Mahatma Education Society's

# School of Engineering

Pillai University
From Knowledge to Creation

Dr. K. M. Vasudevan Pillai's Campus , Sector 16, New Panvel – 410 206.

## Department of Electronics & Computer Science

**Syllabus**

*of*

## M.Tech. in Electronics & Computer Science

*for*

**The Admission Batch of AY 2026-27**

**First Year -** Effective from Academic Year **2026-27**

**Second Year -** Effective from Academic Year **2027-28**

*as per*

**Choice Based Credit and Grading System**

Mahatma Education Society's

# School of Engineering

Dr. K. M. Vasudevan Pillai's Campus , Sector - 16, New Panvel – 410 206

## Vision

Pillai College of Engineering (PCE) will admit, educate and train a diverse population of students who are academically prepared to benefit from the Institute's infrastructure and faculty experience, to become responsible professionals or entrepreneurs in a technical arena. It will further attract, develop and retain, dedicated, excellent teachers, scholars and professionals from diverse backgrounds whose work gives them knowledge beyond the classroom and who are committed to making a significant difference in the lives of their students and the community.

## Mission

To develop professional engineers with respect for the environment and make them responsible citizens in technological development both from an Indian and global perspective. This objective is fulfilled through quality education, practical training and interaction with industries and social organizations.

# Department of Electronics & Computer Science

## Vision

To produce professionally competent and socially responsible engineers capable of working globally.

## Mission

To provide in-depth quality education in Electronics & Computer Science Engineering and prepare the students for lifelong learning.

To develop professional engineers who can critically and creatively apply the knowledge of engineering principles to solve real world problems.

To inculcate entrepreneurship skills and impart ethical and social values.

Engineering Graduates will be able to

1. Gain knowledge and skills to analyse and design Electronics circuits as well as Computer Programs.
2. Develop hardware and software systems in the areas like Artificial Intelligence & Machine learning, Big Data, Information Security, Automation, Embedded Systems, Signal Processing and Communication Systems.
3. Apply modern Electronics and Computer engineering techniques and tools to find solutions for real life interdisciplinary problems.

The Autonomous status of the institute has given an opportunity to design and frame the curriculum in such a way that it incorporates all the needs and requirements of recent developments in all fields within the scope of the Technical education. This curriculum will help graduates to attain excellence in their respective field. The curriculum has a blend of basic and advanced courses along with provision of imparting practical knowledge to students through projects. The syllabus has been approved and passed by the Board of Studies.

Outcome based education is implemented in the academics and every necessary step is undertaken to attain the requirements. Every course has its objectives and outcomes defined in the syllabus which are met through continuous assessment and end semester examinations. Evaluation is done on the basis of Choice Based Credit and Grading System (CBCGS). Optional courses are offered at department and institute level. Selection of electives from the same specialization makes the student eligible to attain a M. Tech. degree.

Every learner/student will be assessed for each course through (i) an Internal/Continuous assessment during the semester in the form of either Practical Performance, Presentation, Demonstration or written examination and (ii) End Semester Examination (ESE), in the form of either theory or viva voce or practical, as prescribed by the respective Board Studies and mentioned in the assessment scheme of the course content/syllabus. This system involves the Continuous Evaluation of students' progress Semester wise. The number of credits assigned with a course is based on the number of contact hours of instruction per week for the course. The credit allocation is available in the syllabus scheme of each semester.

The performance of a learner in a semester is indicated by a number called Semester Grade Performance Index (SGPI). The SGPI is the weighted average of the grade points obtained in all the courses by the learner during the semester. For example, if a learner passes five courses (Theory/labs./Projects/ Seminar etc.) in a semester with credits C1, C2, C3, C4 and C5 and learners grade points in these courses are G1, G2, G3, G4 and G5 respectively, then learners SGPI is equal to:

$$SGPI = \frac{C_1G_1 + C_2G_2 + C_3G_3 + C_4G_4 + C_5G_5}{C_1 + C_2 + C_3 + C_4 + C_5}$$

The learner's up to date assessment of the overall performance from the time s/he entered for the programme is obtained by calculating a number called the Cumulative Grade Performance Index (CGPI), in a manner similar to the calculation of SGPI. The CGPI therefore considers all the courses mentioned in the scheme of instructions and examinations, towards the minimum requirement of the degree learners have enrolled for. The CGPI at the end of this semester is calculated as,

$$CGPI = \frac{C_1G_1 + C_2G_2 + C_3G_3 + \ldots + C_i * G_i + \ldots + C_nG_n}{C_1 + C_2 + C_3 + \cdots + C_i + \ldots + C_n}$$

The Department of Electronics & Computer Science offers a M. Tech. programme in Electronics & Computer Science. This is a four semester course. The complete course is a 72 credit course which comprises core courses and elective courses.

The credit requirement for the M.Tech. in Electronics & Computer Science is tabulated in Table 1.

Table 1. Credit Requirement for M.Tech in Electronics & Computer Science

| Semester | Credits |
|---|---|
| I | **20** |
| II | **20** |
| III | **20** |
| IV | **20** |
| **Total Credits** | **80** |

# Program Structure for
# Master of Technology in Electronics & Computer Science
# Semester I

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | Credits Assigned | | |
|---|---|---|---|---|---|---|
| | | Theory | Pract | Theory | Practical | Total |
| CE 500 | Computer programming Paradigms | 04 | - | 04 | - | 04 |
| COMM 501 | Business Communication and Intellectual Property Rights | 04 | -- | 04 | -- | 04 |
| ECS 50x | Department Level Optional Course-I | 03 | -- | 03 | -- | 03 |
| ECS 50x | Department Level Optional Course-II | 03 | -- | 03 | -- | 03 |
| ECS 50x | Department Level Optional Course-III | 03 | -- | 03 | -- | 03 |
| ECS 507 | ECS Course Lab-I | - | 02 | - | 01 | 01 |
| ENGG 597 | Dissertation-I | -- | 04 | -- | 02 | 02 |
| **TOTAL** | | **17** | **06** | **17** | **03** | **20** |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Oral/Practical | Total |
| | | Internal Assessment | | | End Sem Exam | Exam Duration (Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| CE 500 | Computer programming Paradigms | 40 | 40 | 40 | 60 | 2 | - | - | 100 |
| COMM 501 | BusinessCommunication and Intellectual Property Rights | 40 | 40 | 40 | 60 | 2 | - | - | 100 |
| ECS 50x | Department Level Optional Course-I | 40 | 40 | 40 | 60 | 2 | - | - | 100 |
| ECS 50x | Department Level Optional Course-II | 40 | 40 | 40 | 60 | 2 | - | - | 100 |
| ECS 50x | Department Level Optional Course-III | 40 | 40 | 40 | 60 | 2 | - | - | 100 |
| ECS 507 | ECS Course Lab-I | -- | -- | -- | -- | -- | 25 | 25 | 50 |
| ENGG 597 | Dissertation-I | -- | -- | -- | -- | -- | 50 | 50 | 100 |
| TOTAL | | **200** | **200** | **200** | **300** | **10** | **75** | **75** | **650** |

| Course Code | Department Level Elective Course-I |
|---|---|
| **CE 316** | Natural Language Processing |
| ECS 501 | Generative and Explainable AI |
| **ITE 332** | Advanced Big Data Analytics |

| Course Code | Department Level Elective Course-II |
|---|---|
| ECS 502 | Advanced Mobile Communication |
| ECS 503 | Wireless Technology |
| ECS 504 | Ethical Hacking and Digital Forensics |

| Course Code | Department Level Elective Course-III |
|---|---|
| ECS 505 | Advanced Processor Architecture-I |
| ECS 506 | Embedded System and RTOS |
| **ECS 324** | Advanced Robotics |

# Program Structure for
# Master of Technology in Electronics & Computer Science
# Semester II

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | Credits Assigned | | |
|---|---|---|---|---|---|---|
| | | Theory | Pract | Theory | Practical | Total |
| **CE 512** | Research Methodology | 04 | - | 04 | - | 04 |
| **ECS 314** | Integrated Circuit Technology | 04 | -- | 04 | -- | 04 |
| ECS 5xx | Department Level Optional Course-IV | 03 | -- | 03 | -- | 03 |
| ECS 5xx | Department Level Optional Course-V | 03 | -- | 03 | -- | 03 |
| ECS 5xx | Department Level Optional Course-VI | 03 | -- | 03 | -- | 03 |
| ECS 523 | ECS Course Lab-II | - | 02 | - | 01 | 01 |
| ENGG 598 | Dissertation-II | -- | 04 | -- | 02 | 02 |
| **TOTAL** | | **15** | **10** | **15** | **05** | **20** |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem Exam | Exam Duration (Hrs) | | | |
| | | Test1 | Test 2 | Avg | | | | | |
| **CE 512** | Research Methodology | 40 | 40 | 40 | 60 | 2 | - | - | 100 |
| **ECS 314** | Integrated Circuit Technology | 40 | 40 | 40 | 60 | 2 | - | - | 100 |
| ECS 5xx | Department Level Optional Course-IV | 40 | 40 | 40 | 60 | 2 | - | - | 100 |
| ECS 5xx | Department Level Optional Course-V | 40 | 40 | 40 | 60 | 2 | - | - | 100 |
| ECS 5xx | Department Level Optional Course-VI | 40 | 40 | 40 | 60 | 2 | - | - | 100 |
| ECS 523 | ECS Course Lab-II | -- | -- | -- | -- | -- | 25 | 25 | 50 |
| ENGG 598 | Dissertation-II | -- | -- | -- | -- | -- | 50 | 50 | 100 |
| **TOTAL** | | **200** | **200** | **200** | **300** | **10** | **75** | **75** | **650** |

| Course Code | Department Level Elective Course-IV |
|---|---|
| **ITE 331** | Deep Learning and Advanced Neural Networks |
| **ECS 409** | Intelligent Robotics |
| **CE 505** | Reinforcement Learning |

| Course Code | Department Level Elective Course-V |
|---|---|
| ECS 520 | Advanced Processor Architecture-II |
| **ECS 327** | Advanced VLSI Design |
| ECS 521 | FPGA-based System Design |

| Course Code | Department Level Elective Course-VI |
|---|---|
| **ECS 522** | Blockchain Technology |
| **ECS 418** | Internet of Everything |
| ECS 411 | Edge and Fog Computing |

