**AC:** 03/26

**Item No. : 04**

## The Bombay Salesian Society's

# Don Bosco Institute of Technology

**(An Autonomous Institute affiliated to University of Mumbai)**

# Bachelor of Engineering

**in**

# Computer Engineering

**(DB25-V1)**
**Effective from Academic Year 2026 – 2027**

# 1. Preamble

Don Bosco Institute of Technology, Kurla, Mumbai, proudly celebrates the achievement of autonomous status—an academic milestone that reaffirms our steadfast commitment to excellence, holistic development, and student-centric learning. This autonomy empowers us to craft and implement a curriculum that is forward-looking, contextually relevant, and deeply rooted in our institutional values and the aspirations of our nation.

As an autonomous institution affiliated with the University of Mumbai, DBIT embraces the opportunity to restructure its academic framework in alignment with the University Grants Commission (UGC) guidelines and the National Education Policy (NEP) 2020. This curriculum framework outlines the undergraduate engineering programs for the EXTC, COMP, IT, and MECH branches. It reflects NEP's emphasis on multidisciplinary learning, flexibility, and outcome-based education, while staying true to the Don Bosco educational philosophy.

The curriculum adopts a top-down approach, beginning with the institutional Vision and Mission, which guides the definition of Program Educational Objectives (PEOs) and Program Outcomes (POs). These outcomes are used to shape Course Outcomes (COs) and the content and assessment methods of each course. This ensures that all academic efforts remain aligned with the broader goals of transforming learners into technically sound, ethically responsible and socially aware citizens. Importantly, this curriculum has been shaped through extensive consultations with stakeholders, including industry experts, academic peers, alumni, and students— to ensure that it remains aligned with contemporary industry requirements and societal expectations. Their inputs have been instrumental in designing a framework that bridges the gap between academic learning and practical applicability.

Key Objectives in developing syllabus are:

1. **Develop Strong Technical Foundations:** Equip students with robust knowledge and skills in core engineering domains to solve real-world problems through design, analysis, and innovation.

2. **Foster Research, Innovation, and Entrepreneurship:** Cultivate a spirit of inquiry, critical thinking, and entrepreneurial mindset to promote research-based problem-solving and startup culture.

3. **Enhance Interdisciplinary and Industry-Ready Competencies:** Integrate emerging technologies, multidisciplinary learning, and practical exposure to prepare students for dynamic industry requirements and lifelong learning.

4. **Promote Ethical, Sustainable, and Socially Responsible Engineering Practice:** Inculcate ethics, human values, and environmental consciousness to enable students to contribute meaningfully to society and sustainable development.

5. **Empower Communication, Leadership, and Teamwork Abilities:** Strengthen students' soft skills, collaboration, and leadership to perform effectively in diverse professional and global environments.

Academic design includes:

- A Choice-Based Credit System (CBCS) for flexibility
- A range of Minor and Honors options to encourage specialization and research
- Opportunities for field engagement, internships, and experiential learning
- Emphasis on skill enhancement and future workforce needs
- Integration of ethical reasoning, social awareness, and environmental consciousness

As an institution inspired by the values of Saint John Bosco, we strive to create a joyful and inclusive learning environment that fosters creativity, curiosity, and compassion. Through this curriculum framework, we renew our pledge to produce graduates who are not only professionally competent but also committed to the greater good of society.

# 2. Vision and Mission

## Vision:

DBIT will be known to have an innovative, enjoyable and holistic learning environment that transforms individuals into socially conscious citizens the Don Bosco way, and will lead in research and entrepreneurship in the area of sustainable technologies.

## Mission:

1. To create future engineers who work with honesty and integrity and excel in the use of technology for the benefit of the underprivileged.

