic Engineering Workflow-Team &planning-preliminary onsite investigation. Sampling-selection of sample-collection- packing-sealing of samples. Source and type of evidence - Paper documentation- digital documentation-electronic data. Physical Evidence-Collection of photograph-cataloguing -Recognizing the Evidence-organizing- Evidence Analysis - Reporting. Investigation Methods- Cause and Causal mechanism analysis-Time and event sequence-STEP method. Human Factors, Human errors - Analysis of Operative Instruction and working Procedures | 6 |
| 3 | **Module 03: Physical Product Failure & Analytical Methods:** Introduction to typical Forensic Engineering Tool box-NDT, Crack detection and human eye - Hardness testing- and Destructive testing Methods with case studies, Indirect stress strain Analysis-Brittle lacquer technique, Contact Radiography-Metallography-EDAX method, Forensic Optical Microscopy-Examination- Magnification-USB Microscopy -Wifi Enabled microscopy - Reflected microscopy, Novel Tools and System -Contour Method-Flash Thermography- Thermographic signal reconstruction (TSR)-Electromagnetically induced acoustic Emission (EMAE)-Pulsed Eddy Current (PEA)-Theory only | 6 |
| 4 | **Module 4: Cyber Forensic, Civil , Electrical Accidents & Standards:** Basics of Digital & Cyber forensics: Technical concepts; labs and tools; collecting evidence Operating System Forensic basics with - Windows, Linux -Mobile Forensic-Anti forensics-Malware- Web attack forensics with Email Crimes-Cyber Laws, Different types of Forensic accident investigations- Civil Engineering- Structural- Road accidents -Fire accidents - Water related accidents- Electrical accidents and Investigation methods, Protocol for forensic Investigations-Standard guides-scope significance - use -procedures- reports. | 6 |

| | | |
|---|---|---|
| | Standards – ASTM standards -FMV Standards - SAE Standards -Relevant Standards -NFPA Standards -International Standards | |
| 5 | **Module 5: Engineer in the Court room& Criminal Cases:** Role of an Engineering Expert-Report-pretrial meetings-Alternative dispute resolution-Single joint expert. Engineer in the court room Criminal Cases-Introduction-Counterfeit coins-fraudulent road accidents-Fraudulent Insurance claims. Cyber Crimes and Cases- SIM Swapping -ATM Cloning-Microsoft Internal Spam- Intellectual property cases. | 6 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Module I** | |
| 1.1 | Forensic Engineering-Definition, Investigation Pyramid, Eyewitness Information, Role in Legal System | 2 |
| 1.2 | Scientific Method-Applying scientific methods in Forensic Engineering-Engineer as expert Witness-Scientific methods and legal system | 2 |
| 1.3 | Qualification of Forensic Engineer-Technical- Knowledge- Oral-written-Communication- other skills-Personality Characteristics<br>Ethics and professional responsibilities. | 2 |
| 2 | **Module II** | |
| 2.1 | Forensic Engineering Workflow-Team &planning-preliminary onsite investigation. Sampling-selection of sample-collection- packing-sealing of samples. | 2 |
| 2.2 | Source and type of evidence - Paper documentation- digital documentation-electronic data. Physical Evidence-Collection of photograph-cataloguing -Recognizing the Evidence-organizing-Evidence Analysis -Reporting | 2 |
| 2.3 | Investigation Methods- Cause and Causal mechanism analysis-Time and event sequence-STEP method. Human Factors, Human errors - Analysis of Operative Instruction and working Procedures | 2 |
| 3 | **Module III** | |
| 3.1 | Introduction to typical Forensic Engineering Tool box-NDT, Crack detection and human eye -Hardness testing- and Destructive testing Methods with case studies | 1 |
| 3.2 | Indirect stress strain Analysis-Brittle lacquer technique, Contact Radiography-Metallography-EDAX method | 2 |
| 3.3 | Forensic Optical Microscopy-Examination- Magnification-USB Microscopy -Wi fi Enabled microscopy -Reflected microscopy | |
| 3.4 | Novel Tools and System -Contour Method-Flash Thermography-Thermographic signal reconstruction (TSR)-Electromagnetically induced acoustic Emission (EMAE)-Pulsed Eddy Current (PEA)-Theory only | |
| 4 | **Module IV** | |
| 4.1 | Basics of Digital & Cyber forensics: Technical concepts; labs and tools; collecting evidence Operating System Forensic basics with - Windows, Linux -Mobile Forensic-Anti forensics-Malware- Web attack forensics | 1 |

| | | |
|---|---|---|
| | with Email Crimes-Cyber Laws | |
| 4.2 | Different types of Forensic accident investigations- Civil Engineering-Structural- Road accidents -Fire accidents - Water related accidents-Electrical accidents and Investigation methods | 2 |
| 4.3 | Protocol for forensic Investigations-Standard guides-scope significance -use -procedures- reports. Standards – ASTM standards -FMV Standards -SAE Standards -Relevant Standards -NFPA Standards -International Standards | 1 |
| 5 | **Module V** | |
| 5.1 | Role of an Engineering Expert-Report-pre trial meetings-Alternative dispute resolution-Single joint expert. Engineer in the court room | 2 |
| 5.2 | Criminal Cases-Introduction-Counterfeit coins-fraudulent road accidents-Fraudulent Insurance claims | 2 |
| 5.3 | Cyber Crimes and Cases- SIM Swapping -ATM Cloning-Microsoft Internal Spam- Intellectual property cases. | 2 |

**Reference Books**

1. Colin R Gagg, *Forensic EngineeringThe Art &Craft of a failure detective* , Taylor & Francis Publishing, 2020
2. Luca Fiorentini ,Luca Marmo *Principles of Forensic Engineering Applied to Industrial Accidents* , Wiley, 2019
3. Harold Franck, Darren Franck , *Forensic Engineering Fundamentals* ,Taylor & Francis publishing 2013
4. Randall K Noon , *Forensic Engineering Investigation*, CRC press limited , 2001
5. Stephen E Petty , *Forensic Engineering: Damage assessment for residential and commercial structures* CRC press 2nd edition , 2017
6. Joshua B Kardon , *Guideliness for forensic Engineering practice* , ASCE, 2012
7. Richard W. Mclay and Robert N. Anderson, *Engineering standards for forensic Applications* , Academic Press; 1st edition 2018
8. Max M Houck ,*Forensic Engineering (Advanced forensic Science ),* Academic press 1st edition 2017
9. Niranjan Reddy - Practical Cyber Forensics. *An Incident-based Approach to Forensic Investigations-Apress (2019)*
10. Peter Rhys Lewis, Ken Reynolds, Colin Gagg - *Forensic Materials Engineering Case Studies- CRC Press (2003) (1)*

| Code | Course name | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 24PAAUCT304 | Data Science for Engineers | Audit Course | 3 | 0 | 0 | 0 |

**Preamble:** This course covers essentials of statistics and Linear Algebra and how to prepare the data before processing in real time applications. The students will be able to handle missing data and detection of any outliers available in the dataset. This course explores data science, Python libraries and it also covers the introduction to machine learning for engineers.

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| **CO1** | Understand the Data Science Concepts and statistics | U |
| **CO2** | Apply the Mathematical Foundations needed for Data Science | A |
| **CO3** | Understand Exploratory analysis and Data Visualization and Preprocessing on given dataset | U |
| **CO4** | Implement Models such as Naive Bayes, K-Nearest Neighbors, Linear and Logistic Regression | A |
| **CO5** | Apply real time data science applications and test use cases | A |

**Mapping of course outcomes with program outcomes**

| CO'S | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | | 2 | | | 2 | |
| **CO 2** | 2 | | 2 | 1 | | 2 | |
| **CO 3** | 2 | | 2 | 2 | 2 | 2 | |
| **CO 4** | 2 | | 2 | 2 | 3 | 2 | |
| **CO 5** | 2 | | 2 | 3 | 3 | 3 | 2 |

1-Low; 2-Medium; 3- Strong

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 20 |
| Apply | 30 |
| Analyze | 10 |

**Mark Distribution**:

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment (CIA) Pattern:**

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination (ESE) Pattern:**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Viva. Each question can carry 12 marks.