# Program Structure for
# Master of Technology in Electronics & Computer Science
# Semester III

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | Credits Assigned | | |
|---|---|---|---|---|---|---|
| | | Theory | Pract | Theory | Practical | Total |
| ECS 530 | Advanced Data Science | 3 | - | 3 | - | 3 |
| ENGG 695 | Internship / Relevant Certification | - | 04 | - | 02 | 02 |
| ENGG 697 | Dissertation-III | - | 30 | - | 15 | 15 |
| **TOTAL** | | - | - | 3 | 17 | **20** |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem Exam | Exam Duration (Hrs) | | | |
| | | Test1 | Test 2 | Avg | | | | | |
| ECS 530 | Advanced Data Science | 40 | 40 | 40 | 60 | 2 | - | - | 100 |
| ENGG 695 | Internship / Relevant Certification | - | - | - | - | - | 50 | 50 | 100 |
| ENGG 697 | Dissertation-III | - | - | - | - | - | 50 | 100 | 150 |
| **TOTAL** | | - | - | - | - | - | 100 | 150 | 350 |

# Program Structure for
# Master of Technology in Electronics & Computer Science
# Semester IV

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | Credits Assigned | | |
|---|---|---|---|---|---|---|
| | | Theory | Pract | Theory | Practical | Total |
| ENGG 698 | Dissertation-IV | - | 40 | - | 20 | 20 |
| **Total** | | - | 40 | - | 20 | **20** |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem Exam | Exam Duration (Hrs) | | | |
| | | Test1 | Test 2 | Avg | | | | | |
| ENGG 698 | Dissertation-IV | - | - | - | - | - | 100 | 100 | 200 |
| **TOTAL** | | - | - | - | - | - | 100 | 100 | 200 |

# Master of Technology
# In
# Electronics & Computer Science

# (Semester I)

| Course Code | Course Name | Theory (Hrs.) | Practical (Hrs.) | Tutorial (Hrs.) | Theory (Credits) | Practical /Oral (Credits) | Tutorial (Credits) | Total (Credits) |
|---|---|---|---|---|---|---|---|---|
| CE500 | Computer programming Paradigms | 04 | - | -- | 04 | - | -- | 04 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory Marks | | | | Term Work | Practical | Oral | Total |
| | | Internal assessment | | | End Sem. Exam | | | | |
| | | 1 | 2 | Average | | | | | |
| CE500 | Computer programming Paradigms | 40 | 40 | 40 | 60 | - | -- | - | 100 |

**Prerequisite:** Basic of programming languages

**Course Objectives:**
This course will help the students to learn

1. To Introduce students to functional, logic and concurrent programming paradigms.
2. To Enable students to formulate newer abstractions in the above paradigms.
3. To Familiarize students with writing functional and Object oriented programs.
4. To Prepare students to solve real-world problems using appropriate programming paradigms.

**Course Outcomes:**
On successful completion of course learner/student will be able to:

1. Understand and apply the concepts that form the basis of functional, logic and object oriented programming paradigms.
2. Formulate abstractions with procedures and data in different programming paradigms.
3. Write programs in different programming paradigms especially functional, logic and object oriented paradigms.
4. Formulate, implement and solve a given problem scenario using appropriate programming paradigm.

**Detailed Theory Syllabus:**

| Sr. No. | Module | Detailed Content | Hours |
|---|---|---|---|
| 1 | **Introduction Programming Paradigms** | **Overview of different programming paradigms** – Imperative,logical, functional and object-oriented Programming. | 4 |
| 2 | **Java Programming** | **Introduction:** Principles of OOP, Classes, Objects, Abstraction, Encapsulation, Inheritance, Polymorphism, Message passing Features of Java Language , Data Types, Operators.<br>**Control Statements:** If-Statement, If-else, Nested-if, Switch Statement, break, continue.<br>**Iteration Statements:** for-loop, while-loop, and do-while-loop. | 10 |
| 3 | **Python Programming** | **Introduction:** Features, Identifiers, Keywords, Indention, Variables and Comments, Basic data types: Numeric, Boolean, Compound.<br>**Operators:** Arithmetic, comparison, relational, assignment, logical, bitwise, membership, identity operators, operator precedence.<br>**Control flow statements:** Conditional statements (if, if…else, nested if. Looping in Python: while-loop, for-loop, nested-loops, Loop manipulation using continue, pass, break.<br>**Functions:** Introduction to Functions, Decorators, Iterators and Generators. | 10 |
| 4 | **R Programming** | **Introduction:** Basic functionalities of R , data types and operations: numbers, characters and composites, Numeric variables, strings and factors,R packages.<br>**Data structures:** vectors, matrices, lists and data frames.Grouping, loops and conditional execution, Functions.<br>**Exploratory data analysis:** Range, summary, mean, variance, median, standard deviation, histogram, box plot, scatterplot,Graphics and tables , Visualizations and interpretation of results. | 10 |
| 5 | **Matlab programming** | **Introduction:** Features, Interface, File Types, Array, Matrix Operation. Arithmetic Operator Logical, Relational.<br>**Branch and Loop:** If-statement, If-else statement, Else-if statement Pause, Break, Continue, Switch-case, try-catch, Return Statement, For Loop,While Loop. Types of Function, Return Types.<br>**Interface and Graphics:** Plotting, Multiple Plot, 2-D Plot, Introduction to Graphical User Interface, GUI Function, Property, GUI Component Design. | 10 |
| 6 | **Metaverse Technology** | History, Features, Metaverse value chain, Technologies Involved in the Metaverse.<br>Blockchain Adoption in Metaverse, AR, VR, MR in Metaverse, NFT (non-fungible token) for Metaverse.<br>Financial and Economics of Metaverse, Benefits of Metaverse, Use-cases. | 8 |

**Theory Assessment:**
**Internal Assessment: 40 marks**

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

**End Semester Examination: 60 Marks**
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

**Books and References:**

**A. Books:**

1. Scott M L, Programming Language Pragmatics, 4th Edn., Morgan Kaufmann Publishers, 2015
2. E. Balaguruswamy, “Programming with Java A primer”, Fifth edition, Tata McGraw Hill Publication
3. Dr. R. Nageswara Rao, ”Core Python Programming” , Dreamtech Press, Wiley Publication
4. Metaverse: Introduction to The Virtual Reality, Augmented Reality,ISBN-13 : 978-1806030484
5. Beginning R: The Statistical Programming Language by Dr. Mark Gardener, Wiley Publications
6. Peter I. Kattan, MATLAB for Beginners: A Gentle Approach, 2008. ISBN: 9781438203096

**B. References:**

1. Programming Languages: Concepts and Constructs; 2nd Edition, Ravi Sethi, Pearson Education
   Asia, 1996.
2. Herbert Schildt, “Java-The Complete Reference”, Tenth Edition, Oracle Press, Tata McGraw Hill Education.
3. Navigating the Metaverse by Cathy Hackl, Dirk Lueth, Tommaso Di Bartolo, John Arkontaky, Siu Released May 2022 Publisher(s): Wiley ISBN: 9781119898993
4. Hands-On Programming with R by Grolemund, O Reilly Publications
5. Stormy Attaway, "MATLAB: A Practical Introduction to Programming and Problem Solving,"2018, Butterworth-Heinemann, ISBN: 978-0128154793

| Course Code | Course Name | Theory (Hrs.) | Practical (Hrs.) | Tutorial (Hrs.) | Theory (Credits) | Practical /Oral (Credits) | Tutorial (Credits) | Total (Credits) |
|---|---|---|---|---|---|---|---|---|
| COMM 501 | Business Communication and Intellectual Property | 04 | -- | -- | 04 | – | -- | 04 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory Marks | | | | Term Work | Practical | Oral | Total |
| | | Internal assessment | | | End Sem. Exam | | | | |
| | | 1 | 2 | Average | | | | | |
| COMM 501 | Business Communication and Intellectual Property | 40 | 40 | 40 | 60 | - | -- | – | 100 |

**Course Objectives:**

1. To provide an outline to effective organisational communication.
2. To enable learners to formulate professional documents in a structured manner that meets the corporate requirements.
3. To foster a comprehensive understanding of marketing strategies for establishing the brand of the business using digital technologies and aim at better customer experience
4. To develop creative and impactful presentation skills
5. To acquaint learners with the procedure of obtaining Patents, Copyrights, Trademarks and Industrial designs
6. To inculcate the ethical code of conduct and corporate etiquettes.

**Course Outcomes:**

1. Apply business communication strategies and principles to prepare effective communication for developing and presenting business messages.
2. Acquire the writing skills necessary for professional documents to meet the corporate requirement.
3. Understand existing and emerging social media tools to execute a comprehensive communication plan.
4. Able to illustrate effective presentation, research, organisational and creative skills necessary for lifelong learning.
5. Recognize the crucial role of IP in organisations of different industrial sectors for the purposes of product and technology development.

6. Able to determine the importance of ethics and etiquettes in social and professional situations

**Prerequisite:** Basic language skills

**DETAILED SYLLABUS:**

| Sr. No. | Module | Detailed Content | Hours |
|---|---|---|---|
| **1.** | **Business Communication** | 1.1 Role of communication in business organisation<br>1.2 Relevance of communication<br>1.3 Types- Verbal Non-verbal<br>1.4 Channels- Vertical, Horizontal and Lateral | 5 |
| **2.** | **Business Writing** | 2.1 Business Proposals ( SWOT analysis)<br>2.2 Grant / Research Proposals<br>2.3 1.2 Memos<br>2.4 1.3 Press Releases<br>2.5 1.4 Business Plans | 12 |
| **3.** | **Digital Social Media** | 3.1 Communicating via Social Media<br>3.2 Social Media and Public Relations, Social Media strategy and Planning<br>3.3. Content Strategy. Web Content, Organisation and Distribution<br>3.4 Social Networking Sites (LinkedIn, Twitter), Photo sharing Sites ( Instagram, Snapchat, Pinterest<br>3.5 News Writing and Community Management<br>3.6. Facebook and business<br>3.7. YouTube and Live Streaming | 8 |
| **4.** | **Speaking Skills** | 4.1 Speaking on Panels, Moderating Panels, Speaking as keynote or Individual Talk<br>4.2 Introducing speakers, Summarising speeches and Meeting conference content<br>4.3 Presentation Skills-<br>Visually present relationship between two or more data sets<br>Data Presentation Methods- Line graph, Column chart, Vertical bar, scatter plot<br>Presentation style- Audience analysis, Care and concern for the audience, effective use of transitions and animations, slide design and content. | 10 |
| **5.** | **Intellectual Property For Business** | 5.1. Meaning, Relevance, Business Impact, Protection of Intellectual Property<br>5.2. Types of Intellectual Property | 12 |

| | | | |
|---|---|---|---|
| | | **Copyrights** – Introduction, Nature of copyright, Indian copyright law, copyright works, Author and ownership of copyright, Licensing of copyrights, Infringement of copyrights, Remedies and actions, Copyright for digital media, Software/ Internet<br>**Patents-** Concept of patent, Product/Process Patents, Patent Law, Patentable subject matter, Patentability criteria, Duration of patent, Procedure for filing Patent Application, Types of Applications, Procedure of Opposition, Revocation of Patents, Ownership and Maintenance of Patents, Compulsory licensing, Qualification and registration Procedure<br>**Trademarks-** Introduction, Rationale of protection of trademark as (a) an aspect of commercial and (b) of consumer rights, Kinds of marks (brand names, logos, signatures, symbols, well known marks, certification marks and service marks), Indian Trademarks Law, Procedure for Registration of Trademarks, Non Registrable Trademarks, Infringement of Trademarks and Right of Goodwill, Offences and Penalties<br>**Trade secrets**<br>**Designs-** Need for Protection of Industrial designs, Procedure and Infringement<br>**Geographical Indications –** Concept, Procedure of Registration, duration of protection, Infringement, Penalties and Remedies | |
| **6.** | **Ethics and Ethical Code of Conduct** | 6.1 Writing Resume and statement of purpose<br>6.2 Business and corporate activities(special emphasis on business meetings, emails, blogs and web pages)<br>6.3 Personal ethics, conflicting values, choosing a moral response, the process of making ethical decisions. | 5 |

**Theory Assessments:**

**1. Internal Assessment:** Two Internal assessments will be conducted for 40 marks each with average marks of both assessments as final score.