2. To train engineers to be innovative problem-solvers and entrepreneurs who engage in research and lifelong learning.

3. To provide a diverse and stimulating environment for staff and students to grow holistically.

# 3. Curriculum Design Philosophy

The curriculum is structured in alignment with the National Education Policy (NEP) 2020 and UGC guidelines. It follows a top-down approach wherein the institutional Vision and Mission guide the Program Educational Objectives (PEOs) and Program Outcomes (POs). These then shape the Course Outcomes (COs) and form the foundation for course structure, delivery, and assessments.

Key design principles include:

- Emphasis on Outcome-Based Education (OBE) with clear mappings of COs to Pos
- Integration of core technical knowledge with interdisciplinary electives
- Inclusion of vocational skills, internships, and community engagement
- Development of entrepreneurship and research aptitude through minor and honors pathways
- Encouragement of ethical, sustainable, and socially responsible engineering practices

This approach ensures that the curriculum remains academically rigorous, industry-relevant, and value-driven.

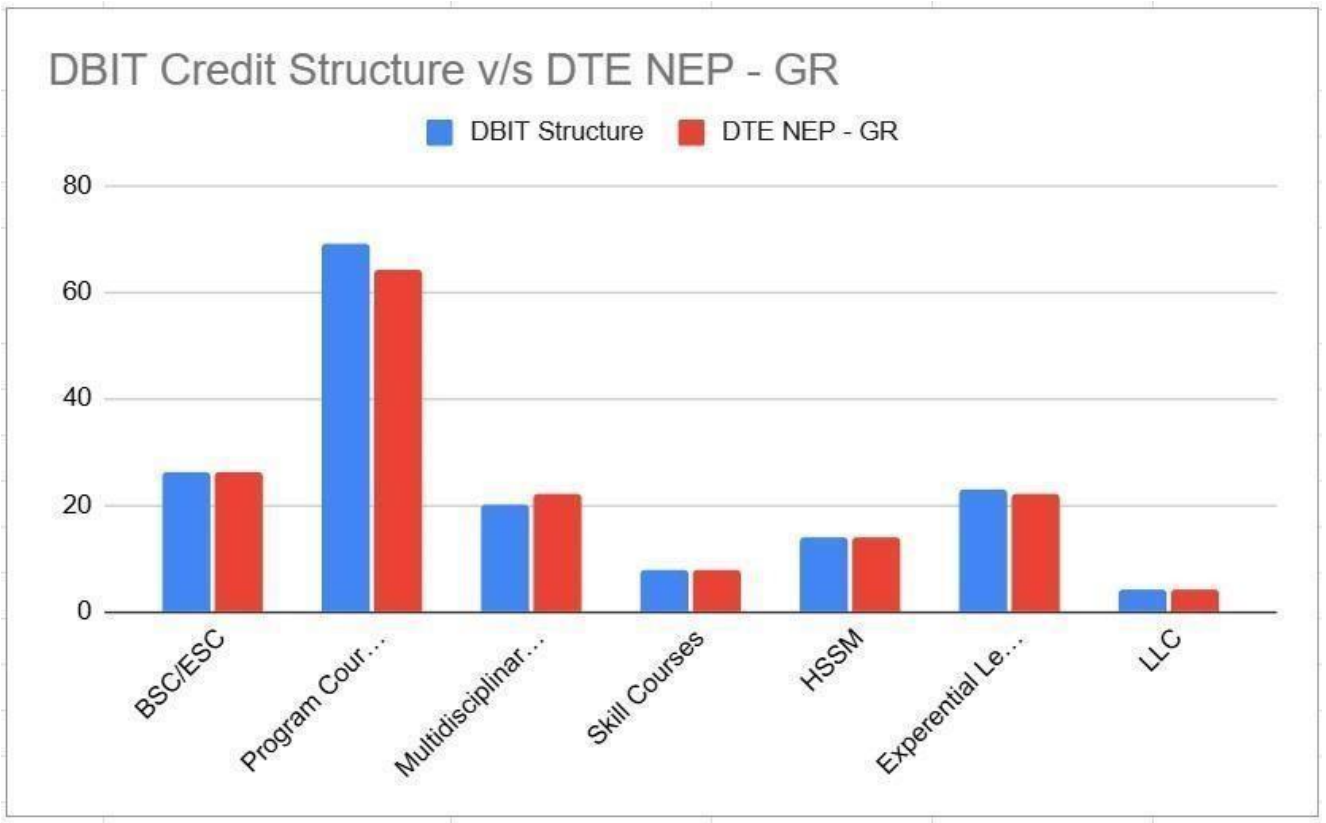
# 4. Credit Allocation Guidelines

The curriculum is delivered through a structured credit system as follows:

| Activity Type | Credit Definition |
|---|---|
| Theory Course | 1 Credit = 15 Teaching Hours |
| Laboratory / Studio / Workshop | 1 Credit = 30 Contact Hours |
| Internship / Field Work | 1 Credit = 40 Hours or 2 weeks |
| Seminar / Group Discussions | 1 Credit = 15 Participation Hours |
| Community Engagement / Field Project | 1 Credit = 30 Contact + 15 Self Hours |

## DBIT Curriculum Credit Structure: (FE to BE)

| Semester | | I | II | III | IV | V | VI | VII | VIII | Total Credits | DTE Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Basic Science Course | BSC/ESC | 9 | 6 | | | | | | | 15 | 14-18 |
| Engineering Science Course | | 7 | 4 | | | | | | | 11 | 12 - 16 |
| Programme Core Course (PCC) | Program Courses | | 3 | 16 | 14 | 8 | 8 | 7 | | 56 | 44-56 |