**Syllabus**

| Module | Description | Contact Hours |
|---|---|---|
| 1 | **Statistics for Data science:** Probability: Basic concepts of probability, conditional probability, total probability, independent events, Bayes' theorem, random variable, Population, Sample, Population Mean, Sample Mean, Population Distribution, Sample Distribution and sampling Distribution, Mean, Mode, Median, Range, Measure of Dispersion, Variance, Standard Deviation, Gaussian/Normal Distribution, covariance, correlation. | 6 |
| 2 | **Linear Algebra:** Vectors and their properties, Sum and difference of Vectors, distance between Vectors, Matrices, Inverse of Matrix, Determinant of Matrix, Trace of a Matrix, Dot Product, Eigen Values, Eigen Vectors, Single Value Decomposition | 6 |
| 3 | **Hypothesis Testing:** Understanding Hypothesis Testing, Null and Alternate Hypothesis, Non-directional Hypothesis, Directional Hypothesis Critical Value Method, P-Value Method, Types of Errors-Type1 Error, Type2 Error, Types of Hypothesis Test Z Test, Chi-Square | 6 |
| 4 | **Exploratory Data Analysis:** Data Collection –Public and Private Data, Data Cleaning-Fixing Rows and Columns, Missing Values, Standardizing values, invalid values, filtering data, Data-Integration, Data-Reduction, Data Transformation | 6 |
| 5 | **Machine Learning and Python for Data Science**: Python Data structures -List, Tuple, Set, Dictionary, Pandas, Numpy, Scipy, Matplotlib, Machine Learning- Supervised Machine Learning, Unsupervised Machine Learning, Regression, Classification, Naïve-Bayes | 6 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Module I** | |
| 1.1 | Probability: Basic concepts of probability, conditional probability, total probability | 1 |
| 1.2 | independent events, Bayes' theorem, random variable, Population | 1 |
| 1.3 | Sample, Population Mean, Sample Mean, Population Distribution | 1 |
| 1.4 | Sample Distribution and sampling Distribution, Mean, Mode, Median, Range, Propositional logic and predicate logic | 1 |
| | Measure of Dispersion, Variance, Standard Deviation Gaussian/Normal Distribution, covariance, correlation. | 2 |
| 2 | **Module II** | |
| 2.1 | Vectors and their properties, | 2 |
| 2.2 | Sum and difference of Vectors, distance between Vectors | 1 |
| 2.3 | Matrices, Inverse of Matrix, | 1 |
| 2.4 | Determinant of Matrix, Trace of a Matrix, Dot Product, Eigen Values, Eigen Vectors, Single Value Decomposition | 2 |
| 3 | **Module III** | |
| 3.1 | Understanding Hypothesis Testing, Null and Alternate Hypothesis | 2 |
| 3.2 | Non-directional Hypothesis, Directional Hypothesis Critical Value Method, P-Value Method, | 2 |
| 3.3 | Types of Errors-Type1 Error, Type2 Error, Types of Hypothesis Test Z Test, Chi-Square, | 2 |
| 4 | **Module IV** | |
| 4.1 | Data Collection –Public and Private Data | 1 |
| 4.2 | Data Cleaning-Fixing Rows and Columns | 2 |
| 4.3 | Missing Values | 1 |
| 4.4 | Standardizing values | 1 |
| 4.5 | Invalid values, filtering data | 1 |
| 5 | **Module V** | |
| 5.1 | Python Data structures-List, Tuple, Set, | 2 |
| 5.2 | Dictionary, Pandas, Numpy, Matplotlib | 2 |
| 5.3 | Machine Learning-Supervised Machine Learning, Unsupervised Machine Learning | 2 |
| 5.4 | Regression, Classification, Naïve-Bayes | |

**Reference Books**

1. Python Data Science Handbook. Essential Tools for Working with Data, Author(s): Jake VanderPlas, Publisher: O'Reilly Media, Year: 2016
2. Practical Statistics for Data Scientists: 50 Essential Concepts, Author(s): Peter Bruce, Andrew Bruce, Publisher: O'Reilly Media, Year: 2017
3. Practical Linear Algebra for Data Science, by Mike X Cohen, Released September 2022, Publisher(s): O'Reilly Media, Inc.
4. Data Science from Scratch 'by Joel Grus, Released, April 2015, Publisher(s): O'Reilly Media, Inc.
5. Hands-On Exploratory Data Analysis with Python, by Suresh Kumar Mukhiya, Usman Ahmed, Released March 2020, Publisher(s): Packt Publishing

| Code | Course name | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 24PAAUCT305 | Design Thinking | Audit Course | 3 | 0 | 0 | 0 |

**Preamble:** This course is designed

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs.After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO1 | Identify and frame design challenges effectively. | U |
| CO2 | Understand the creative ideas through brainstorming and ideation | U |
| CO3 | Apply the concepts of designs based on user insights | A |
| CO4 | Apply Design Thinking to real-world problems and projects. | A |
| CO 5 | Apply various Entrepreneur and Business ideas. | A |

**Mapping of course outcomes with program outcomes**

| CO'S | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| CO 1 | | | | 2 | | 2 | 2 |
| CO 2 | 2 | | 2 | 2 | | | 2 |
| CO 3 | | 2 | | 2 | | 2 | 2 |
| CO 4 | 2 | | 2 | 3 | 2 | | 2 |
| CO 5 | 2 | | 2 | 2 | | | |

1-Low; 2-Medium; 3- Strong

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 10 |
| Apply | 30 |
| Analyze | 20 |

**Mark Distribution**:

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment (CIA) Pattern:**

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination (ESE) Pattern:**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Viva. Each question can carry 12 marks.

**Syllabus**

| Module | Description | Contact Hours |
|---|---|---|
| 1 | **Module 1 Design process:** Traditional design, Design Thinking Approach, Introduction to Design Thinking, History and evolution of Design Thinking, Role of design thinking in the human-centred design process. Design space, Design Thinking in a Team Environment, Team formation. | 6 |
| 2 | **Module 2 Design Thinking Stages:** Empathize, Define, Ideate, Prototype and Test. The importance of empathy, Building a user-centred mindset. Problem statement formulation, User needs and pain points, establishing target specifications, Setting the final specifications. | 6 |
| 3 | **Module 3 Generating Ideas:** Brainstorming techniques, Application of Aesthetics and Ergonomics in Design. Bio-mimicry, Conceptualization, Visual thinking, Drawing/Sketching, Presenting ideas. | 6 |
| 4 | **Module 4 Use of prototyping:** Types of prototypes, Rapid prototyping techniques, User testing and feedback collection, Iterative prototyping, testing to gauge risk and market interest | 6 |
| 5 | **Module 5 Entrepreneurship/business ideas:** Patents and Intellectual Property, Agility in design, Ethical considerations in design. Overcoming common implementation challenges | 6 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Module I** | |
| 1.1 | Design process: Traditional design, Design Thinking Approach, Introduction to Design Thinking, History and evolution of Design Thinking. | 1 |
| 1.2 | Role of design thinking in the human-centered design process. Design space, | 1 |
| 1.3 | Design Thinking formation. | 2 |
| 2 | **Module II** | |
| 2.1 | Design Thinking Stages: Empathize, Define, Ideate, Prototype and Test. | 1 |
| 2.2 | The importance of empathy, Building a user-centered mindset. | 1 |
| 2.3 | Problem statement formulation, User needs and pain points, establishing target specifications, Setting the final specifications | 2 |
| 3 | **Module III** | |
| 3.1 | Generating Ideas, Brainstorming techniques. | 2 |
| 3.2 | Application of Aesthetics and Ergonomics in Design. Bio-mimicry. | 2 |
| 3.3 | Conceptualization, Visual thinking, Drawing/Sketching, Presenting ideas. | 2 |
| 4 | **Module IV** | |
| 4.1 | Use of prototyping, Types of prototypes, Rapid prototyping techniques. | 1 |
| 4.2 | User testing and feedback collection, Iterative prototyping, testing to gauge risk and market interest | 2 |
| 5 | **Module V** | |
| 5.1 | Entrepreneurship/business ideas, Patents and Intellectual Property. | 2 |
| 5.2 | Agility in design, Ethical considerations in design. Overcoming common implementation challenges | 2 |

**Reference Books**

1. Christoph Meinel, Larry Leifer and Hasso Plattner- "Design Thinking: Understand – Improve – Apply", Springer Berlin, Heidelberg, 2011.
2. Thomas Lockwood and Edgar Papke – "Design Thinking: Integrating Innovation, Customer Experience, and Brand Value", Allworth Press, 2009.
3. Pavan Soni – "Design Your Thinking", Penguin Random House India Private Limited, 2020.
4. Andrew Pressman- "Design Thinking: A Guide to Creative Problem Solving for Everyone", Taylor & Francis, 2018.
5. N Siva Prasad, "Design Thinking Techniques an Approaches" Ane Books Pvt. Ltd.,2023

| Code | Course name | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 24PAAUCT306 | Functional Programming in HASKELL | Audit Course | 3 | 0 | 0 | 0 |

**Preamble:** This course introduces a functional programming approach in problem solving. Salient features of functional programming like recursion, pattern matching, higher order functions etc. and the implementation in Haskell are discussed.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs.After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO1 | Understand the functional programming paradigm which is based on the mathematics of lambda calculus. | U |
| CO2 | Develop Haskell programs using functions, guards and recursive functions | A |
| CO3 | Apply the concept of tuples, lists and strings in Haskell programming | A |
| CO4 | Apply the concept of algebraic data types, abstract data types, modules, recursive data types and user defined data types in Haskell programming | A |
| CO5 | Develop Haskell programs with files for reading input and storing output. | A |

**Mapping of course outcomes with program outcomes**

| CO'S | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| CO 1 | | | | | 3 | | |
| CO 2 | 2 | | | 2 | 3 | | |
| CO 3 | 2 | | | 2 | 3 | | |
| CO 4 | 2 | | | 2 | 3 | | |
| CO 5 | 2 | | | 2 | 3 | | |

1-Low; 2-Medium; 3- Strong

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 30 |
| Analyze | 20 |

**Mark Distribution**:

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment (CIA) Pattern:**

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination (ESE) Pattern:**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Viva. Each question can carry 12 marks.