**2. End Sem Theory Examination:**

- Question paper will consist of 5 questions, each carrying 20 marks.
- Total 3 questions need to be solved.
- Q.1 will be compulsory, based on the entire syllabus.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

**Text Books and References:**

1.Raman Meenakshi & Singh Prakash, *Business Communication Second edition,* Oxford University Press, Paperback, 2012.

2. Jeremy Harris Lipschultz, *Social Media Communication: Concepts, Practices, Data, Law and Ethics Third edition,* Paperback, 2020

3. V. K. Ahuja, *Intellectual Property Rights In India,* Hardcover, 2015

| Course Code | Course Name | Theory (Hrs.) | Practical (Hrs.) | Tutorial (Hrs.) | Theory (Credits) | Practical /Oral (Credits) | Tutorial (Credits) | Total (Credits) |
|---|---|---|---|---|---|---|---|---|
| CE316 | Natural Language Processing | 03 | -- | -- | 03 | -- | -- | 03 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory Marks | | | | Term Work | Practical | Oral | Total |
| | | Internal assessment | | | End Sem. Exam | | | | |
| | | 1 | 2 | Average | | | | | |
| CE316 | Natural Language Processing | 40 | 40 | 40 | 60 | – | – | – | 100 |

**Course Objectives:**

1. To understand natural language processing and to learn how to apply basic algorithms in this field.
2. To understand the basic text processing techniques and significance of morphology.
3. To get acquainted with the basic concepts and algorithmic description of the main language levels, syntax, semantics.
4. To understand language models generation and applications.
5. To recognize the significance of pragmatics and discourse for natural language understanding.
6. To design and implement applications based on natural language processing

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

1. Have a broad understanding of the field of natural language processing.
2. Apply text processing techniques and analysis of morphology of text
3. Model linguistic phenomena with formal grammars and design semantic structure
4. Create language model and apply it for NLP applications
5. Understand the mathematical and linguistic foundations underlying approaches to analyse pragmatic and resolve coreference
6. Apply NLP techniques to design real world NLP applications such as machine translation, text categorization, text summarization, information extraction...etc

**Prerequisite:** Data structure & Algorithms, Theory of computer science, Probability Theory

**DETAILED THEORY SYLLABUS:**

| Sr. No. | Module | Detailed Content | Hrs |
|---|---|---|---|
| 1. | **Introduction** | Introduction Introduction to Natural Language Processing, History of NLP, Natural Language Generation, Natural Language Understanding, Generic NLP system, Ambiguity in Natural language, Stages in NLP, Challenges of NLP | 07 |
| **2.** | **Morphology analysis and Language modeling** | Text Processing Challenges, Pre-processing of text (tokenization, text filtration, script validation, stop words), Survey of English and Indian Language Morphology, Inflectional morphology & Derivational morphology, Stemming (Porter stemmer), Lemmatization, Regular expression, Morphological parsing with FST, The role of language models, Simple N-gram models, N-gram for spelling correction. | 07 |
| **3.** | **Syntax analysis** | Part-Of-Speech tagging( POS)- Tag set for English ( Penn Treebank), Rule based POS tagging, Stochastic POS tagging, Introduction to CFG, Parsing with CFG,Sequence labelling: Hidden Markov Model (HMM), Maximum Entropy, and Conditional Random Field (CRF). | 07 |
| **4.** | **Semantic Analysis** | Lexical Semantics, Attachment for fragment of English sentences, noun phrases, Verb phrases, prepositional phrases, Relations among lexemes & their senses (Homonymy, Polysemy, Synonymy, Hyponymy) WordNet, Vector Space Models of Semantics, Word Sense Disambiguation (WSD), Semantic Role Labelling, Semantic Parsing | 06 |
| **5.** | **Discourse Context and World Knowledge** | Pragmatic analysis and understanding, Discourse: reference resolution, Reference Phenomena, Preferences in Pronoun Interpretation and resolution, Syntactic and Semantic Constraints on Coreference, Coreference Resolution: Coreference, Distinctions in Coreference, Coreference vs. Anaphora, Application,Challenges of Coreference Resolution | 06 |
| **6.** | **Applications of NLP** | Machine translation, Information retrieval, Question answers system, categorization, summarization, sentiment analysis, Named Entity Recognition,Plagiarism Detection | 06 |

**Theory Assessments:**

**1. Internal Assessment:** Two Internal assessments will be conducted for 40 marks each with average marks of both assessments as final score.

**2. End Sem Theory Examination:**

- Question paper will consist of 4 questions, each carrying 20 marks.
- Total 3 questions need to be solved.
- Q.1 will be compulsory, based on the entire syllabus.

- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

**Books & References:**

**A. Books:**

1. Sharvari Govilkar, Sagar Kulkarni, Dhiraj Amin — Natural Language Processing, 2018, StartEDU solutions.
2. Daniel Jurafsky, James H. Martin —Speech and Language Processing‖ Second Edition, Prentice Hall, 2008.
3. Christopher D.Manning and Hinrich Schutze, — Foundations of Statistical Natural Language Processing —, MIT Press, 1999.

**B. References:**

1. Siddiqui and Tiwary U.S., Natural Language Processing and Information Retrieval, Oxford University Press (2008).
2. Daniel M Bikel and ImedZitouni — Multilingual natural language processing applications Pearson, 2013.
3. Alexander Clark (Editor), Chris Fox (Editor), Shalom Lappin (Editor) — The Handbook of Computational Linguistics and Natural Language Processing
4. Steven Bird, Ewan Klein, Natural Language Processing with Python, O'Reilly
5. Brian Neil Levine, An Introduction to R Programming
6. Niel J le Roux, Sugnet Lubbe, A step by step tutorial: An introduction into R application and programming.

| Course Code | Course Name | Theory (Hrs.) | Practical (Hrs.) | Tutorial (Hrs.) | Theory (Credits) | Practical /Oral (Credits) | Tutorial (Credits) | Total (Credits) |
|---|---|---|---|---|---|---|---|---|
| ECS 501 | Generative and Explainable AI | 03 | -- | -- | 03 | -- | -- | 03 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory Marks | | | | Term Work | Practical | Oral | Total |
| | | Internal assessment | | | End Sem. Exam | | | | |
| | | Test1 | Test 2 | Avg. of 2 Tests | | | | | |
| ECS 501 | Generative and Explainable AI | 40 | 40 | 40 | 60 | - | -- | - | 100 |

**Course Objectives:**

1. To Understand the fundamentals and mathematical foundations of generative models.
2. To Design and train GANs for realistic data generation and various applications.
3. To Implement VAEs for feature learning, dimensionality reduction, and probabilistic data modeling.
4. To Develop explainable AI (XAI) skills using feature attribution, saliency maps, and attention mechanisms for model interpretability.
5. To Apply explainability techniques along with visualization methods to interpret generative models.
6. To Explore advanced generative models and their explainability for real-world AI applications.

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

1. Explain the fundamental concepts, mathematical foundations, and significance of generative models.
2. Design and implement Generative Adversarial Networks (GANs) for various applications.
3. Develop and Apply Variational Autoencoders (VAEs) for feature learning, dimensionality reduction, and probabilistic data modeling.
4. Apply Explainable AI (XAI) techniques to interpret AI models and enhance transparency, trust, and decision-making.
5. Evaluate explainable generative models using XAI and visualization techniques.
6. Assess advanced generative and explainable AI models for emerging applications and research.

**Prerequisite:** Applied Mathematics, Machine Learning Fundamentals, Probability and Statistics, Programming Skills

**DETAILED THEORY SYLLABUS:**

| Sr. No. | Module | Detailed Content | Hours |
|---|---|---|---|
| 1. | **Introduction to Generative Models** | Overview of generative models, Basic concepts: generative processes, probability theory, and mathematical foundations, Role of Generative models in various applications. | 06 |
| **2.** | **Generative Adversarial Networks (GANs)** | History and motivation for GANs, Adversarial Training: Adversarial networks, generator and discriminator, Loss functions: binary cross-entropy, KL-divergence, Optimization algorithms: gradient descent, Adam; GAN Architectures: Convolutional GANs (CGANs), Conditional GANs (CGANs), Variational Autoencoder-GAN (VAE-GAN), StyleGAN; Realistic Image generation, Data augmentation, Challenges and limitations of GANs. | 08 |
| **3.** | **Variational Autoencoders (VAEs) and Variational Inference** | Overview of VAEs and variational inference, Mathematical foundations: evidence lower bound, and reparameterization trick; Role of VAEs in dimensionality reduction, feature learning, and density estimation. | 06 |
| **4.** | **Explainable AI Fundamentals** | Introduction to Explainable AI (XAI); Evolution of XAI, Need for Explainability: Trust and transparency in AI, Legal and regulatory requirements, User acceptance and adoption; Explainability vs Interpretability; Types of Interpretability, Interpretability techniques: feature attribution, saliency maps, attention mechanisms; model interpretability and decision-making systems using XAI. | 08 |
| **5.** | **Explainable Generative Models** | Types of explainable generative models: neural networks, Bayesian networks, Explainable generative models: LIME, TreeExplainer, SHAP, Visualization techniques for generative models: t-SNE, PCA, UMAP; Evaluation of Explainability: Quantitative Metrics, Qualitative Methods; Case Study: applying explainability techniques to various domains (e.g. medical imaging, recommender systems). | 06 |
| **6.** | **Advanced Models in Generative and Explainable AI** | Advanced topics in generative models: flow-based models, normalizing flows, diffusion models, Advanced topics in explainable AI: causality detection, model-based explanations, multi-modal fusion. Research directions and future trends in generative and explainable AI. | 05 |

**Theory Assessments:**

**1. Internal Assessment:** Two Internal assessments will be conducted for 40 marks each with average marks of both assessments as final score.