| Programme Elective Course (PEC) | | | | | | 3 | 3 | 6 | 6 | 18 | 20 |
| Multidisciplinary Minor (MDM) | Multidisciplinary Courses | | | | 3 | 4 | 4 | 3 | | 14 | 14 |
| Open Elective (OE) Other than a particular program | | | | | | 2 | 2 | 2 | | 6 | 8 |
| Vocational and Skill Enhancement Course (VSEC) | Skill Courses | 3 | 3 | 2 | | | | | | 8 | 8 |
| Ability Enhancement Course (AEC -01, AEC-02) | Humanities Social Science and Management (HSSM) | | 2 | | | 2 | | | | 4 | 4 |
| Entrepreneurship/Economics/ Management Courses | | | | | 2 | | 2 | | | 4 | 4 |
| Indian Knowledge System (IKS) | | | 2 | | | | | | | 2 | 2 |
| Value Education Course (VEC) | | | | 2 | | | | | | 4 | 4 |
| Research Methodology | Experiential Learning Courses | | | | | 2 | | | | 2 | 4 |
| Community. Engagement. Project (CEP)/ Field Project (FP) (Mini - Project) | | | | 1 | 1 | 1 | | | | 3 | 2 |
| Project | | | | | | | 3 | 3 | | 6 | 4 |
| Internship/ OJT | | | | | | | | | 12 | 12 | 12 |
| Co-curricular Courses (CC) | Liberal Learning Courses | | 1 | | 1 | | 1 | | 1 | 4 | 4 |
| Total Credits (Major) | | 21 | 21 | 21 | 21 | 22 | 23 | 21 | 19 | 169 | 160 - 176 |




# 5. Degree Options and Exit Pathways

Students are offered flexible learning pathways through the following options:

**Undergraduate Degree Options:**

- B.E (Major) – Minimum 160 credits
- B.E with Double Minor/Honors (Multidisciplinary + Specialization) –178-180 credits
- B.E with Double Minor/Honors with Research – 178 -180 credits

**Multiple Entry-Exit Options (Aligned with NEP 2020)**

| Exit Options | Credits Structure |
|---|---|
| Certificate after Year 1: | ● 42 Credits + 08 credits (04 credit Exit course + 04 Summer internship). |
| Diploma after Year 2: | ● 84 credits + 08 credits (04 credit Exit course + 04 Summer internship). |
| B. Vocational Degree after Year 3: | ● 125 credits + + 08 credits (04 credit Exit course + 04 Summer internship). |
| Final Degree after Year 4: | ● 160 credits |

Credits earned are banked in the Academic Bank of Credits (ABC) for lifelong learning flexibility.