**Syllabus**

| Module | Description | Contact Hours |
|---|---|---|
| 1 | **Introduction to Functional Programming:** Programming language paradigms, imperative style programming, comparison of programming paradigms. Functional programming, Functions - Mathematical concepts and terminology, Lambda calculus, Function definitions, programs as functions, Functional programming Languages. Haskell basics, GHCi interpreter. | 6 |
| 2 | **Programming in Haskell:** Expressions and evaluation, Lazy evaluation, let expressions, scopes. Basic data types in Haskell, operators, infix operators, associativity and precedence, Arithmetic functions. types, definitions, currying and un currying, type abstraction. Function definitions, pattern matching, guards, anonymous functions, higher order functions. Recursion, Programming exercises. | 6 |
| 3 | **Data types:** tuples and lists: Tuples , Lists: building lists, decomposing lists, functions on lists, built- in functions on lists, primitive and general recursion over lists, infinite lists. Strings: functions on strings. Polymorphism and overloading, conditional polymorphism | 6 |
| 4 | **User defined data types** Type classes, Algebraic data types, Modules, Recursive data types. User defined data types, Records, Stacks, Queues, Binary trees, Constructors, Destructors. | 6 |
| 5 | **Programming with actions** Functor, Applicative functor, Monad, Programming with actions: Functions vs actions, Basics of input / output, the do notation interacting with the command line and lazy I/O, File I/O | 6 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Module I** | |
| 1.1 | Programming language paradigms, imperative style programming, comparison of programming paradigms | 1 |
| 1.2 | Functional programming, Functions - Mathematical concepts and terminology | 1 |
| 1.3 | Lambda calculus | 1 |
| 1.4 | Function definitions, programs as functions, Functional programming Languages | 2 |
| 1.5 | Haskell basics, GHCi interpreter | 1 |
| 2 | **Module II** | |
| 2.1 | Expressions and evaluation, Lazy evaluation | 1 |
| 2.2 | let expressions, scopes, Basic data types in Haskell | 1 |
| 2.3 | operators, infix operators, associativity and precedence, Arithmetic functions | 1 |
| 2.4 | types, definitions, currying and uncurrying, type abstraction. | 1 |
| 2.5 | Function definitions, pattern matching, Guards | 1 |
| 2.6 | anonymous functions, higher order functions, Recursion | 1 |
| 3 | **Module III** | |
| 3.1 | Tuples, Lists: building lists, decomposing lists functions on lists, built-in functions on lists | 2 |
| 3.2 | primitive and general recursion over lists infinite lists Strings: functions on strings | 2 |
| 3.3 | Polymorphism and overloading conditional polymorphism | 2 |
| 4 | **Module IV** | |
| 4.1 | Type classes, Algebraic data types, Modules | 1 |
| 4.2 | Recursive data types | 2 |
| 4.3 | User defined data types, Records | 1 |
| 4.4 | Stacks, Queues | 1 |
| 4.5 | Binary trees Constructors, Destructors | 1 |
| 5 | **Module V** | |
| 5.1 | Functor, Applicative functor, Monad | 2 |
| 5.2 | Programming with actions: Functions vs actions, Basics of input / output, the do notation | 2 |
| 5.3 | interacting with the command line and lazy I/O, File I/O | 2 |

**Reference Books**

1. Richard Bird, “Introduction to functional programming using Haskell', second edition, Prentice Hall series in computer science
2. Bryan O'Sullivan, Don Stewart, and John Goerzen, “Real World Haskell”
3. Richard Bird, “Thinking Functionally with Haskell”, Cambridge University Press, 2014
4. Simon Thompson, “Haskell: The Craft of Functional Programming”, Addison-Wesley, 3rd Edition, 2011
5. H. Conrad Cunningham, “Notes on Functional Programming with Haskell”, 2014
6. Graham Hutton, “Programming in Haskell”, Cambridge University Press, 2nd Edition, 2016
7. Alejandro Serrano Mena, “Practical Haskell: A Real-World Guide to Functional Programming”, 3rd Edition, Apress, 2022
8. Miran Lipovaca, “Learn You a Haskell for Great Good!: A Beginner's Guide”, No Starch Press, 2011

| Code | Course name | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 24PAAUCT310 | Principles of Automation | Audit Course | 3 | 0 | 0 | 0 |

**Preamble:** This course deals in detail with the various aspects of automation such as sensors, actuators, controllers, mechanical and electrical elements and their integration for automating new and existing manufacturing and process industries and applications.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs.After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO1 | Explain the fundamentals of sensor systems and to choose a suitable sensor system for the given application based on the evaluation of the constraints. | A |
| CO2 | Explain the fundamentals of signal conditions and to design a suitable signal conditioning scheme for given application. | A |
| CO3 | Describe the characteristics of various actuator systems and to decide the right type of actuator for the given application. | A |
| CO4 | Describe the importance of an industrial robot and fundamentals of numerical control in automation. | U |
| CO5 | Explain the fundamentals of controllers used in industrial automation and to construct simple automation schemes by ladder logic programs. | A |

**Mapping of course outcomes with program outcomes**

| CO'S | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| CO 1 | 2 | | 2 | 2 | 2 | | |
| CO 2 | 2 | | 2 | 2 | 2 | | |
| CO 3 | 2 | | 2 | 2 | 2 | | |
| CO 4 | 2 | | 2 | 2 | 2 | | |
| CO 5 | 2 | | 2 | | | | |

1-Low; 2-Medium; 3- Strong

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 20 |
| Apply | 40 |

**Mark Distribution**:

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment (C I A) Pattern:**

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination (ESE) Pattern:**
The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Viva. Each question can carry 12 marks.

**Syllabus**

| Module | Description | Contact Hours |
|---|---|---|
| 1 | **Introduction to Industrial Automation:** Basic Elements of an Automated System, Levels of Automation, Hardware components for Automation: Sensors, classification, Static and dynamic behaviour of sensors. Basic working principle of different sensors: Proximity sensors, Temperature sensors, flow sensors, Pressure sensors, Force sensors. Position sensors | 6 |
| 2 | **Signal conditioning:** Need for signal conditioning, Types of signal conditioning. Signal conditioning using operational amplifier-Amplifier (Inverting and Non-inverting) and Filter circuits (Basic concepts). Design of first order low pass filter. Signal conditioning for data acquisition systems, anti-aliasing filters, Analog–Digital Conversions, Analog-to-Digital Converters (ADC)- Steps in analog-to-digital conversion, Successive Approximation Method, Digital-to-Analog Converters (DAC)- Steps in digital to analog conversion, Zero-order and first order data hold circuits. | 6 |
| 3 | **Actuators:** Types of actuators- mechanical, electrical, pneumatic and hydraulic actuators. (Basic working principle) Mechanical systems for motion conversion, transmission systems Solenoids, Electric and stepper motors control. | 6 |
| 4 | **Robotics and Automated Manufacturing Systems:** Robot Anatomy and Related Attributes: Joints and Links, Common Robot Configurations, Joint Drive Systems, Sensors in Robotics (Basic concepts) Robot Control Systems, Applications of Industrial Robots-Material handling, Fundamentals of Numerical control (NC) Technology | 6 |
| 5 | **Discrete Control and Programmable Logic Controllers:** Discrete Process Control: Logic and Sequence control Ladder Logic Diagrams, Programmable Logic Controllers: Components of the PLC, PLC Operating Cycle, Programming the PLC (Basic concepts only) Introduction to Distributed control system (DCS) and Supervisory Control and Data Acquisition Systems (SCADA) | 6 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Module I** | |
| 1.1 | Basic Elements of an Automated System, Levels of Automation | 2 |
| 1.2 | Hardware components for Automation: Sensors, classification, Static and dynamic behaviour of sensors | 2 |
| 1.3 | Basic working principle of different sensors: Proximity sensors, Temperature sensors, flow sensors, Pressure sensors, Force sensors. Position sensors | 2 |
| 2 | **Module II** | |
| 2.1 | Need for signal conditioning, Types of signal conditioning. | 2 |
| 2.2 | Signal conditioning using operational amplifier-Amplifier (Inverting and Non-inverting) and Filter circuits (Basic concepts). Design of first order low pass filter. | 2 |
| 2.3 | Signal conditioning for data acquisition systems, anti-aliasing filters, Analog–Digital Conversions, Analog-to-Digital Converters (ADC)- Steps in analog-to-digital conversion, Successive Approximation Method, Digital-to-Analog Converters (DAC)- Steps in digital to analog conversion, Zero-order and first order data hold circuits | 2 |
| 3 | **Module III** | |
| 3.1 | Types of actuators- mechanical, electrical, pneumatic and hydraulic actuators. (Basic working principle) | 2 |
| 3.2 | Mechanical systems for motion conversion, transmission systems | 2 |
| 3.3 | Solenoids, Electric and stepper motors control. | 2 |
| 4 | **Module IV** | |
| 4.1 | Robot Anatomy and Related Attributes: Joints and Links, Common Robot Configurations, Joint Drive Systems, Sensors in Robotics (Basic concepts) | 2 |
| 4.2 | Robot Control Systems, Applications of Industrial Robots- Material handling | 2 |
| 4.3 | Fundamentals of Numerical control (NC) Technology | 2 |
| 5 | **Module V** | |
| 5.1 | Discrete Process Control: Logic and Sequence control | 2 |
| 5.2 | Ladder Logic Diagrams, Programmable Logic Controllers: Components of the PLC, PLC Operating Cycle, Programming the PLC (Basic concepts only) | 2 |
| 5.3 | Introduction to Distributed control system (DCS) and Supervisory Control and Data Acquisition Systems (SCADA) | 2 |