**2. End Sem Theory Examination:**

- Question paper will consist of 4 questions, each carrying 20 marks.
- Total 3 questions need to be solved.
- Q.1 will be compulsory, based on the entire syllabus.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

**Books and References:**

**A. Textbooks:**

1. "Generative Models" by David M. Blei, Publisher: Cambridge University Press, Edition: 2020.
2. "Generative Adversarial Networks" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Publisher: MIT Press Edition: 1st Edition (2016).
3. "Explainable AI: Interpreting, Explaining and Visualizing Deep Learning" by Christoph Molnar. Publisher: Lulu Press, Edition: 2019
4. "Interpretable Machine Learning" by Christoph Molnar

**B. References:**

1. "Generative Adversarial Text to Image Synthesis" by T. Han et al. (2017)
2. "What You Don't Know About Deep Learning" by Jason Eisner (2017)
3. "Interpretability Beyond Feature Attribution" by Marco Tulio Ribeiro et al. (2018)
4. "Generative Adversarial Networks" by Ishaan Gulrajani, et al. (2017), Publisher: Cambridge University Press Edition: 1st edition.

**List of Experiments:**

| Exp. No. | Title of Experiment |
|---|---|
| 1 | Introduction to Generative Models and Probability-Based Data Generation |
| 2 | Implementation and Performance Analysis of Generative Adversarial Networks (GANs) |
| 3 | Image Generation using Advanced GAN Architectures and Variational Autoencoders (VAEs) |

| | |
|---|---|
| 4 | Model Explainability using LIME and SHAP |
| 5 | Visualization and Explainability of Generative Models |
| 6 | Case Study: Explainable Generative AI for Real-World Applications |

| Course Code | Course Name | Theory (Hrs) | Practical (Hrs) | Tutorial (Hrs) | Theory (Credits) | Practical/Oral (Credits) | Tutorial (Credits) | Total (Credits) |
|---|---|---|---|---|---|---|---|---|
| ITE 332 | Advanced Big Data Analytics | 03 | -- | -- | 03 | -- | -- | 03 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory Marks | | | | Term Work | Practical | Oral | Total |
| | | Internal assessment | | | End Sem. Exam | | | | |
| | | Test1 | Test 2 | Avg | | | | | |
| ITE 332 | Advanced Big Data Analytics | 40 | 40 | 40 | 60 | - | -- | - | 100 |

**Course Objectives:**
**The course is aimed to:**

1. To introduce the fundamental concepts, characteristics, and applications of Big Data.
2. To explain the architecture and components of Hadoop and MapReduce frameworks for large-scale data processing.
3. To describe the structure, types, and business applications of NoSQL databases.
4. To familiarize students with data stream models and stream processing algorithms.
5. To teach various similarity detection techniques and clustering algorithms used in Big Data Analytics.
6. To expose students to real-time Big Data models, recommendation systems, and industrial case studies.

**Course Outcomes:**
**On successful completion of course learner/student will be able to:**

1. Identify the characteristics, types, challenges, and real-life applications of Big Data.
2. Demonstrate the ability to process large-scale data using Hadoop and MapReduce programming models.
3. Analyze NoSQL database architectures and distinguish between different NoSQL models for solving Big Data problems.
4. Apply stream processing techniques and evaluate algorithms for real-time data analysis.
5. Design clustering models and compare similarity measures for Big Data pattern recognition.
6. Develop real-time Big Data applications using graph-based models and illustrate recommendation systems.

**Prerequisite:** Database Management Systems (DBMS), Data Structures and Algorithms, Python Programming / Programming for Data Science

**DETAILED SYLLABUS:**

| Sr. No. | Module | Detailed Content | Hours |
|---|---|---|---|
| **1.** | **Overview Of big data analytics** | Introduction to Big Data, Big Data characteristics, types of Big Data, Traditional vs. Big Data business approach Big Data Challenges, Examples of Big Data in Real Life, Big Data Applications | 03 |
| **2.** | **Data analytics using MapReduce/ Hadoop** | Introduction to Big Data Frameworks: Hadoop, Core Hadoop Components; Hadoop Ecosystem-Overview, Hadoop Limitations. MapReduce: The Map Tasks, Grouping by Key, The Reduce Tasks, Combiners, Details of MapReduce Execution, Coping With Node Failures. Algorithms Using MapReduce: Matrix-Vector Multiplication by MapReduce, Relational-Algebra Operations, Computing Selections by MapReduce, Computing Projections by MapReduce, Union, Intersection, and Difference by MapReduce | 10 |
| **3.** | **No SQL** | Introduction to NoSQL, NoSQL Business Drivers, NoSQL Data Architecture Patterns: Key-value stores, Graph stores, Column family (Bigtable)stores, Document stores, Variations of NoSQL architectural patterns, NoSQL Case Study, NoSQL solution for big data. Understanding the types of big data problems; Analyzing big data with a shared-nothing architecture; Choosing distribution models: master-slave versus peer-to-peer; NoSQL systems to handle big data problems. | 6 |
| **4.** | **Mining Data Streams** | The Stream Data Model: A Data- Stream-Management System, Examples of Stream Sources, Stream Queries, Issues in Stream Processing. Sampling Data in a Stream : Sampling Techniques.<br>Filtering Streams: The Bloom Filter Counting Distinct Elements in a Stream : The Count-Distinct Problem, The Flajolet-Martin Algorithm, Combining Estimates, Space Requirements . Counting Ones in a Window: The Cost of Exact Counts, The Datar-Gionis-Indyk-Motwani Algorithm, Query Answering in the DGIM Algorithm. | 12 |

| | | | |
|---|---|---|---|
| **5.** | **Finding Similar Items and Clustering** | Distance Measures: Definition of a Distance Measure, Euclidean Distances, Jaccard Distance, Cosine Distance, Edit Distance, Hamming Distance.<br>CURE Algorithm, Stream-Computing , A stream-Clustering Algorithm, Initializing & Merging Buckets, Answering Queries. | 10 |
| **6.** | **Real-Time Big Data Models** | PageRank Overview, Efficient computation of PageRank: PageRank Iteration Using MapReduce, Use of Combiners to Consolidate the Result Vector. Introduction to Recommendation System: content based Recommendation System, collaborative Recommendation System, hybrid Recommendation System. Issues and challenges Recommendation System Big Data Case Studies – How big companies use Big Data : Walmart, Netflix, eBay etc….<br>Demonstration of Graph Database : NEO4J Example: Social Network Circle , | 4 |

**Assessments:**

1. **Internal Assessment:** Two Internal assessments will be conducted for 40 marks each. Two tests should cover at least 80% syllabus. The average marks of two tests should be considered as final IA marks.

**2. End Sem Theory Examination:**

- Question paper will consist of 4 questions, each carrying 20 marks.
- Total 3 questions need to be solved.
- Q.1 will be compulsory, based on the entire syllabus.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to the number of hours assigned to each module.

**3. Suggested Experiments:**

Software Requirements if any: Windows / Linux Desktop OS / Kali Linux, Hadoop, R studio, Mongodb

1. HDFS Basics, Hadoop Ecosystem Tools Overview. Installing Hadoop.
2. Copying File to Hadoop.
3. Copy from Hadoop File system and delete file.
4. Moving and displaying files in HDFS.
5. Programming exercises on Hadoop.
6. To install and configure MongoDB/ Cassandra/ HBase/ Hypertable to execute NoSQL commands.
7. Experiment on Hadoop Map-Reduce / PySpark:
8. Write a program to implement a word count program using MapReduce.
9. Implementing simple algorithms in Map-Reduce: Matrix multiplication, Aggregates, Joins, Sorting, Searching, etc.
10. Implementing DGIM algorithm using any Programming Language/ Implement Bloom Filter using any programming language

11. Implementing any one Clustering algorithm (K-Means/CURE) using Map-Reduce
12. Mini Project: One real life large data application to be implemented (Use standard Datasets available on the web)

**4. Theory Assessment:**

**A. Internal Assessment (IA):** Two class tests of 40 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and the second class test when an additional 35% syllabus is completed. Duration of each test shall be one and a half hours.

**B. End Semester Theory Examination:** In question, paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

**1.** Question paper will consist of 3 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total three questions need to be solved.

**5. Books and References:**

**A. Books:**

1. CreAnand Rajaraman and Jeff Ullman Mining of Massive Datasets, Cambridge University Press,
2. Alex Holmes Hadoop in Practice, Manning Press, Dreamtech Press.
3 Dan Mcary and Ann Kelly Making Sense of NoSQL – A guide for managers and the rest of us Manning Press.

**B. References:**

1. Anand Rajaraman and Jeff Ullman "Mining of Massive Datasets", Cambridge University Press
2. Alex Holmes "Hadoop in Practice", Manning Press, DreamTech Press. [3] Dan McCreary and Ann Kelly "Making Sense of NoSQL" – A guide for managers and the rest of us, Manning Press.
3. Bill Franks , "Taming The Big Data Tidal Wave: Finding Opportunities In Huge Data Streams With Advanced Analytics", Wiley
4. Chuck Lam, "Hadoop in Action", Dreamtech Press
5. Judith Hurwitz, Alan Nugent, Dr. Fern Halper, Marcia Kaufman, "Big Data for Dummies",
6. MongoDB: The Definitive Guide Paperback, Kristina Chodorow (Author), Michael Dirolf, O'Reilly Publication

| Course Code | Course Name | Theory (Hrs.) | Practical (Hrs.) | Tutorial (Hrs.) | Theory (Credits) | Practical /Oral (Credits) | Tutorial (Credits) | Total (Credits) |
|---|---|---|---|---|---|---|---|---|
| ECS 502 | Advanced Mobile Communication | 03 | -- | -- | 03 | -- | -- | 03 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory Marks | | | | Term Work | Practical | Oral | Total |
| | | Internal assessment | | | End Sem. Exam | | | | |
| | | Test 1 | Test 2 | Average | | | | | |
| ECS 502 | Advanced Mobile Communication | 40 | 40 | 40 | 60 | - | -- | - | 100 |

**Course Objectives:**

1. To get familiar with the basics of mobile networks.
2. To understand various aspects of Mobile radio propagation.
3. To study 2G system technologies i.e. GSM and CDMA.
4. To explore details of 3G system technologies i.e. GSM and CDMA.
5. To study 4G LTE advanced technologies used in mobile services.
6. To discuss the advanced technologies and introduction of 5G technology.