# Abbreviations

| Sr. No | Word / Term / Phrase | Abbreviation |
|---|---|---|
| 1 | The Bombay Salesian Society's Don Bosco Institute of Technology | DBIT |
| 2 | Computer Engineering Department | CE |
| 3 | Electronics and Telecommunication Department | EC |
| 4 | Information Technology Department | IT |
| 5 | Mechanical Engineering Department | ME |
| 6 | Basic Science Course | BSC |
| 7 | Engineering Science Course | ESC |
| 8 | Basic Science / Engineering Science Course | BSESC |
| 9 | Program Core Course | PCC |
| 10 | Program Elective Course | PEC |
| 11 | Vocational Skill Enhancement Course | VSEC |
| 12 | Multidisciplinary Minore | MDM |
| 13 | Open Elective | OE |
| 14 | Ability Enhancement Course | AEC |
| 15 | Entrepreneurship / Economics / Management Course | EEM |
| 16 | Indian Knowledge System | IKS |
| 17 | Value Education System | VEC |
| 18 | Research Methodology | RM |
| 19 | Community Engagement Project / Field Project / Mini – Project | CEP |
| 20 | Project | PRJ |
| 21 | Internship / OJT | OJT |
| 22 | Liberal Learning Course / Co-curricular Course | LLC |
| 23 | Modified Bloom's Taxonomy | BT |
| 24 | Course Outcome | CO |
| 25 | Outcome Based Education | OBE |
| | | |

# Preface

Dear Students and Teachers,

It gives us immense pride and joy, as members of the Board of Studies for Computer Engineering at Don Bosco Institute of Technology, Kurla, Mumbai, to present the Computer Engineering syllabus, implemented under our Autonomous status, effective from the Academic Year 2025–26, aligned with the DB25-V1 Scheme.

This curriculum represents a pivotal academic advancement under the autonomy granted to DBIT—enabling us to tailor our academic offerings with greater flexibility, innovation, and responsiveness to emerging global trends. It has been thoughtfully structured in accordance with the University Grants Commission (UGC) guidelines and the vision of the National Education Policy (NEP) 2020, ensuring that students receive a future-ready, multidisciplinary, and outcome-based education.

Computer Engineering remains a highly dynamic and in-demand discipline. This revised syllabus is rooted in the belief that graduates must be well-equipped to tackle challenges in both foundational and cutting-edge domains. In line with this, the curriculum focuses on key verticals that define the future of technology, namely:

- Cybersecurity
- Cloud Computing
- Data Engineering
- Artificial Intelligence

These verticals have been carefully integrated into the syllabus through specialized electives, skill-based labs, and project-based learning, providing students with the opportunity to build deep domain expertise and practical proficiency in areas that are transforming industries worldwide.

Key Highlights of the Revised Curriculum:

1. Credit Rationalization: The overall credits have been optimized to 170, giving students a balanced academic load and more time to engage in research, innovation, and extracurricular pursuits.
2. Specialization through Electives: A curated selection of department-level optional courses enables students to pursue focused learning in the above key verticals, nurturing domain-specific capabilities alongside a strong generalist foundation.
3. Skill-Based Labs & Mini Projects: Emphasis on hands-on experimentation, real-world problem solving, and mini projects allows students to build strong portfolios and demonstrate technical creativity and application.
4. MOOCs Integration: Students are encouraged to leverage platforms like SWAYAM for self-paced learning in specialized or emerging topics, promoting lifelong and independent learning.
5. Industry and Outcome-Oriented Design: The curriculum is shaped through extensive consultations with industry experts, alumni, faculty, and students, ensuring its relevance to current professional landscapes and evolving technologies.
6. Ethical and Holistic Development: True to the legacy of Saint John Bosco, this academic framework emphasizes the development of not only technical skills, but also ethical responsibility, social awareness, and environmental stewardship.