**Reference Books**

1. Mikell Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson, 2019.
2. Yoram Koren, "Computer Control of Manufacturing Systems",TataMcGraw Hill Edition2005.
3. S. R. Deb; Sankha Deb. Robotics Technology and Flexible Automation, Second Edition McGraw-Hill Education: New York, 2010.
4. W. Bolton, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering" - PrenticeHall- 2013 - 5th Edition.
5. Doebelin, E.O. and Manic, D.N., "Measurement Systems: Applications and Design", 7th Edition, McGraw Hill, 2019.
6. Krishna Kant, Computer Based Industrial Control-, EEE-PHI,2nd edition,2010.
7. Nathan Ida, Sensors, Actuators, and Their Interfaces- A multidisciplinary introduction, 2nd Edition, IET Digital Library, 2020.
8. Salivahanan, S., and VS Kanchana Bhaaskaran. Linear integrated circuits. McGraw-Hill Education, 2nd edition, 2014.
9. Petruzella, Frank D. Programmable logic controllers. Tata McGraw-Hill Education, 2005
10. Chapman and Hall, "Standard Handbook of Industrial Automation", Onsidine DM C & Onsidine GDC", NJ, 1986

| Code | Course name | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 24PAAUCT311 | Reuse and Recycle Technology | Audit Course | 3 | 0 | 0 | 0 |

**Preamble:** This course is designed

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs.After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO1 | Explain the principles and technologies behind waste reduction, resource conservation, and sustainable practices | A |
| CO2 | Describe and Analyze waste generation and management. | A |
| CO3 | Apply the knowledge of various reuse strategies and their application in different industries and Analyze various recycling technologies | A |
| CO4 | Appraise the methods of E-waste management and Eco friendly packaging | A |
| CO5 | Comprehend Environmental Regulations and Policies, Understand the importance of environmental regulations and policies in addressing environmental challenges | U |

**Mapping of course outcomes with program outcomes**

| CO'S | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| CO 1 | | | 3 | | | | |
| CO 2 | | | | 3 | | | |
| CO 3 | | | | 3 | | | |
| CO 4 | | | | | 3 | | |
| CO 5 | | | 3 | | | | |

1-Low; 2-Medium; 3- Strong

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 20 |
| Apply | 40 |

**Mark Distribution**:

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment (CIA) Pattern:**

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination (ESE) Pattern:**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Viva. Each question can carry 12 marks.

**Syllabus**

| Module | Description | Contact Hours |
|---|---|---|
| 1 | **Introduction to Sustainability:** Understanding sustainability and its importance, The three pillars of sustainability: Environmental, Social, and Economic. Biodiversity conservation, Climate change and mitigation Sustainable resource management. | 6 |
| 2 | **Waste Management:** Definition and classification of waste, Waste Generation and Composition, Waste Collection and Transportation, Waste Segregation and Sorting. Waste Disposal Methods Historical perspectives on waste management, The three Rs:Reduce, Reuse, and Recycle. | 6 |
| 3 | **Recycling and Reuse:** Importance of reuse, Application of reuse in various industries, Challenges and opportunities in reuse, Overview of recycling technologies, Circular economy, Sorting and processing of recyclable materials, Advanced recycling methods. Emerging technologies in recycling. | 6 |
| 4 | **E-waste Recycling,** Challenges and environmental impact of electronic waste, E-waste recycling methods and regulations, Sustainable electronics design, Sustainable Packaging, Packaging materials and them environmental impact, Eco-friendly packaging alternatives, Packaging design for sustainability. | 6 |
| 5 | **Environmental Regulations and Policies,** Understand the importance of environmental regulations and policies in addressing environmental challenges, National and international waste and recycling regulations, Compliance and enforcement, Industry standards and certifications | 6 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Module I** | |
| 1.1 | Understanding sustainability and its importance | 1 |
| 1.2 | The three pillars of sustainability: Environmental, Social, and Economic. | 1 |
| 1.3 | Biodiversity conservation, Climate change and mitigation | 2 |
| 1.4 | Sustainable resource management | 2 |
| 2 | **Module II** | |
| 2.1 | Definition and classification of waste | 1 |
| 2.2 | Waste Generation and Composition | 1 |
| 2.3 | Waste Collection and Transportation. | 1 |
| 2.4 | Waste Segregation and Sorting. | 1 |
| 2.5 | Waste Disposal Methods | 1 |
| 2.6 | Historical perspectives on waste management, The three Rs: Reduce, Reuse, and Recycle. | 1 |
| 3 | **Module III** | |
| 3.1 | Importance of reuse, Examples of reuse in various industries. | 2 |
| 3.2 | Challenges and opportunities in reuse | 2 |
| 3.3 | Overview of recycling technologies, Sorting and processing of recyclable materials | 2 |
| 3.4 | Advanced recycling methods | |
| 3.5 | Emerging technologies in recycling. | |
| 4 | **Module IV** | |
| 4.1 | Challenges and environmental impact of electronic waste | 1 |
| 4.2 | E-waste recycling methods and regulations | 2 |
| 4.3 | Sustainable electronics design | 1 |
| 4.4 | Packaging materials and their environmental impact | 1 |
| 4.5 | Eco-friendly packaging alternatives | 1 |
| 4.6 | Packaging design for sustainability | |
| 5 | **Module V** | |
| 5.1 | Importance of environmental regulations and policies in addressing environmental challenges | 2 |
| 5.2 | National and international waste and recycling regulations | 2 |
| 5.3 | Industry standards and certifications, Compliance and enforcement | 2 |

**Reference Books**

1. Sustainable Engineering: Concepts, Design and Case Studies, David T. Allen, Pearson Publication.
2. A Comprehensive Book on Solid Waste Management with Application, Dr. H.S. Bhatia , Misha Books, 2019
3. "Cradle to Cradle: Remaking the Way We Make Things" by William McDonough and Michael Braungart.
4. "Recycling of Plastic Materials" edited by Vijay Kumar Thakur
5. E-waste: Implications, Regulations and Management in India and Current Global Best Practices, Rakesh Johri, TERI
6. "Sustainable Packaging", Subramanian Senthilkannan Muthu , Springer Nature.
7. Indian Environmental Law: Key Concepts and Principles " Orient Black swan Private Limited, New Delhi.

| Code | Course name | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 24PAAUCT312 | System Modelling | Audit Course | 3 | 0 | 0 | 0 |

**Preamble:** This course is designed

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs.After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO1 | analyze the requirement and find appropriate tool for simulation. | An |
| CO2 | Differentiate the different statistical models. | U |
| CO3 | Discuss the different techniques for generating random numbers. | U |
| CO4 | analyze the different methods for selecting the different input models. | An |
| CO5 | explain the different measures of performance and their estimation | A |

**Mapping of course outcomes with program outcomes**

| CO'S | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| CO 1 | 2 | | 1 | 1 | 2 | | |
| CO 2 | 2 | | 1 | 1 | 1 | | |
| CO 3 | 1 | | | | | | |
| CO 4 | 1 | | 1 | 1 | | | |
| CO 5 | 2 | | 1 | 1 | 1 | | |

1-Low; 2-Medium; 3- Strong

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 10 |
| Apply | 30 |
| Analyze | 20 |

**Mark Distribution**:

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment (CIA) Pattern:**

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination (ESE) Pattern:**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Viva. Each question can carry 12 marks.