**Course Outcomes:**

Students will be able to:

1. Get familiar with the basics of mobile networks.
2. Understand various aspects of Mobile radio propagation.
3. Study 2G system technologies i.e. GSM and CDMA.
4. Explore 3G system technologies i.e. GSM and CDMA.
5. Study 4G LTE advanced technologies used in mobile services.
6. Discuss the advanced technologies and introduction of 5G technology.

**Prerequisite:** Computer Communication and Network

**Detailed Theory Syllabus:**

| Sr. No. | Module | Detailed Content | Hours |
|---|---|---|---|
| 1 | **Introduction to Mobile Networks** | Introduction to Mobile Computing, Telecommunication enerations, Electromagnetic Spectrum, Antenna, Signal ropagation, Signal Characteristics, , Multiplexing, Spread pectrum: DSSS & FHSS | 06 |
| 2 | **Mobile Radio Propagation** | Large scale fading: Free space propagation model, the three basic propagation mechanisms, reflection, ground reflection (two-ray) model, diffraction, scattering, practical Link budget design using path loss models<br><br>Small scale fading: Small scale multipath propagation, parameters of mobile multipath channels, types of small-scale fading, Rayleigh and Ricean distributions. | 08 |
| 3 | **2G GSM and CDMA Mobile Services** | GSM: GSM Network Architecture, air interface specifications, GSM signalling protocol architecture, GSM channels, GSM services and features, GSM multifare structure, GSM speech coding, GSM Call procedures, Authentication and security in GSM, and handoff procedures in GSM.<br><br>GSM evolution: GPRS, HSCSD and EDGE architecture, radio specifications.<br><br>IS-95: CDMA air interface, CDMA channels, power control in CDMA system, handoff, and RAKE receiver. | 08 |
| 4 | **3G GSM and CDMA Mobile Services** | UMTS: Objectives, standardization and releases, network architecture, air interface specifications, channels, security procedure, W-CDMA air interface, attributes of W-CDMA system, W-CDMA channels.<br><br>Cdma2000 cellular technologies: Forward and Reverse Channels, Handoff and Power Control. | 06 |
| 5 | **4G LTE Mobile Services** | Introduction, system overview: Frequency bands and spectrum flexibility, network structure, protocol structure.<br><br>Physical layer: Frames, slots, and symbols, modulation, coding, multiple-antenna techniques.<br><br>Logical and Physical Channels: Mapping of data onto (logical) sub-channels, Establishing a connection, Physical layer retransmissions and reliability, Power control, and handover. | 06 |

| | | | |
|---|---|---|---|
| **6** | **Advanced techniques for 4G deployment and beyond, Introduction to 5G Technology** | Multi-antenna Techniques: Smart antennas, Multiple input Multiple output systems.<br><br>Cognitive radio: Architecture, spectrum sensing. Software Defined Radio (SDR): Components and Applications.<br><br>Salient features of 5G , 5G technology, 5G Architecture, Advantages and disadvantages, Applications, 5G Advancements, 5G Challenges, 5G future scope. | 06 |

**Theory Assessment:**

**Internal Assessment for 40 marks:**

Consisting of Two Compulsory Internal assessment of **40 Marks each** on 40% syllabus for each test. The final marks will be the average of the score of both the tests.

**End Semester Examination: 60 Marks**

- Question paper will consist of 4 questions, each carrying 20 marks.
- Total 3 questions need to be solved.
- Q.1 will be compulsory, based on the entire syllabus.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to the number of hours assigned to each module.

**DETAILED LAB SYLLABUS:**

**Software Requirements:** MATLAB, NS-2

| Sr. No. | Detailed Lab Description |
|---|---|
| 1 | Implementation of Two Ray Propagation Model |
| 2 | Implementation of MIMO Channel Capacity |
| 3 | Implementation of CDMA Encode and Decode |
| 4 | Implementation of PN Sequence |
| 5 | Implementation of OFDM |
| 6 | Implementation of Rake Receiver |

**Textbooks:**

1. Vijay K. Garg, “Wireless Communication and Networking”, Morgan –Kaufmann Series in Networking—Elsevier
2. KE- LIN DU & M. N. S. Swamy, ―Wireless Communication Systems, Cambridge University Press India Pvt. Ltd
3. Dr. Sunilkumar S. Manvi, Mahabaleshwar S. Kakkasageri, ―Wireless & Mobile Networks: Concepts and Protocols Wiley India
4. Theodore S. Rappaport “wireless communications - principles and practice”, PEARSON Second edition.

**References:**

1. T L Singal “wireless communications”, Mc Graw Hill Education
2. Fundamentals of 5G Mobile Networks: Jonathan Rodriguez (Ist Edition), Wiley Publication.
3. Carlos de Morais Cordeiro, Dharma Prakash Agrawal, ―AD HOC & Sensor Networks – Theory & Applications , Cambridge University Press India Pvt. Ltd

| Course Code | Course Name | Theory (Hrs.) | Practical (Hrs.) | Tutorial (Hrs.) | Theory (Credits) | Practical /Oral (Credits) | Tutorial (Credits) | Total (Credits) |
|---|---|---|---|---|---|---|---|---|
| ECS 503 | Wireless Technology | 03 | -- | -- | 03 | -- | -- | 03 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory Marks | | | | Term Work | Practical | Oral | Total |
| | | Internal assessment | | | End Sem. Exam | | | | |
| | | Test1 | Test2 | Avg. | | | | | |
| ECS 503 | Wireless Technology | 40 | 40 | 40 | 60 | - | -- | - | 100 |

**Course Objectives:**

1. To get familiar with the basics of wireless systems.
2. To understand the planning and design of various mobile and wireless networks.
3. To study various emerging WPAN technologies like Bluetooth, Zigbee etc.
4. To study Wireless Local Area Network.
5. To explore advanced technologies in Wireless Communication.
6. To discuss the introduction of 5G technology.

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

1. Get familiar with the basics of wireless systems.
2. Understand planning and design of various mobile and wireless networks.
3. Study various emerging WPAN technologies like Bluetooth, Zigbee etc..
4. Study types, fundamental concept of Wireless Local Area Network.
5. Explore advanced technologies in Wireless Communication.
6. Discuss introduction of 5G technology.

**Prerequisite:** Wireless and mobile communication.

**Detailed Theory Syllabus:**

| Sr. No. | Module | Detailed Content | Hours |
|---|---|---|---|
| 1 | **Overview of Wireless System** | Advantages, limitations and application wireless media, Infrared Modulation Techniques, DSSS and FHSS, Frequency Spectrum: Radio and Infrared, Wireless generations: 1G: Cellular,2G: Mobile Radio, 3G: UMTS- Security related Encryption Algorithm | 08 |
| 2 | **Planning and design of WWANs** | Basics of fundamental of WWANs, Planning and design of wireless networks, Receiver sensitivity and link budget, Pole capacity of CDMA cell, Uplink and downlink radio link budget for CDMA system | 08 |
| 3 | **Emerging Wireless Technologies (Wireless Personal Area Networks)** | Concept of PAN: Definition and scope of WPANs, overview of short-range device communication, and the IEEE 802.15 working group<br>Bluetooth: Architecture & Topology, Protocol Stack, Operational States<br>ZigBee: Overview, Architecture, Device Types, Topologies, Applications<br>WiMax: Standardization, Network Deployment,<br>Wireless sensor networks: Sensor Node Architecture, Network Architecture, Routing Protocols, Applications & Challenges | 08 |
| 4 | **Wireless Local Area Networks** | Introduction:Fundamentals of electromagnetic wave propagation, radio frequency (RF) spectrums, and network architecture, Core Components: Wireless Access Points (APs), wireless adapters/cards, switches, routers, and antenna types, Basic Service Set (BSS) & Extended Service Set (ESS): Concepts of service areas, infrastructure mode, and roaming capabilities advantages, disadvantages, different types of WLANs, practical use of WLANs, Wi-fi, Ad-hoc wireless networks | 04 |
| 5 | **Advanced technologies in Wireless Communication** | Mobile Machine to Machine communication: Fundamentals of M2M & IoT: Architectures, device-to-device (D2D) communication, and differences between M2M and human-to-human (H2H) communication, M2M Standardization & Protocols: 3GPP standards (MTC, eMTC, NB-IoT), IPv6 over Low Power Wireless Personal Area Networks (6LoWPAN), | 06 |

| | | | |
|---|---|---|---|
| | | MQTT, and CoAP, Mobile traffic management, cooperative communication | |
| **6** | **Introduction to 5G** | Salient features of 5G: 5G Evolution and Vision. Transition from 1G, 2G, 3G, and 4G to 5G. Drivers of 5G: Market demands and emerging technologies. Critical usage scenarios: eMBB (Enhanced Mobile Broadband), URLLC (Ultra-Reliable Low Latency Communication), and mMTC (Massive Machine Type Communication. 5G technology, 5G Architecture, Advantages and disadvantages, Applications, 5G Advancements, 5G Challenges, 5G future scope | 05 |

**Theory Assessments:**

**1. Internal Assessment**: Two Internal assessments will be conducted for 40 marks each with average marks of both assessments as final score.

**2. End Sem Theory Examination:**

- Question paper will consist of 4 questions, each carrying 20 marks.
- Total 3 questions need to be solved.
- Q.1 will be compulsory, based on the entire syllabus.
- Remaining questions will be randomly selected from all the modules.

Weightage of marks should be proportional to number of hours assigned to each module

**Software Requirements:** MATLAB, NS-2

| Sr. No. | Detailed Lab Description |
|---|---|
| 1 | Study , discussion and installation of NS-2 |
| 2 | To develop a TCL script for NS-2 simulation for simple topologies |
| 3 | To plot the graph of Delay, Throughput, PDR, Energy of MAC layer protocol 802.11 and 802.15.4 |
| 4 | To implement Wireless communication between nodes with AODV and DSR routing protocols using NS2 software |
| 5 | To generate .tr file in NS-2 simulation for wireless network |
| 6 | To implement a new protocol in NS-2 software |

**Text Books:**

1. Vijay K. Garg, "Wireless Communication and Networking", Morgan -Kaufmann Series in Networking—Elsevier
2. Theodore S. Rappaport, "wireless communications - principles and practice", PEARSON, Second edition.
3. T L Singal ,"Wireless Communications", Mc Graw Hill Education.
4. Fundamentals of 5G Mobile Networks: Jonathan Rodriguez (Ist Edition), Wiley Publication

**References:**

1. WAP Development with WML and WML Script: Ben Forta and Keith
2. Dr SunilkumarS. Manvi, Mahabaleshwar S. Kakkasageri, "Wireless and Mobile
3. Networks Concepts and Protocol", Wiley India Pvt Ltd.
4. Raj Kamal, "Internet of Things Architecture & Design Principles" Mcgraw Hill
5. Kazem Sohraby, Daniel Minoli, and Taieb Znati, "Wireless Sensor Networks:
6. Technology, Protocols, and Applications", Wiley Student Edition.

| Course Code | Course Name | Theory (Hrs.) | Practical (Hrs.) | Tutorial (Hrs.) | Theory (Credits) | Practical /Oral (Credits) | Tutorial (Credits) | Total (Credits) |
|---|---|---|---|---|---|---|---|---|
| ECS 504 | Ethical Hacking and Digital Forensics | 03 | -- | -- | 03 | -- | -- | 03 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory Marks | | | | Term Work | Practical | Oral | Total |
| | | Internal assessment | | | End Sem. Exam | | | | |
| | | Test1 | Test 2 | Avg. of 2 Tests | | | | | |
| ECS 504 | Ethical Hacking and Digital Forensics | 40 | 40 | 40 | 60 | - | -- | - | 100 |

**Course Objectives:**

1. To understand underlying principles of Ethical hacking and digital forensic practices.
2. To learn gathering information from various cyber spaces.
3. To perform security scan to test the applications and systems for vulnerability.
4. To understand and deal with the hacking environment and strategies for covering attack tracks.
5. To learn the importance of incident response and evidence handling in digital forensics.
6. To apply digital forensic knowledge to use various digital forensic tools for live data collection.