Through this forward-looking curriculum, the Department of Computer Engineering continues its mission to cultivate technologically skilled, socially responsible, and globally competent professionals. We are confident that this framework will prepare our students to lead and innovate in a digital world increasingly shaped by intelligent systems and human-centered technology.

We sincerely thank all contributors' faculty, students, industry collaborators, and academic partners who played a vital role in shaping this curriculum. Together, we strive to foster an inclusive, inspiring, and intellectually vibrant learning environment that reflects the core values of our institution.

Warm regards, Board of Studies
Department of Computer Engineering
Don Bosco Institute of Technology, Kurla, Mumbai

# UG Second Year Computer Engineering

## Program Semester wise Curriculum

## Structure Semester – V

| Course Code | Course Vertical | Course Name | Teaching Scheme (Contact Hours) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | P | T | L | P | T | Total |
| **25CE5PCC01** | **PCC** | System Programming and Compiler Construction | 3 | 2 | - | 3 | 1 | - | 4 |
| **25CE5PCC02** | **PCC** | Artificial Intelligence | 3 | 2 | - | 3 | 1 | - | 4 |
| **25CE5PCE01** | **PCE** | Program Elective# | 2 | 2 | | 2 | 1 | | 3 |
| **25XX5MDMYY** | **MDM** | MDM 02[@] | 3 | 2 | - | 3 | 1 | - | 4 |
| **25CE5OE01** | **OE** | Open Elective 01[*] | 2 | - | - | 2 | - | - | 2 |
| **25CE5AEC02** | **AEC** | Professional Communication & Ethics 02 | - | 2*2 | - | - | 2 | - | 2 |
| **25CE5ELC** | **ELC** | Research Methodology | 2 | - | - | 2 | - | - | 2 |
| **25CE4CEP02** | **CEP** | Community Engagement Project III – Innovation, Research and Product Engineering | - | 2 | - | - | 1 | - | 1 |
| | | **Total** | **15** | **14** | **-** | **15** | **7** | **-** | **22** |

**@ List of MDM courses is attached as annexure.** *** Online NPTEL courses approved by Institute**

## Examination Scheme & Assessment Structure

### Examination Marking Scheme: Semester V

| Course Code | Course Vertical | Course Name | Examination Marks | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | CA1 | MSE | ESE | TW | OR | PR | Total |
| **25CE5PCC01** | **PCC** | System Programming and Compiler Construction | 20 | 30 | 50 | 25 | - | 25 | 150 |
| **25CE5PCC02** | **PCC** | Artificial Intelligence | 20 | 30 | 50 | 25 | - | 25 | 150 |
| **25CE5PCE01** | **PCE** | Program Elective# | 20 | 30 | 50 | 25 | 25 | - | 150 |
| **25XX5MDMYY** | **MDM** | MDM 02[@] | 20 | 30 | 50 | 25 | - | - | 125 |
| **25CE5OE01** | **OE** | Open Elective 01[*] | 20 | - | 30 | - | - | - | 50 |
| **25CE5AEC02** | **AEC** | Professional Communication & Ethics 02 | - | - | - | 50 | - | - | 50 |
| **25CE5ELC** | **ELC** | Research Methodology | - | - | - | 50 | - | - | 50 |
| **25CE4CEP03** | **CEP** | Community Engagement Project III – Innovation, Research and Product Engineering | - | - | - | 25 | - | 25 | 50 |
| | | **Total Marks** | **130** | **120** | **230** | **225** | **25** | **75** | **775** |