**Syllabus**

| Module | Description | Contact Hours |
|---|---|---|
| 1 | When simulation is the appropriate tool. Advantages and disadvantages of Simulation; Areas of application, Systems and system environment; Components of a system; Discrete and continuous systems, Model of a system; Types of Models, Discrete-Event System Simulation, Steps of a simulation study. | 6 |
| 2 | Review of terminology and concepts, Useful statistical models, Discrete distributions. Continuous distributions, Poisson process, Empirical distributions. (basic idea only) | 6 |
| 3 | Properties of random numbers; Generation of pseudo- random numbers, Techniques for generating random numbers, Tests for Random Numbers | 6 |
| 4 | Data Collection; Identifying the distribution with data, Parameter estimation, Goodness of Fit Tests, fitting a non-stationary Poisson process, Selecting input models without data, Multivariate and Time-Series input models. | 6 |
| 5 | Measures of performance and their estimation, Output analysis for terminating simulations, Output analysis for steady-state simulations, Verification, calibration and validation | 6 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Module I** | |
| 1.1 | When simulation is the appropriate tool, Advantages and disadvantages of Simulation; | 1 |
| 1.2 | Areas of application, Systems and system environment; | 1 |
| 1.3 | Components of a system; Discrete and continuous systems, | 2 |
| 1.4 | Model of a system; Types of Models, | 2 |
| 1.5 | Discrete-Event System Simulation, Steps of a simulation study | |
| 2 | **Module II** | |
| 2.1 | Review of terminology and concepts, Empirical distributions. (basic idea only) | 1 |
| 2.2 | Useful statistical models, Discrete distributions | 1 |
| 2.3 | Continuous distributions | 1 |
| 2.4 | Poisson process | 1 |
| 2.5 | Empirical distributions | 1 |
| 3 | **Module III** | |
| 3.1 | Properties of random numbers; | 1 |
| 3.2 | Generation of pseudo-random numbers, | 2 |
| 3.3 | Techniques for generating random numbers | 2 |
| 3.4 | Tests for Random Numbers | |
| 4 | **Module IV** | |
| 4.1 | Data Collection; | 1 |
| 4.2 | Identifying the distribution with data. | 2 |
| 4.3 | Parameter estimation, Goodness of Fit Tests | 1 |
| 4.4 | Fitting a non-stationary Poisson process | 1 |
| 4.5 | Selecting input models without data, | 1 |
| 4.6 | Multivariate and Time-Series input models | |
| 5 | **Module V** | |
| 5.1 | Measures of performance and their estimation, Measures of performance and their estimation | 2 |
| 5.2 | Output analysis for terminating simulations | 2 |
| 5.3 | Verification, calibration and validation | 2 |

**Reference Books**

1. Jerry Banks, John S. Carson II, Barry L. Nelson, David M. Nicol: Discrete-Event System Simulation, 5th Edition, Pearson Education, 2010.

**Text Books**

1. Lawrence M. Leemis, Stephen K. Park: Discrete – Event Simulation: A First Course, Pearson Education, 2006.
2. Averill M. Law: Simulation Modeling and Analysis, 4 th Edition, Tata McGraw-Hill, 2007
3. System Modelling and Response by Ernest O. Doebelin
4. Averill M Law, “Simulation Modeling and Analysis”, McGraw-Hill Inc,2007 Geoffrey Gorden, “System Simulation”, Prentice Hall of India,1992.

| Code | Course name | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 24PAAUCT313 | Expert Systems | Audit Course | 3 | 0 | 0 | 0 |

**Preamble:** This course aims to provide an understanding of the basic concepts of Artificial Intelligence (AI) and Expert Systems. The course also covers the knowledge representation in expert systems, classes of expert systems, applications of expert systems.

**Course Outcomes:** After the completion of the course the student will be able to

| Course Outcomes | Description | Bloom's Level |
|---|---|---|
| CO1 | Explain the concepts of Artificial Intelligence and different ways of knowledge representations. | A |
| CO2 | Explain the components of expert systems, development stages of expert systems and tools available for expert system design. | A |
| CO3 | Apply the concept of knowledge representation in expert systems | A |
| CO4 | Differentiate the classes of expert systems and examine properties of existing systems | U |
| CO 5 | Explain the currents trends in expert systems | A |

**Mapping of course outcomes with program outcomes**

| CO'S | PO 1 | PO 2 | PO 3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| CO 1 | 1 | | 2 | 1 | 2 | 2 | |
| CO 2 | 1 | | 1 | 3 | 2 | 2 | |
| CO 3 | 1 | | 1 | 2 | 2 | 2 | |
| CO 4 | 2 | | 2 | 2 | 3 | 2 | |
| CO 5 | 1 | | 1 | 2 | 1 | 1 | |

1-Low; 2-Medium; 3- Strong

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 20 |
| Apply | 40 |

**Mark Distribution**:

| Total Marks | CIA | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Assessment (C I A) Pattern:**

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination (ESE) Pattern:**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Viva. Each question can carry 12 marks.

**Syllabus**

| Module | Description | Contact Hours |
|---|---|---|
| 1 | **Overview of Artificial Intelligence (AI):** Definition & Importance of AI. Knowledge general concepts: Definition and Importance of knowledge, Knowledge-Based Systems, Knowledge organization, Knowledge Manipulation and acquisition. Knowledge Representation: Introduction, Syntax and Semantics- Propositional logic and predicate logic. | 9 |
| 2 | **Basic concepts of expert systems-**Introduction to expert systems, Components of expert systems. Features of Expert System, Stages in the development of expert system, Types of tools available for expert system design | 9 |
| 3 | **Knowledge representation in expert systems:** Structured Knowledge representation: Graphs, Frames and related structures, Associative networks, Conceptual dependencies, Examples of structured knowledge representation. | 9 |
| 4 | **Classes of expert systems:** Rule-based expert systems, Example-MYCIN, Frame-based expert system, terminologies, IF-THEN structure. Fuzzy and Neural network based expert systems(basic concepts) | 9 |
| 5 | **Currents trends in expert systems,** Advantages and limitations of expert systems, Applications of expert systems. | 9 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Module I** | |
| 1.1 | Definition & Importance of AI, Definition and Importance of Knowledge | 1 |
| 1.2 | Knowledge-Based Systems, Knowledge Organization Knowledge Manipulation and acquisition | 1 |
| 1.3 | Knowledge Representation: Introduction, Syntax and Semantics | 2 |
| 1.4 | Propositional logic and predicate logic | 2 |
| 2 | **Module II** | |
| 2.1 | Introduction to Expert System, Components of expert systems | 1 |
| 2.2 | Features of Expert System, Stages in the development of expert system | 1 |
| 2.3 | Types of tools available for expert system design | 2 |
| 3 | **Module III** | |
| 3.1 | Structured Knowledge representation | 2 |
| 3.2 | Graphs, Frames and Related Structures | 2 |
| 3.3 | Associative Networks, Conceptual Dependencies | 1 |
| 3.4 | Examples of structured knowledge representation | 1 |
| 4 | **Module IV** | |
| 4.1 | A rule-based expert system -Introduction, MYCIN | 1 |
| 4.2 | IF-THEN structure | 2 |
| 4.3 | Frame-based expert system | 1 |
| 4.4 | Fuzzy based expert systems | 1 |
| 4.5 | Neural network based expert systems | 1 |
| 5 | **Module V** | |
| 5.1 | Currents trends of expert systems | 2 |
| 5.2 | Advantages and limitations of expert systems | 2 |
| 5.3 | Applications of expert systems | 2 |

## Reference Books

1. E. Rich & K. Knight - Artificial Intelligence, 2/e, TMH, New Delhi, 2005.
2. P.H. Winston - Artificial Intelligence, 3/e, Pearson Edition, New Delhi, 2006.
3. D.W. Rolston - Principles of AI & Expert System Development, TMH, New Delhi
4. Kevin Night and Elaine Rich, Nair B., "Artificial Intelligence (SIE) ", McGraw Hill – 2010
5. Dan W Patterson, 'Introduction to Artificial intelligence and Expert systems', Prentice Hall of India Pvt. Ltd,2007
6. Russel (Stuart), 'Artificial Intelligence- Modern approach, Pearson Education series in AI', 3rd Edition, 2009.
7. I. Gupta, G. Nagpal · Artificial Intelligence and Expert Systems, Mercury Learning and Information -2020

## INTERNSHIP

A student shall opt for carrying out the Internship at an Industry/ResearchOrganization or at another institute of higher learning and repute (Academia). The organization for Internship shall be selected/decided by the students on their own withprior approval from the faculty advisor/respective PG Programme Coordinator/Guide/Supervisor. Every student shall be assigned an internship Supervisor/Guide at the beginning of the Internship. The training shall be related to their specialisation after the second semester for a minimum duration of six to eight weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

### Objectives

- Exposure to the industrial environment, which cannot be simulated in theclassroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understand and sharpen the real timetechnical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subjectarea of training.
- Create conducive conditions with quest for knowledge and its applicabilityon the job.
- Understand the social, environmental, economic and administrative considerations that influence the working environment.
- Expose students to the engineer's responsibilities and ethics.

### Benefits of InternshipBenefits to

### Students

- An opportunity to get hired by the industry/ organization.
- Practical experience in an organizational setting & Industry environment.
- Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more professional experience which is often worth more than classroom teaching.
- Helps them decide if the industry and the profession is the best career option to pursue.
- Opportunity to learn new skills and supplement knowledge.
- Opportunity to practice communication and teamwork skills.
- Opportunity to learn strategies like time management, multi-tasking etc. in an industrial setup.
- Makes a valuable addition to their resume.
- Enhances their candidacy for higher education/placement.
- Creating network and social circle and developing relationships with industry people.
- Provides opportunity to evaluate the organization before committing to a full-time position.

**Benefits to the Institute**

- Build industry academia relations.
- Makes the placement process easier.
- Improve institutional credibility & branding.
- Helps in retention of the students.
- Curriculum revision can be made based on feedback from Industry/ students.
- Improvement in teaching learning process.

**Benefits to the Industry**

- Availability of ready to contribute candidates for employment.
- Year round source of highly motivated pre-professionals.
- Students bring new perspectives to problem solving.
- Visibility of the organization is increased on campus.
- Quality candidate's availability for temporary or seasonal positions and projects.
- Freedom for industrial staff to pursue more creative projects.
- Availability of flexible, cost-effective workforce not requiring a long-term employer commitment.
- Proven, cost-effective way to recruit and evaluate potential employees.
- Enhancement of employer's image in the community by contributing to the educational enterprise.