**Course Outcomes:**

1. Describe principles of Ethical hacking and digital forensic.
2. Gather the information required for Digital forensics and Ethical hacking from various cyber spaces.
3. Evaluate testing plan for applications and systems for vulnerability.
4. Understand hacking environments and learn hacker hiding techniques.
5. Explain the methodology of incident response and various security issues.

6. Install and examine various Digital forensics tools for data collection.

**Prerequisite:** Basic Mathematics, Algorithms, Data Structures, Basic Probability and Statistics, Algorithms

**DETAILED THEORY SYLLABUS:**

| Sr. No. | Module | Detailed Content | Hours |
|---|---|---|---|
| 1 | **Introduction to Ethical Hacking and Digital Forensics** | Introduction to Ethical hacking: definition, difference between hacking and ethical hacking. Vulnerability, Attack Vector. Five stages of hacking:<br><br>Reconnaissance, Probing, Actual attack, maintaining presence, Covering attack tracks, Digital Forensic, Rules for Digital Forensic, The Need for Digital Forensics, Types of Digital Forensics, Ethics in Digital Forensics, Digital Evidences: Types and characteristics and challenges for Evidence Handling. | 04 |
| 2 | **Information Gathering** | **Information gathering:** from social media accounts, extraction of photographs, exit data, phone number, vehicle registration number, dumpster dumping, Google street view and Google history. Social Engineering techniques, Google Dork query, Browser extension to collect information. Principles of Ethical hacking (Legality & Ethics).<br><br>Introduction to OWAPS, types of OWAPS | 05 |
| 3 | **Enumeration and System Hacking** | **Scanning & Enumeration**: Port Scanning, Network Scanning, Vulnerability Scanning, NMAP Scanning tool, OS Fingerprinting, Enumeration.<br>**System Hacking**: Password cracking techniques, Key loggers, Escalating privileges, URL Hiding Files, Sniffers & SQL Injection: Active and passive sniffing, ARP Poisoning, Session Hijacking, DNS Spoofing, Conduct SQL Injection attack, Countermeasures. Study of open-source scanning tools. | 06 |
| 4 | **Hacking Environment by Hiding hacker details** | Installation and configuration of DVWA environment. Virtual box installation, Installation of Kali Linux within virtual box. Kali Linux penetration testing and ethical hacking tools. What is TOR? How can you use it to protect your anonymity online?<br><br>Proxy chain for using proxy servers, hiding your IP and obtaining access. What is VPN and how you can stay anonymous with VPN. | 10 |

| | | | |
|---|---|---|---|
| | | Mac-changer,use of mac-changer to change your MAC address. Incident Response and Forensic Analysis. | |
| **5** | **Incident Response Methodology** | Incident Goals of Incident response, Incident Response Methodology, Formulating Response Strategy, IR Process – Initial Response, Investigation, Remediation, Tracking of Significant, Investigative Information, Reporting Pre-Incident Preparation, Incident Detection. | 08 |
| **6** | **Digital Forensic Tools** | Live Data Collection: Live Data Collection on Microsoft Windows Systems: Live Data Collection on Unix-Based Systems Forensic Duplication Forensic Image Formats, Traditional Duplication, Live System Duplication, Forensic Duplication tools Disk and File System Analysis: Media Analysis Concepts, File System Abstraction Model The Sleuth Kit: Installing the Sleuth Kit, Sleuth Kit Tools Partitioning and Disk Layouts : Partition Identification and Recovery, Redundant Array of Inexpensive Disks Special Containers : Virtual Machine Disk Images, Forensic Containers Hashing, Carving : Foremost , Forensic Imaging : Deleted Data , File Slack , dd , dcfldd , dc3dd Data Analysis Analysis Methodology Investigating Windows systems, Investigating UNIX systems, Investigating Applications, Web Browsers, Email, Malware Handling: Static and Dynamic Analysis, Writing a Report, sample for writing a forensic report. | 06 |

**Theory Assessments:**

**1. Internal Assessment:** Two Internal assessments will be conducted for 40 marks each with average marks of both assessments as final score.

**2. End Sem Theory Examination:**

- Question paper will consist of 4 questions, each carrying 20 marks.
- Total 3 questions need to be solved.
- Q.1 will be compulsory, based on the entire syllabus.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

**Text Books:**

1. Mark Rhodes-Ousley,"Information Security: The Complete Reference", Second Edition, McGraw-Hill, 2013.
2. Dafy dd Stutarf, Marcus Pinto,"Web Application Hackre's Handbook",Wiley.
3. Skoudis E. Perlman R. "Counter hack: A step by step Guide to Computer Attacks andeffective Defense", Prentice Hall Professional technical Reference, 2001.

4. Jason Luttgens, Matthew Pepe, Kevin Mandia, "Incident Response and computer forensics",3rd Edition Tata McGraw Hill, 2014.
5. Nilakshi Jain, Dhananjay Kalbande,"Digital Forensic: The fascinating world of Digital Evidences" Wiley India Pvt Ltd 2017.
6. Cory Altheide, Harlan Carvey"Digital forensics with open-source tools"Syngress Publishing, Inc. 2011

**References:**

1. The Internet of Things (MIT Press) by Samuel Greengard.
2. The Internet of Things (Connecting objects to the web) by Hakima Chaouchi (Wiley Publications)..
3. RFID and the Internet of Things, by Hervechabanne, Wiley.

**Software Requirements: Linux,Wireshark,nmap.**

| Sr. No. | Detailed Lab Description |
|---|---|
| 1 | Design and Implementation of Product Cipher. |
| 2 | Implementation of RSA Algorithm. |
| 3 | To implement Diffie Hellman Symmetric Key Agreement Algorithm . |
| 4 | To Understand the working of nmap using different options to scan open ports, perform OS fingerprinting, do a ping scan, tcp port scan, udp port scan, xmas scan etc. |
| 5 | Simulate DOS attack using Hping and Wireshark |
| 6 | Explore the GPG tool of Linux to implement email security |

| Course Code | Course Name | Theory (Hrs.) | Practical (Hrs.) | Tutorial (Hrs.) | Theory (Credits) | Practical /Oral (Credits) | Tutorial (Credits) | Total (Credits) |
|---|---|---|---|---|---|---|---|---|
| ECS 505 | Advanced Processor Architecture-I | 03 | -- | -- | 03 | -- | -- | 03 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory Marks | | | | Term Work | Practical | Oral | Total |
| | | Internal assessment | | | End Sem. Exam | | | | |
| | | Test 1 | Test 2 | Average | | | | | |
| ECS 505 | Advanced Processor Architecture-I | 40 | 40 | 40 | 60 | - | -- | - | 100 |

**Course Objectives:**

1. To review fundamental computer architecture concepts
2. To classify and analyze parallel processing systems.
3. To differentiate between multiprocessor and multi-core architectures .
4. To understand pipelining hazards and instruction-level parallelism (ILP)
5. To explore memory hierarchy designs and optimizations.
6. To study advanced and emerging processor design techniques..

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

1. Explain the fundamental concepts of computer architecture including ISA, pipelining, and memory organization.
2. Classify and evaluate parallel processing systems using Flynn's taxonomy and differentiate array processors, clusters, and NUMA systems.
3. Analyze the design and performance of multiprocessor and multi-core architectures, including interconnection networks and memory models.
4. Identify and resolve pipelining hazards using techniques such as forwarding and branch prediction; explain instruction-level parallelism using superscalar and VLIW approaches.
5. Evaluate cache and virtual memory designs, replacement policies, and understand memory consistency models for parallel programs.
6. Describe and analyze advanced processor design techniques including speculative execution, simultaneous multi-threading, vector processing, and emerging architectures like quantum and neuromorphic computing..

**Prerequisite:** Basic Computer Architecture, Digital Logic Design, Microprocessors and Microcontrollers

**DETAILED THEORY SYLLABUS:**

| Sr. No. | Module | Detailed Content | Hrs |
|---|---|---|---|
| **1.** | **Introduction to Advanced Processor Architectures** | **Fundamentals:** Review of basic computer architecture concepts, including instruction set architecture (ISA), pipelining, and memory organization. **Parallel Processing:** Classification of parallel systems (Flynn's Taxonomy), array processors, clusters, and NUMA (Non-Uniform Memory Access) computers. **Multiprocessor Systems:** Interconnection networks, shared memory vs. distributed memory architectures. **Multi-Core Architectures:** Introduction to multi-core processors, their organization and performance evaluation. | 06 |
| **2.** | **Pipelining and Instruction-Level Parallelism** | **Pipeline** Fundamentals: Introduction to pipelining, pipeline stages, pipeline performance and speedup. **Pipeline Hazards:** Structural, data, and control hazards; hazard detection and resolution techniques. **Instruction-Level Parallelism (ILP)**: Concepts of ILP, dependency analysis, loop unrolling, and software pipelining. **Dynamic Scheduling:** Scoreboarding and Tomasulo's algorithm. **Superscalar Processors**: Multiple instruction issue, out-of-order execution, register renaming, and reorder buffer. | 08 |
| **3.** | **Memory Hierarchy and Optimization** | **Cache Memory:** Cache organization, mapping functions, replacement policies, and write policies. **Virtual Memory:** Segmentation, paging, and page replacement algorithms. **Memory Consistency Models:** Sequential consistency, weak consistency, and their implications for parallel programming | 10 |
| **4.** | | **Branch Prediction:** Static and dynamic branch prediction techniques. | 08 |

| | | | |
|---|---|---|---|
| | **Advanced Processor Design Techniques** | **Speculative Execution:** Techniques for speculative execution and its impact on performance.<br>**Multi-Threading:** Simultaneous multi-threading (SMT) and its benefits.<br>**Vector Processing:** Introduction to vector instructions and their use in high-performance computing | |
| **5.** | **Parallel Programming and Architectures** | **Parallel Programming Models:** Shared memory, message passing, and data parallelism.<br>**Synchronization and Communication:** Techniques for synchronization and communication in parallel systems.<br>**Case Studies:** Examining specific advanced processor architectures (e.g., Intel Core series, AMD Ryzen, GPUs) | 04 |
| **6.** | **Emerging Trends in Processor Architecture** | **Heterogeneous Computing**: CPU-GPU architectures, System-on-Chip (SoC), and heterogeneous multicore processors.<br>**Domain-Specific Architectures (DSA)**: AI/ML accelerators, Tensor Processing Units (TPUs), Neural Processing Units (NPUs), and edge AI processors.<br>**Chiplet-Based Processor Design**: Chiplet architecture, advanced packaging, and interconnect technologies.<br>**Energy-Efficient Processor Design**: Dynamic Voltage and Frequency Scaling (DVFS), power-aware architectures, and green computing.<br>**Future Trends**: RISC-V architecture, processing-in-memory (PIM), and security features in modern processors. | 03 |