**DBIT/COMP/DB25-V1 Scheme**

# UG Second Year Computer Engineering Program

## Semester wise Curriculum Structure Semester – V

| Curriculum Scheme and Structure: Semester VI | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Course Vertical** | **Course Name** | **Teaching Scheme (Contact Hours)** | | | **Credits Assigned** | | | |
| | | | **L** | **P** | **T** | **L** | **P** | **T** | **TOTAL** |
| 25ET6PCC01 | PCC | Software Engineering | 3 | 2 | - | 3 | 1 | - | 4 |
| 25ET6PCC02 | PCC | Distributed Computing | 3 | 2 | - | 3 | 1 | - | 4 |
| 25ET6PCE02 | PEC | Program Elective# | 2 | 2 | - | 2 | 1 | | 3 |
| 25XX4MDMYY | MDM | MDM03@ | 3 | 2 | - | 3 | 1 | - | 4 |
| 25ET6HSSM02 | HSSM | Entrepreneurship/ Economics/Management Courses | 2 | - | - | 2 | - | - | 2 |
| 25ET6ELC01 | ELC | Project | - | 6 | - | 3 | - | - | 3 |
| 25ET6LLC02 | LLC | LLC@ | - | 2 | - | - | 1 | - | 1 |
| | | **Total** | **13** | **16** | **-** | **16** | **5** | **-** | **21** |

| Examination Marking Scheme: Semester VI | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Course Vertical** | **Course Name** | **Examination Marks** | | | | | | |
| | | | **CA** | **MSE** | **ESE** | **TW** | **OR** | **PR** | **Total** |
| 25ET6PCC01 | PCC | Software Engineering | 20 | 30 | 50 | 25 | - | 25 | 150 |
| 25ET6PCC02 | PCC | Distributed Computing | 20 | 30 | 50 | 25 | - | 25 | 150 |
| 25ET6PCE02 | PEC | Program Elective# | 20 | 30 | 50 | 25 | 25 | - | 150 |
| 25XX4MDMYY | MDM | Multidisciplinary Minor 03[@] | 20 | 30 | 50 | 25 | - | - | 150 |
| 25IL6OEXX | OE | Open Elective 02* | 20 | - | 30 | - | - | - | 50 |
| 25ET6HSSM02 | HSSM | Entrepreneurship/ Economics/Management Courses | 50 | - | - | - | - | - | 50 |
| 25ET6ELC01 | ELC | Project01 | - | - | - | 25 | - | 25 | 50 |
| 25ET6LLC02 | LLC | LLC@ | - | - | - | 50 | | - | 50 |
| | | **TOTAL** | **150** | **120** | **230** | **175** | **25** | **75** | **775** |

**List of Program Electives Offered: Semester V**

| Sr. No. | Course Code | Course Name |
|---|---|---|
| 01 | 25CE5PEC01 | Cloud Computing |
| 02 | 25CE5PEC02 | Cyber Security |
| 03 | 25CE5PEC03 | Statistics for Machine Learning and Data Science |

**List of Multidisciplinary Courses offered: Semester V**

| Sr. No. | Course Code | Course Name |
|---|---|---|
| 01 | 25ET5MDM01 | IoT System Design |
| 02 | 25ET5MDM02 | Data Acquisition and Industrial Monitoring |
| 03 | 25ME5MDM01 | Quality Engineering |
| 04 | 25ME5MDM02 | Industrial Automation |

**List of Open Electives offered: Semester V**

| Sr. No. | Course Code | Course Name |
|---|---|---|
| 01 | 25IL5OE01 | Energy Economics and Policy |
| 02 | 25IL5OE02 | Ethics in Engineering Practice |
| 03 | 25IL5OE03 | Intellectual Property, Rights and Competition Law |
| 04 | 25IL5OE04 | Principle of Human Resource Management |
| 05 | 25IL5OE05 | Patent Search for Engineers and Lawyers |
| 06 | 25IL5OE06 | Developing Soft Skills and Personality |
| 07 | 25IL5OE07 | Soft Skill Development |
| 08 | 25IL5OE08 | Any other course with the approval of Principal |