**Types of Internships**

- Industry Internship with/without Stipend
- Govt / PSU Internship (BARC/Railway/ISRO etc)
- Internship with prominent education/research Institutes
- Internship with Incubation centres /Start-ups

**Guidelines**

- All the students need to go for internship for minimum duration of 6 to 8 weeks.
- Students can take mini projects, assignments, case studies by discussing it with concerned authority from industry and can work on it during internship.
- All students should compulsorily follow the rules and regulations as laid by industry.
- Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any other document from industry.
- Student should follow all ethical practices and SOP of industry.
- Students have to take necessary health and safety precautions as laid by the industry.
- Student should contact his /her Guide/Supervisor from college on weekly basis to communicate the progress.
- Each student has to maintain a diary/log book
- After completion of internship, students are required to submit
    - Report of work done
    - Internship certificate copy

- Feedback from employer / internship mentor
- Stipend proof (in case of paid internship).

**Total Marks 100:** The marks awarded for the Internship will be on the basis of (i) Evaluation done by the Industry (ii) Students diary (iii) Internship Report and (iv) Comprehensive Viva Voce.

**Continuous Internal Evaluation: 50 marks**

Student's diary - 25 Marks

Evaluation done by the industry - 25 Marks

**Student's Diary/ Daily Log**: The main purpose of writing daily diary is to cultivatethe habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily training diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit. Student's diary will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary
- Adequacy & quality of information recorded
- Drawings, design, sketches and data recorded
- Thought process and recording techniques used
- Organization of the information.

**The format of student's diary**

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Brief description about the nature of internship:

| Day | Brief write up about the Activities carried out: Such as design, sketches, result observed, issues identified, data recorded, etc. |
|---|---|
| 1 | |
| 2 | |
| 3 | |

*Signature of Industry Supervisor* *Signature of Section Head/HR*

*ManagerOffice Seal*

**Attendance Sheet**

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

| Month & Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| Month & Year | | | | | | | | | | |
| | | | | | | | | | | |
| Month & Year | | | | | | | | | | |
| | | | | | | | | | | |

*Signature of Industry Supervisor* *Signature of Section Head/HR*

*ManagerOffice Seal*

**Note:**

- Student's Diary shall be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.
- Attendance Sheet should remain affixed in daily training diary. Do not remove or tear it off.
- Student shall sign in the attendance column. Do not mark 'P'.
- Holidays should be marked in red ink in the attendance column. Absent should be marked as 'A' in red ink.

**Evaluation done by the Industry (Marks 25)**

**Format for Supervisor Evaluation of Intern**

Student Name :_____Date:_____ Supervisor Name : _____Designation:_____

Company/Organization :_____

Internship Address: _____ Dates of Internship:

From_____To _____

***Please evaluate intern by indicating the frequency with which you observed the following parameters:***

| **Parameters** **Marks** | Needs improvement (0 – 0.25 mark) | Satisfactory (0.25 – 0.50 mark) | Good (0.75 mark) | Excellent (1 mark) |
|---|---|---|---|---|
| Behavior | | | | |
| Performs in a dependable Manner | | | | |
| Cooperates with coworkers and supervisor | | | | |
| Shows interest in work | | | | |
| Learns quickly | | | | |
| Shows initiative | | | | |
| Produces high quality work | | | | |
| Accepts responsibility | | | | |
| Accepts criticism | | | | |
| Demonstrates organizational skills | | | | |
| Uses technical knowledge and expertise | | | | |
| Shows good judgment | | | | |
| Demonstrates creativity/originality | | | | |
| Analyzes problems effectively | | | | |
| Is self-reliant | | | | |

| | | | | |
|---|---|---|---|---|
| Communicates well | | | | |
| Writes effectively | | | | |
| Has a professional attitude | | | | |
| Gives a professional appearance | | | | |
| Is punctual | | | | |
| Uses time effectively | | | | |

**Overall performance of student**

Intern (Tick one) : Needs improvement (0 - 0.50 mark) / Satisfactory (0.50 – 1.0 mark) /Good (1.5 mark) / Excellent (2.0 mark)

Additional comments, if any (2 marks) :

*Signature of Industry Supervisor* *Signature of Section Head/HR*

*ManagerOffice Seal*

**End Semester Evaluation (External Evaluation): 50 Marks**

Internship Report - 25 Marks

Viva Voce - 25 Marks

**Internship Report**: After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty Supervisor. The student may contact Industrial Supervisor/ Faculty Mentor for assigning special topics and problems and should prepare the final report on the assigned topics. Daily diary will also help to a great extent in writing the industrial report since much of the information has already been incorporated by the student into the daily diary. The training report should be signed by the Internship Supervisor, Programme Coordinator and Faculty Mentor.

The Internship report (25 Marks) will be evaluated on the basis of following criteria:

- Originality
- Adequacy and purposeful write-up
- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taught in the course

Viva Voce (25 Marks) will be done by a committee comprising Faculty Supervisor, PG Programme Coordinator and an external expert (from Industry or research/academic Institute). This committee will be evaluating the internship report also.

## RESEARCH PROJECT/DISSERTATION

**Research Project:** Students choosing track 2 shall carry out the research projectin their parent Institution only under the guidance of a supervisor assigned by the DLAC.

**Dissertation:** All categories of students in track 1 are to carry out the dissertationin the Institute they are studying or can work either in any CSIR/Industrial R&D organization/any other reputed Institute which have facilities for dissertation work in the area proposed.

**Mark Distribution:**

**Phase 1: Total marks: 100, only CIA**

## ASSESSMENT PATTERN

### (i) CORE COURSES

Evaluation shall only be based on application, analysis or design based questions(for both internal and end semester examinations).

**Continuous Internal Evaluation: 40 marks**

Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

**End Semester Examination: 60 marks**

The end semester examination will be conducted by the University. There will betwo parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 7 marks. Total duration of theexamination will be 150 minutes.

### (ii) ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design based

questions(for both internal and end semester examinations).

**Continuous Internal Evaluation: 40 marks**

Preparing a review article based on peer reviewed

| | | |
|---|---|---|
| Original publications (minimum 10 publications shall be referred) | : | 15 marks |
| Course based task/Seminar/Data collection and interpretation | : | 15 marks |
| Test paper, 1 no. | : | 10 |

marksTest paper shall include minimum 80% of the

syllabus.

**End Semester Examination: 60 marks**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Note:** The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

**(iii) RESEARCH METHODOLOGY & IPR/AUDIT COURSE Continuous Internal Evaluation: 40 marks**

| | | |
|---|---|---|
| Course based task | : | 15 marks |
| Seminar/Quiz | : | 15 marks |
| Test paper, 1 no. | : | 10 marks |

Test paper shall include minimum 80% of the

syllabus.

**End Semester Examination: 60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question fromeach module of which student should answer any five. Each question can carry 12 marks.

### (iv) INTERNSHIP

Internships are educational and career development opportunities, providing practical experience in a field or discipline. They are structured, short-term, supervised placements often focused around particular tasks or projects with defined

timescales. An internship may be compensated or non-compensated by the organization providing the internship. The internship has to be meaningful and mutually beneficial to the intern and the organization. It is important that the objectivesand the activities of the internship program are clearly defined and understood. The internship offers the students an opportunity to gain hands-on industrial or organizational exposure; to integrate the knowledge and skills acquired through the coursework; interact with professionals and other interns; and to improve their presentation, writing, and communication skills. Internship often acts as a gateway for final placement for many students.

A student shall opt for carrying out the Internship at an Industry/Research Organization or at another institute of higher learning and repute (Academia). The organization for Internship shall be selected/decided by the students on their own with prior approval from the faculty advisor/respective PG Programme Coordinator/Guide/Supervisor. Every student shall be assigned an internship Supervisor/Guide at the beginning of the Internship. The training shall be related to their specialisation after the second semester for a minimum duration of six to eight weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

**Objectives**

- Exposure to the industrial environment, which cannot be simulated in theclassroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understand and sharpen the real timetechnical / managerial skills required at the job.

- Exposure to the current technological developments relevant to the subjectarea of training.
- Create conducive conditions with quest for knowledge and its applicabilityon the job.
- Understand the social, environmental, economic and administrativeconsiderations that influence the working environment.
- Expose students to the engineer's responsibilities and ethics.

**Benefits of Internship**

**Benefits to Students**

- An opportunity to get hired by the Industry/ organization.

- Practical experience in an organizational setting & Industry environment.
- Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more professional experience which is often worth more than classroom teaching.
- Helps them decide if the industry and the profession is the best career optionto pursue.
- Opportunity to learn new skills and supplement knowledge.
- Opportunity to practice communication and teamwork skills.
- Opportunity to learn strategies like time management, multi-tasking etc in anindustrial setup.
- Makes a valuable addition to their resume.
- Enhances their candidacy for higher education/placement.
- Creating network and social circle and developing relationships with industrypeople.
- Provides opportunity to evaluate the organization before committing to a fulltime position.

**Benefits to the Institute**

- Build industry academia relations.
- Makes the placement process easier.
- Improve institutional credibility & branding.
- Helps in retention of the students.
- Curriculum revision can be made based on feedback

from Industry/students.