## List of Laboratory Experiments

| Exp. No. | Title of Experiment |
|---|---|
| 1 | Study pipelined processor architecture, identify structural, data, and control hazards, implement hazard resolution techniques, and evaluate pipeline speedup and efficiency using a simulator. |
| 2 | Analyze direct-mapped, set-associative, and fully associative cache organizations. Compare cache mapping techniques, replacement policies (LRU, FIFO, Random), and write policies by measuring cache hit rate, miss rate, and Average Memory Access Time (AMAT). |

| | |
|---|---|
| 3 | Evaluate superscalar execution, dynamic scheduling (Scoreboarding/Tomasulo's Algorithm), register renaming, and out-of-order execution. Measure IPC (Instructions Per Cycle) and processor performance for different workloads. |
| 4 | Compare contemporary processor architectures (Intel Core, AMD Ryzen, ARM Cortex, RISC-V, GPU) with respect to pipeline organization, cache hierarchy, execution units, multicore architecture, power efficiency, and application domains. |

**Theory Assessments:**

**1. Internal Assessment:** Two Internal assessments will be conducted for 40 marks each with average marks of both assessments as final score.

**2. End Sem Theory Examination:**

- Question paper will consist of 4 questions, each carrying 20 marks.
- Total 3 questions need to be solved.
- Q.1 will be compulsory, based on the entire syllabus.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

**Text Books:**

1. **John L. Hennessy and David A. Patterson ,***"Computer Architecture: A Quantitative Approach",*Morgan Kaufmann, 6th Edition, 2019
2. **David A. Patterson and John L. Hennessy,** *"Computer Organization and Design: The Hardware/Software Interface",* Morgan Kaufmann, 5th or 6th Edition

**References:**

1. **Kai Hwang,** *"Advanced Computer Architecture: Parallelism, Scalability, Programmability",* McGraw-Hill Education, 2003
2. **Andrew S. Tanenbaum and Todd Austin,** *"Structured Computer Organization",* Pearson Education, 6th Edition
3. **Richard Y. Kain,** *"Advanced Computer Architecture: A Systems Design Approach",* Pearson Education

| Course Code | Course Name | Theory (Hrs.) | Practical (Hrs.) | Tutorial (Hrs.) | Theory (Credits) | Practical /Oral (Credits) | Tutorial (Credits) | Total (Credits) |
|---|---|---|---|---|---|---|---|---|
| ECS 506 | Embedded Systems and RTOS | 03 | -- | -- | 03 | -- | -- | 03 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory Marks | | | | Term Work | Practical | Oral | Total |
| | | Internal assessment | | | End Sem. Exam | | | | |
| | | Test1 | Test 2 | Avg. of 2 Tests | | | | | |
| ECS 506 | Embedded Systems and RTOS | 40 | 40 | 40 | 60 | - | -- | - | 100 |

**Course Objectives:**

1: Develop a comprehensive understanding of advanced embedded system architectures, processor technologies, and System-on-Chip (SoC) design principles.
2: Apply modern embedded software development methodologies, including embedded Linux, bootloader design, device drivers, and software engineering practices.
3: Analyze and implement real-time operating system concepts, task scheduling algorithms, synchronization mechanisms, and resource management for deterministic embedded applications.
4: Design embedded communication systems using wired and wireless protocols for Industrial IoT, automotive, and connected embedded applications.
5: Apply hardware-software co-design methodologies, system modeling, verification techniques, and functional safety principles in embedded system development.
6: Evaluate emerging technologies such as Edge AI, TinyML, embedded cybersecurity, and Industry 4.0 applications to develop intelligent embedded solutions.

**Course Outcomes: After successfully completing this course, students will be able to:**

1. Analyze advanced embedded processor architectures, memory organizations, and SoC-based system designs for developing efficient embedded applications.
2. Design and develop reliable embedded software using advanced programming techniques, embedded Linux concepts, bootloaders, device drivers, and software engineering practices.
3. Implement real-time embedded applications using RTOS concepts, scheduling algorithms, synchronization mechanisms, and inter-process communication techniques.

4. Design secure embedded communication systems by selecting appropriate wired and wireless communication protocols for real-time and IoT applications.
5. Evaluate hardware-software co-design methodologies, system modeling techniques, verification methods, and functional safety standards for reliable embedded system development.
6. Develop innovative embedded solutions by integrating emerging technologies such as TinyML, Edge AI, embedded security, and Industry 4.0 concepts for real-world applications.

**Prerequisite:** Microprocessor and Peripherals, Microcontroller & Applications

**DETAILED THEORY SYLLABUS:**

| Sr. No. | Module | Detailed Content | Hours |
|---|---|---|---|
| 1. | **Advanced Embedded System Architecture** | **1.1** Modern Embedded System Architecture and Characteristics **1.2** Introduction to RISC-V Architecture **1.3** System-on-Chip (SoC) Architecture and Heterogeneous Computing **1.4** Hardware Accelerators and FPGA-Based Embedded Systems (Overview) **1.5** ARM Cortex-M, Cortex-R, and Cortex-A Architectures and Features (including NVIC Overview) **1.6** Low-Power Modes and Energy-Efficient Embedded System Design | 06 |
| 2. | **Embedded Software Design and Development** | **2.1** Advanced Embedded C/C++ Programming Techniques, **2.2** Cross-Compilation and Toolchains, **2.3** Build Systems and CMake, **2.4** Bootloader Architecture and Firmware Update Mechanisms, **2.5** Device Drivers, Middleware, and Board Support Package (BSP), **2.6** Software Testing, Debugging, Static Code Analysis, and MISRA-C Guidelines | 06 |
| 3. | **Real-Time Operating Systems** | **3.1** Real-time system characteristics, RTOS architecture, **3.2** Task management, basic scheduling concepts, **3.3** Context switching, interrupt handling, **3.4** Inter-process communication using semaphores, mutexes, and queues, **3.5** Memory basics, real-time timers, watchdog timers, deterministic execution, **3.6** FreeRTOS programming and VxWorks overview. | 08 |
| 4 | **Embedded Communication Systems** | **4.1** High-speed embedded interfaces: UART, SPI, I²C, CAN, CAN FD, USB, **4.2** Embedded Ethernet fundamentals, **4.3** Wireless communication: BLE, ZigBee, **4.4** Wireless Sensor Networks. | 07 |

| | | | |
|---|---|---|---|
| **5** | **Hardware–Software Co-Design, Modeling, and System Verification** | **5.1** Hardware–Software Partitioning and Co-design Methodology **5.2** SoC-Based Embedded Systems (Overview) **5.3** System Modeling using UML and State Machines **5.4** Model-Based Design Concepts using MATLAB/Simulink (Overview) **5.5** Worst Case Execution Time (WCET) Analysis **5.6** Hardware-in-the-Loop (HIL) Testing **5.7** Reliability, Fault Tolerance, and Functional Safety Overview (IEC 61508, ISO 26262) | 07 |
| **6** | **Emerging Trends and Industrial Applications** | **6.1** TinyML and Edge AI for Embedded Systems **6.2** Embedded Cybersecurity: Secure Boot, Trusted Execution Environment (TEE), and Over-the-Air (OTA) Updates **6.4** Embedded Systems for Industry 4.0 and Industrial IoT **6.5** Industrial Case Studies: Automotive Electronics and Robotics & Autonomous Systems, Future Trends in Embedded Systems | 05 |

## List of Laboratory Experiments

| Exp. No. | Title of Experiment |
|---|---|
| 1 | Study of ARM Cortex-M Architecture and Development Environment |
| 2 | Embedded C Programming and Cross-Compilation using Toolchain |
| 3 | Bootloader Development and Firmware Download Techniques |
| 4 | Implementation of Multitasking using FreeRTOS |
| 5 | Inter-Task Communication using Semaphores, Mutexes and Queues |
| 6 | Interfacing using UART, I²C and SPI Communication Protocols |
| 7 | CAN/CAN-FD Communication for Real-Time Embedded Applications |
| 8 | Embedded Linux Application Development and Device Interfacing |
| 9 | Performance Analysis of Real-Time Systems using RTOS Tools |
| 10 | Mini Project on Hardware–Software Co-Design for Intelligent Embedded Systems |

**Theory Assessments:**

**1. Internal Assessment:** Two Internal assessments will be conducted for 40 marks each with average marks of both assessments as final score.

**2. End Sem Theory Examination:**

- The question paper will consist of 4 questions, each carrying 20 marks.
- A total of 3 questions need to be solved.
- Q.1 will be compulsory, based on the entire syllabus.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to the number of hours assigned to each module.

**Text Books:**

1. Jonathan W. Valvano, **"Embedded Systems: Introduction to Arm® Cortex™-M Microcontrollers"**, Fifth Edition, CreateSpace Independent Publishing Platform, 2017.
2. Tammy Noergaard, **"Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers"**, Second Edition, Newnes (Elsevier), 2012.
3. Qing Li and Caroline Yao, **"Real-Time Concepts for Embedded Systems"**, CMP Books, 2003.
4. Frank Vahid and Tony Givargis, **"Embedded System Design: A Unified Hardware/Software Introduction"**, Second Edition, John Wiley & Sons, 2010.