- Improvement in teaching learning process.

**Benefits to the Industry**

- Availability of ready to contribute candidates for employment.
- Year round source of highly motivated pre-professionals.
- Students bring new perspectives to problem solving.
- Visibility of the organization is increased on campus.

- Quality candidate's availability for temporary or seasonal positions and projects.
- Freedom for industrial staff to pursue more creative projects.
- Availability of flexible, cost-effective workforce not requiring a long-term employer commitment.
- Proven, cost-effective way to recruit and evaluate potential employees.
- Enhancement of employer's image in the community by contributing to theeducational enterprise.

**Types of Internships**

- Industry Internship with/without Stipend
- Govt / PSU Internship (BARC/Railway/ISRO etc)
- Internship with prominent education/research Institutes
- Internship with Incubation centres /Start-ups

**Guidelines**

- All the students need to go for internship for minimum duration of 6 to 8 weeks.
- Students can take mini projects, assignments, case studies by discussing itwith concerned authority from industry and can work on it during internship.
- All students should compulsorily follow the rules and regulations as laid by industry.

- Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any otherdocument from industry.
- Student should follow all ethical practices and SOP of industry.
- Students have to take necessary health and safety precautions as laid bythe industry.
- Student should contact his /her Guide/Supervisor from college on weeklybasis to communicate the progress.
- Each student has to maintain a diary/log book

- After completion of internship, students are required to submit
  - Report of work done
  - Internship certificate copy
  - Feedback from employer / internship mentor
  - Stipend proof (in case of paid internship).

**Total Marks 100:** The marks awarded for the Internship will be on the basis of (i) Evaluation done by the Industry (ii) Students diary (iii) Internship Report and (iv) Comprehensive Viva Voce.

**Continuous Internal Evaluation: 50 marks**

Student's diary - 25 Marks

Evaluation done by the Industry - 25 Marks

**Student's Diary/ Daily Log**: The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily training diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit. Student's diary will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary
- Adequacy & quality of information recorded

- Drawings, design, sketches and data recorded
- Thought process and recording techniques used
- Organization of the information.

**The format of student's diary**

Name of the Organization/Section:

Name and Address of the Section

Head: Name and Address of the

Supervisor: Name and address of the

student:

Internship Duration: From ..... To .....

Brief description about the nature of internship:

| Day | Brief write up about the Activities carried out: Such as design, sketches, result observed, issues identified, data recorded, etc. |
|---|---|
| 1 | |
| 2 | |
| 3 | |

*Signature of Industry Supervisor* *Signature of Section*

*Head/HR Manager Office Seal*

## Attendance Sheet

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

| Month & Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | ... |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | |
| Month & Year | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| Month & Year | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |

*Signature of Industry Supervisor* *Signature of Section Head/HR Manager Office Seal*

**Note:**

- Student's Diary shall be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.
- Attendance Sheet should remain affixed in daily training diary.

Do not remove or tear it off.

- Student shall sign in the attendance column. Do not mark ‘P’.
- Holidays should be marked in red ink in the attendance column. Absent should be marked as ‘A’ in red ink.

**Evaluation done by the Industry (Marks 25)**

**Format for Supervisor Evaluation of Intern**

Student Name :_____Date:_____

Supervisor Name :_____Designation:_____

Company/Organization :_____

Internship Address: _____

Dates of Internship: From_____To _____

***Please evaluate intern by indicating the frequency with which you observed the following parameters:***

| **Parameters** **Marks** | Needs improvement(0 – 0.25 mark) | Satisfactory(0.25 – 0.50 mark) | Good (0.75 mark) | Excellent(1 mark) |
|---|---|---|---|---|
| Behavior | | | | |
| Performs in a dependable Manner | | | | |
| Cooperates with coworkers and supervisor | | | | |
| Shows interest in work | | | | |
| Learns quickly | | | | |
| Shows initiative | | | | |
| Produces high quality work | | | | |
| Accepts responsibility | | | | |
| Accepts criticism | | | | |
| Demonstrates organizational skills | | | | |
| Uses technical knowledge and expertise | | | | |
| Shows good judgment | | | | |
| Demonstrates creativity/originality | | | | |
| Analyzes problems effectively | | | | |

| | | | | |
|---|---|---|---|---|
| Is self-reliant | | | | |
| Communicates well | | | | |
| Writes effectively | | | | |
| Has a professional attitude | | | | |
| Gives a professional appearance | | | | |
| Is punctual | | | | |
| Uses time effectively | | | | |

Overall performance of student

Intern (Tick one) : Needs improvement (0 - 0.50 mark) / Satisfactory (0.50 – 1.0 mark) /Good (1.5 mark) / Excellent (2.0 mark)

Additional comments, if any (2 marks):

*Signature of Industry Supervisor* *Signature of Section*

*Head/HR Manager Office Seal*

**End Semester Evaluation (External Evaluation): 50 Marks**

Internship Report - 25 Marks

Viva Voce - 25 Marks

**Internship Report**: After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty Supervisor. The student may contact Industrial Supervisor/ Faculty Mentor for assigning special topics and problems and should prepare the final report on the assigned topics. Daily diary will also help to a great extent in writing the industrial report since much of the information has alreadybeen incorporated by the student into the daily diary. The training report should be signed by the Internship Supervisor, Programme Coordinator and Faculty Mentor.

The Internship report (25 Marks) will be evaluated on the basis of following criteria:

- Originality
- Adequacy and purposeful write-up
- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taughtin the course

Viva Voce (25 Marks) will be done by a committee comprising Faculty Supervisor, PG Programme Coordinator and an external expert (from Industry or research/academic Institute). This committee will be evaluating the internship report also.

### (v) LABORATORY COURSES

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

### (vi) INDUSTRY BASED ELECTIVE/INTERDISCIPLINARY ELECTIVE

Engineering students frequently aspire to work in areas and domains that are keytopics in the industry. There are concerns by recruiters that skill sets of engineering students did not match with the Industry requirements, especially in the field of latesttopics. In response to their desires, the University has incorporated Industry/Interdisciplinary electives in the curriculum.

Interdisciplinary knowledge is critical for connecting students with current industry trends, where multitasking is the norm. Interdisciplinary knowledge aids in the bridge- building process between academic institutions and industry. It aids pupils in expanding their knowledge and innovating by allowing them to create something new. While core engineering courses provide students with a strong foundation, evolving technology necessitates new methods and approaches to progress, prosperity, and the inculcation of problem-solving techniques. Other courses' knowledge, on the other hand, can assist them to deal with any scenario more effectively. Interdisciplinary courses may be one approach to address such needs, as they can aid in the enhancement of engineering education and the integration of desirable specialised subjects into the current engineering education system. This will enable students to fulfil the current industry demands. Students with multidisciplinary knowledge and projects are more likely to be placed in top industries, according to the placement trend. The future of developing engineers will be influenced by their understanding of emerging technology and interdisciplinary approaches such as big data, machine learning, and 3-D printing.

Rapid technological advancements and the onset of the Fourth Industrial Revolution have resulted in a massive revival in the way engineering works in the industry. Projects necessitate the integration of knowledge and abilities from a diversevariety of engineering specialities, with the barriers between them becoming increasingly blurred.

Students can choose courses offered by other departments/nearby Industries that cover a wide range of highly relevant topics such as artificial intelligence, internet of things, big data, automation, and other

software or other relatable courses.

The assessment pattern for Interdisciplinary electives is as follows:

**Continuous Internal Evaluation: 40 marks**

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination: 60 marks**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

The assessment pattern for Industry based electives is as follows:

**Continuous Internal Evaluation: 40 marks**

The continuous internal evaluation will be done by the expert in the Industry handling the course.

Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

**End Semester Examination: 60 marks**

The examination will be conducted by the respective College with the question paper provided by the Industry. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from

each module of which studentshould answer any five. Each question can carry 12 marks. The valuation of the answer scripts shall be done by the expert in the Industry handling the course.

### (vii) MOOC COURSES

The MOOC course shall be considered only if it is conducted by the agencies namely AICTE/NPTEL/SWAYAM or NITTTR. The MOOC course should have a minimum duration of 8 weeks and the content of the syllabus shall be enough for at least 40 hours of teaching. The course should have a proctored/offline end semesterexamination. The students can do the MOOC according to their convenience, but

shall complete it by third semester. The list of MOOC courses will be provided by theconcerned BoS if at least 70% of the course content match with the area/stream of study. The course shall not be considered if its content has more than 50% of overlapwith a core/elective course in the concerned discipline or with an open elective.

MOOC Course to be successfully completed before the commencement of fourthsemester (starting from semester 1). A credit of 2 will be awarded to all students whoever successfully completes the MOOC course as per the evaluation pattern of the respective agency conducting the MOOC.

### (viii) MINIPROJECT

**Total marks: 100, only CIA**

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem-solving skills. The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation withPG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Interim evaluation: 40 (20 marks for each review), final evaluation by a Committee(will be evaluating the level of completion and demonstration of functionality/specifications, clarity of presentation, oral examination,

work knowledge and involvement): 35, Report (the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level is not more than 25%): 15, Supervisor/Guide: 10

### (ix) RESEARCH PROJECT/DISSERTATION

**Research Project:** Students choosing track 2 shall carry out the research project in their parent Institution only under the guidance of a supervisor assigned by the DLAC.

**Dissertation:** All categories of students in track 1 are to carry out the dissertation in the Institute they are studying or can work either in any CSIR/Industrial R&D organization/any other reputed Institute which have facilities for dissertation work in the area proposed.

**Dissertation outside the Institute**: For doing dissertation outside the Institution, the following conditions are to be met:

- They have completed successfully the course work prescribed in the approved curriculum up to the second semester.
- The student has to get prior approval from the DLAC and CLAC.
- Facilities required for doing the dissertation shall be available in the Organization/Industry (A certificate stating the facilities available in the proposed organization and the time period for which the facilities shall be made available to the student, issued by a competent authority from the Organization/Industry shall be submitted by the student along with the application).
- They should have an external as well as an internal supervisor. The internal supervisor should belong to the parent institution and the external supervisor should be Scientists or Engineers from the Institution/Industry/ R&D organization with which the student is associated for doing the dissertation work. The external supervisor shall be with a minimum post graduate degree in the related area.
- The student has to furnish his /her monthly progress as well as attendance report signed by the external guide and submit the same to the concerned Internal guide.
- The external guide is to be preferably present during all the stages of evaluation of the dissertation.

Note1- Students availing this facility should continue as regular students

ofthe parent institute itself.

Note 2-The course work in the 3rd semester is to be completed as per the curriculum requirements (i) MOOC can be completed as per the norms mentioned earlier (ii) Audit course are to be carried out either in their parentInstitution or by self-learning. However, for self-learning students, all assessments shall be carried out in their parent Institution as in the case ofregular students.

**Internship leading to Dissertation:** The M. Tech students who after completionof 6 to 8 weeks internship at some reputed organization are allowed to continue theirwork as dissertation for the third and fourth semester after getting approval from the DLAC. Such students shall make a brief presentation regarding the work they

propose to carry out before the DLAC for a detailed scrutiny and to resolve its suitability for accepting it as an M.Tech dissertation. These students will be continuing as regular students of the Institute in third semester for carrying out all academic requirements as per the curriculum/regulation. However, they will be permitted to complete their dissertation in the Industry/Organization (where they have successfully completed their internship) during fourth semester.

**Dissertation as part of Employment:** Students may be permitted to discontinue the programme and take up a job provided they have completed all the courses till second semester (FE status students are not permitted) prescribed in the approved curriculum. The dissertation work can be done during a later period either in the organization where they work if it has R & D facility, or in the Institute. Such students should submit application with details (copy of employment offer, plan of completion of their project etc.) to the Dean (PG) through HoD. The application shall be vetted by CLAC before granting the approval. When the students are planning to do the dissertation work in the organization with R & D facility where they are employed, they shall submit a separate application having following details:

- Name of R&D Organization/Industry
- Name and designation of an external supervisor from the proposed Organization/Industry (Scientists or Engineers with a minimum post graduate degree in the related area) and his/her profile with consent
- Name and designation of a faculty member of the Institute as internal supervisor with his/her consent
- Letter from the competent authority from the

Organization/Industry granting permission to do the dissertation

- Details of the proposed work
- Work plan of completion of project

DLAC will scrutinize the proposal and forward to CLAC for approval.

When students are doing dissertation work along with the job in the organization (with R & D facility) where they are employed, the dissertation work shall be completed in four semesters normally (two semesters of dissertation work along with the job may be considered as equivalent to one semester of dissertation work at the Institute). Extensions may be granted based on requests from the student and recommendation of the supervisors such that he/she will complete the M. Tech programme within four years from the date of admission as per the regulation. Method of assessment and grading of the dissertation will be the same as in the case of

regular students. The course work in the 3rd semester for such students are to be completed as per the curriculum requirements (i) MOOC can be completed as per thenorms mentioned earlier (ii) Audit course are to be carried out either in their parent Institution or by self learning. However, for self learning students, all assessments shall be carried out in their parent Institution as in the case of regular students.

**Mark Distribution:**

**Phase 1: Total marks: 100, only CIA**

**Phase 2: Total marks: 200, CIA = 100 and ESE = 100 marks**

### (x) TEACHING ASSISTANCESHIP (TA)

All M.Tech students irrespective of their category of admission, shall undertake TA duties for a minimum duration as per the curriculum. Being a TA, the student will get an excellent opportunity to improve their expertise in the technical content of thecourse, enhance communication skills, obtain a hands-on experience in handling theexperiments in the laboratory and improve peer interactions.

The possible TA responsibilities include the following: facilitate a discussion section or tutorial for a theory/ course, facilitate to assist the students for a laboratorycourse, serve as a mentor for students, and act as the course web-master. TAs maybe required to attend the instructor's lecture regularly. A TA shall not be employed asa substitute instructor, where the effect is to relieve the instructor of his or her teaching responsibilities (specifically prohibited by University Policy).

**For the tutorial session:**

(i) Meet the teacher and understand your responsibilities well in advance, attend the lectures of the course for which you are a tutor, work out the solutions for all the tutorial problems yourself, approach the teacher if you find any discrepancy or if you need help in solving the tutorial problems, use reference text books, be innovative and express everything in English only.

(ii) Try to lead the students to the correct solutions by providing appropriate hints rather than solving the entire problem yourself, encourage questions from the students, lead the group to a discussion based on their questions, plan to ask them some questions be friendly and open with the students, simultaneously being firm with them.

(iii) Keep track of the progress of each student in your group, give a periodic feedback to the student about his/her progress, issue warnings if the student is

consistently under-performing, report to the faculty if you find that a particular student is consistently underperforming, pay special attention to slow-learners and be open to the feedback and comments from the students and faculty.

(iv) After the tutorial session you may be required to grade the tutorials/assignments/tests. Make sure that you work out the solutions to the questions yourself, and compare it with the answer key, think and work out possible alternate solutions to the same question, understand the marking scheme from the teacher. 3. Consult the teacher if are and make sure that you are not partial to some student/students while grading. Follow basic ethics.

**Handling a laboratory Session:**

(i) Meet the faculty – in- charge a few days in advance of the actual lab class and get the details of the experiment, get clarifications from him/her regarding all aspects of the experiment and the expectations, prepare by reading about the theoretical background of the experiment, know the physical concepts involved in the experiment, go to the laboratory and check out the condition of the equipment/instrumentation, perform the laboratory experiment at least once one or two days before the actual laboratory class, familiarize with safety/ security aspects of the experiment / equipment/laboratory, prepare an instruction sheet for the experiment in consultation with the faculty, and keep sufficient copies ready for distribution to students for their reference.

(ii) Verify condition of the equipment/set up about 30 minutes before the students arrive in the class and be ready with the hand outs, make brief introductory remarks about the experiment, its

importance, its relevance to the theory they have studied in the class, ask the students suitable questions to know there level of preparation for the experiment, discuss how to interpret results, ask them comment on the results.

(iii) Correct/evaluate/grade the submitted reports after receiving suitable instructions from the faculty in charge, continue to interact with students if theyhave any clarifications regarding any aspect of the laboratory session, including of course grading, Carefully observe instrument and human safety in laboratoryclass, Preparing simple questions for short oral quizzing during explanation of experiments enables active participation of students, facilitate attention, provides feedback and formative assessment.

**POINTS TO REMEMBER**

1. Arrange an awareness programme to all M.Tech students on day 1 regarding the curriculum and the regulation.
2. Make them aware about two tracks and its distinct features.
3. The departments should prepare the list of MOOC courses suitable to their programmes and encourage the students to complete at the earliest.
4. Make a tie up with industries by the middle of semester for Industry Electives. While choosing the Industry and the Industry electives, it should be ensured that the programme is relevant and updated in that discipline. The Industry expert handling the elective shall be a postgraduate degree holder. The evaluation procedure shall also be clearly explained to them.
5. If nearby Industries are not available, encourage all departments to offer courses for other disciplines that enrich interdisciplinary research.
6. Each department offering M.Tech programme should be careful in selecting the miniproject in semester 2. The miniproject should lead to dissertation/research project.
7. The departments should invite the Industries/research organizations during first semester and inform them about the mandatory 6-8 weeks internship that the students should undergo after their second semester. The possibility of doing their dissertation at the Industry shall also be explored. They should also be made aware about the evaluation procedure of the Internships. They may also be informed that it is possible to continue internship provided if it leads to their dissertation. Proposals may be collected from them for allotting to students

according to their fields of interest.

8. Make sure that all internal assessments and the end semester examinationsto be conducted by the respective Institutions are carried out as per the assessment procedure listed in the curriculum. Any dilution from the prescribed procedure shall be viewed seriously.
9. Teaching assistance shall be assigned to all students as per the curriculum. However, a TA shall not be employed as a substitute instructor, where the effect is to relieve the instructor of his or her teaching responsibilities (strictly prohibited by University Policy).
10. The possible TA responsibilities include the following: facilitate a discussionsection or tutorial for a theory/ course, facilitate to assist the students for a laboratory course, serve as a mentor for students, and act as the course web-master