**References:**

1. Michael Barr and Anthony Massa, **"Programming Embedded Systems: With C and GNU Development Tools"**, Second Edition, O'Reilly Media, 2006.
2. Elecia White, **"Making Embedded Systems: Design Patterns for Great Software"**, Second Edition, O'Reilly Media, 2024.
3. Christopher Hallinan, **"Embedded Linux Primer: A Practical Real-World Approach"**, Second Edition, Pearson Education, 2010.
4. Wayne Wolf, **"Computers as Components: Principles of Embedded Computing System Design"**, Fourth Edition, Morgan Kaufmann (Elsevier), 2023.

| Course Code | Course Name | Theory (Hrs.) | Practical (Hrs.) | Tutorial (Hrs.) | Theory (Credits) | Practical /Oral (Credits) | Tutorial (Credits) | Total (Credits) |
|---|---|---|---|---|---|---|---|---|
| ECS 402 | Advanced Robotics | 03 | -- | -- | 03 | -- | -- | 03 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory Marks | | | | Term Work | Practical | Oral | Total |
| | | Internal assessment | | | End Sem. Exam | | | | |
| | | Test1 | Test 2 | Avg. of 2 Tests | | | | | |
| ECS 402 | Advanced Robotics | 40 | 40 | 40 | 60 | - | -- | - | 100 |

**Course Objectives:**

1. Understand the fundamental concepts and specifications of robotic systems.
2. Develop mathematical models of robotic manipulators using transformation techniques.
3. Analyze robot kinematics and dynamics including direct and inverse approaches.
4. Formulate velocity and dynamic equations using Jacobian and Lagrangian methods.
5. Plan trajectories in joint and Cartesian spaces using appropriate algorithms.
6. Design and evaluate control strategies (PID, LQR) for robotic motion control.

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

1. Describe various robot specifications, classifications, and coordinate systems.
2. Construct mathematical models using homogeneous transformation matrices and D-H parameters.
3. Solve forward and inverse kinematics problems for simple robotic systems.
4. Analyze robot velocity kinematics and derive dynamic equations using Jacobian, Lagrangian, and Newton-Euler methods.
5. Implement trajectory planning techniques in both joint and Cartesian spaces for robotic arms.
6. Design and analyze control systems including PID and LQR for one-axis robot models.

**Theory Syllabus:**

| Sr. No. | Module | Detailed Content | Hours |
|---|---|---|---|
| 1 | **Basics of Robotic Technology** | Robot Specifications: Axes, Capacity & Speed, Reach & Stroke, Tool Orientation, Resolution, accuracy and precision of Robot.<br>Robot Degrees of Freedom,<br>Robot Links, Joints and Symbols, Robot Coordinates, Robot Reference Frames<br>Robot Classification | 06 |
| 2 | **Mathematical Modeling of a Robot** | Homogeneous transformation matrices,<br>Inverse transformation matrices,<br>Forward and inverse kinematic equations - position and orientation<br>Denavit-Hartenberg representation of forward kinematics, | 06 |
| 3 | **Kinematics & Dynamics of Robot** | Direct (Forward) Kinematics: Homogeneous coordinates, Link coordinates, Coordinate frame, coordinate transform, Arm equations, An example – Four Axis SCARA.<br>Inverse Kinematics: Inverse kinematics problem, Tool Configuration, An example – Four Axis SCARA. | 06 |
| 4 | **Velocity Kinematics & Dynamics** | Differential motions and velocities: Differential relationship, Jacobian, Differential motion of a frame and robot, Inverse Jacobian, Singularities.<br>Dynamic Analysis of Forces: Lagrangian mechanics, Newton Euler formulation,<br>Dynamic equations of two-axis robot | 07 |
| 5 | **Trajectory planning** | Path vs. Trajectory<br>Joint-Space vs. Cartesian-Space Descriptions<br>Basics of Trajectory Planning<br>Joint-Space Trajectory Planning: Third-Order Polynomial Trajectory Planning, Fifth-Order Polynomial Trajectory Planning, Linear Segments with Parabolic Blends, Linear Segments with Parabolic Blends and Via Points, Higher-Order Trajectories, Other Trajectories<br>Cartesian-Space Trajectories<br>Continuous Trajectory Recording | 07 |
| 6 | **Robotic Control** | Basics of control systems for one-axis robots.State-Space Control Methodology(one-axis robot).Introduction to Controllers.Design of Controllers (P, PI, PD, PID). Study of LQR Controller for One Axis Robot. | 07 |

**Hardware Requirements:** STM microcontroller
**Software Requirements:** Scilab, Matlab

| Sr. No. | Detailed Lab Description |
|---|---|
| 1 | Forward Kinematics of Cylindrical Robot Coordinates. |
| 2 | Forward Kinematics of 3 DOF Robots using D-H algorithm. |
| 3 | Inverse Kinematics of 2 DOF Robots |
| 4 | Inverse Kinematics of 3 DOF Robots |
| 5 | Inverse Kinematics of 3 DOF Robot Arm. |
| 6 | Trajectory using Third Order Polynomial. |
| 7 | PID Controller Tuning for Motor Control |
| 8 | Inverted Pendulum Control |
| 9 | Modeling of Mobile Robot and Manipulator |
| 10 | Mini Project |

**Theory Assessments:**

**Internal Assessment:** Two Internal assessments will be conducted for 40 marks each with the average marks of both assessments as final score.

**End Sem Theory Examination:**

- Question paper will consist of 4 questions, each carrying 20 marks.
- Total 3 questions need to be solved.
- Q.1 will be compulsory, based on the entire syllabus.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

**Text Books:**

1 Saeed B. Niku, "Introduction to Robotics: Analysis, Systems,Applications",Pearson Education Inc., New DELHI, 2006

2. Schilling, Robert J. Fundamentals of robotics: analysis and control. Simon & Schuster Trade, 1996.

3. Corke, Peter I., Witold Jachimczyk, and Remo Pillat. Robotics, vision and control: fundamental algorithms in MATLAB. Vol. 73. Berlin: Springer, 2011.

**References:**

1. R Mittle, I Nagrath, "Robotics and Control", Tata Mc Graw Hill, 2017

| Course Code | Course Name | Theory (Hrs.) | Practical (Hrs.) | Tutorial (Hrs.) | Theory (Credits) | Practical /Oral (Credits) | Tutorial (Credits) | Total (Credits) |
|---|---|---|---|---|---|---|---|---|
| ECS 507 | ECS Course Lab I | -- | 02 | -- | -- | 01 | -- | 01 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory Marks | | | | Term Work | Practical | Oral | Total |
| | | Internal assessment | | | End Sem. Exam | | | | |
| | | Test1 | Test 2 | Avg. of 2 Tests | | | | | |
| ECS 507 | ECS Course Lab I | -- | -- | -- | -- | 25 | 25 | -- | 50 |

## Course Name: Course Lab

Students have to perform course lab I based on DLOC I ,II and III.

Students have to complete lab experiments/lab work/case studies specified with respect to the course.

**List of Experiments: DLOC-I (Generative and Explainable AI)**

| Exp. No. | Title of Experiment |
|---|---|
| 1 | Introduction to Generative Models and Probability-Based Data Generation |
| 2 | Implementation and Performance Analysis of Generative Adversarial Networks (GANs) |
| 3 | Image Generation using Advanced GAN Architectures and Variational Autoencoders (VAEs) |
| 4 | Model Explainability using LIME and SHAP |
| 5 | Visualization and Explainability of Generative Models |
| 6 | Case Study: Explainable Generative AI for Real-World Applications |

**List of Experiments: DLOC-II (Wireless Technology)**

**Software Requirements:** MATLAB, NS-2

| Sr. No. | Detailed Lab Description |
|---|---|
| 1 | Study , discussion and installation of NS-2 |
| 2 | To develop a TCL script for NS-2 simulation for simple topologies |
| 3 | To plot the graph of Delay, Throughput, PDR, Energy of MAC layer protocol 802.11 and 802.15.4 |
| 4 | To implement Wireless communication between nodes with AODV and DSR routing protocols using NS2 software |
| 5 | To generate .tr file in NS-2 simulation for wireless network |
| 6 | To implement a new protocol in NS-2 software |

**List of Experiments: DLOC-III (Embedded Systems and RTOS)**

| Exp. No. | Title of Experiment |
|---|---|
| 1 | Study of ARM Cortex-M Architecture and Development Environment |
| 2 | Embedded C Programming and Cross-Compilation using Toolchain |
| 3 | Bootloader Development and Firmware Download Techniques |
| 4 | Implementation of Multitasking using FreeRTOS |
| 5 | Inter-Task Communication using Semaphores, Mutexes and Queues |
| 6 | Interfacing using UART, I²C and SPI Communication Protocols |
| 7 | CAN/CAN-FD Communication for Real-Time Embedded Applications |
| 8 | Embedded Linux Application Development and Device Interfacing |
| 9 | Performance Analysis of Real-Time Systems using RTOS Tools |
| 10 | Mini Project on Hardware–Software Co-Design for Intelligent Embedded Systems |

| Course Code | Course Name | Theory (Hrs.) | Practical (Hrs.) | Tutorial (Hrs.) | Theory (Credits) | Practical /Oral (Credits) | Tutorial (Credits) | Total (Credits) |
|---|---|---|---|---|---|---|---|---|
| ENGG 597 | Dissertation I | -- | 04 | -- | -- | 02 | -- | 02 |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory Marks | | | | Term Work | Practical | Oral | Total |
| | | Internal assessment | | | End Sem. Exam | | | | |
| | | Test1 | Test 2 | Avg. of 2 Tests | | | | | |
| ENGG 597 | Dissertation I | -- | -- | -- | -- | 50 | 50 | -- | 100 |

## Guidelines for PG Dissertation

### Selection of Dissertation Topic

- Students must select their dissertation topic from the repository of research topics prepared by the department faculty.
- The faculty member who proposed the selected topic will serve as the **Guide/Supervisor** throughout **Dissertation I, II, III, and IV**, ensuring continuity in research guidance.

### Literature Survey

- Students shall conduct a comprehensive literature survey on the selected topic in consultation with their Guide/Supervisor.
- The literature review should include **at least 20 research papers** published in refereed journals and reputed international/national conferences.
- Based on the review, students should identify the research gap, define the problem statement, and finalize the scope of the dissertation.

### Research Work

- Students are expected to carry out systematic research under the guidance of their Supervisor, following appropriate research methodologies.
- Regular discussions with the Guide should be conducted to review progress and refine the research direction.

**Seminar and Progress Evaluation**

- Students shall prepare a dissertation report in the prescribed format and deliver a seminar presentation before the Departmental Panel of Examiners.
- The seminar should clearly present the literature review, identified research gap, objectives, methodology, progress made, and future work.

**Research Methodology Training**

- During the first semester, students must undergo **4–5 hours of training in Research Methodology**, covering:
    - Literature survey techniques
    - Identification of research problems
    - Research methodology and experimental design
    - Analysis and interpretation of results
    - Technical paper writing and publication ethics

# Master of Technology
# In
# Electronics & Computer Science

# (Semester II)