## Assessment Methodology

| Type of Courses | Assessment Tools | Marks Distribution |
|---|---|---|
| **Theory** | **CA-20** | Certification: NPTEL (20 Marks) (Approved by Instructor)<br>**OR**<br>Any two Pedagogies (10 marks each)<br>• MCQ /Class Test<br>• Case study/Assignment<br>• GATE based Tutorial<br>• MOOCs Certification (Approved by Instructor)<br>• Open Book Test<br>• Working model / Simulation of a course-based concept. |
| **Theory (VEC)** | **CA-50** | • Active Participation = 5 marks<br>• MCQ /Class Test= 10 marks<br>• Assessment of the activity carried out by student = 25 marks<br>• Assignment = 10 marks |
| **Workshop** | **CA-50** | • Active Participation = 5 marks<br>• Trade 1# = 15 marks<br>• Trade 2# = 15 marks<br>• Trade 3# = 15 marks<br># Based on the performance and satisfactory completion of trade wise tasks. |
| **Liberal Learning Courses (LLC)** | **CA-50** | • Active Participation = 5 marks<br>• Assessment of the Activity carried out by student = 25 marks<br>• Cultural Event Participation = 10 marks<br>• Technical Event Participation = 10 marks |
| **Theory** | **MSE** | Question Paper Pattern is as follows:<br>All Questions are compulsory.<br>• Q1 A or B - 10 marks<br>• Q2 A or B - 10 marks<br>• Q3 A or B - 10 marks<br>• For each question, A and B should be based on the same CO.<br>• MSE should be based on 50% syllabus.<br>• Time: 90 minutes (1 hour 30 minutes)<br>• Total Marks: 30 |
| **Theory** | **ESE** | Question Paper Pattern is as follows:<br>All Questions are compulsory.<br>• Q1 A or B - 10 marks<br>• Q2 A or B - 10 marks<br>• Q3 A or B - 10 marks<br>• Q4 A or B - 10 marks<br>• Q5 A or B - 10 marks |

| | | |
|---|---|---|
| | | • For each question, A and B should be based on the same CO.<br>• ESE should be based on 30% syllabus of MSE and 70% syllabus after MSE.<br>• Time: 120 minutes (2 hours)<br>• Total Marks: 50 |
| **Course - Laboratory** | **TW- 25** | • Active Participation (Lab) = 5 marks<br>• Laboratory Report = 10 marks<br>• Laboratory Performance = 10 marks<br>Based on the performance and satisfactory completion of assigned laboratory work. |
| **Community Engagement Project (CEP)** | **TW-25** | • Active Participation = 05 marks<br>• Project Report = 10 marks<br>• Progress Presentations (min 02) & Demonstration = 10 marks |
| **Tutorial** | **TW-25** | • Active Participation = 5 marks<br>• Tutorial Submission = 20 marks<br>Tutorials should cover the entire syllabus. |
| **Laboratory** | **OR-25** | Oral examination will be based on the entire syllabus. |
| **Laboratory** | **PR-25** | Practical examination will be based on the experiments performed by the students during laboratory sessions. |

## Weightage of COs across all Assessments:

| Course Outcomes | Weightage (Percentage) |
|---|---|
| CO-1, CO-2 | 20-30 |
| CO-3, CO-4 | 40-50 |
| CO-5, CO-6 | 20-30 |

Note: Total weightage of all COs should be 100%.

## 1. System Programming and Compiler Construction

**Course Code: 25CE5PCC01 | Category: PCC**

| Course Code | Course Name | Teaching Scheme (Hrs./Week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | **L** | **P** | **T** | **L** | **P** | **T** | **Total** |
| **25CE5PCC01** | **System Programming and Compiler Construction** | 3 | 2 | - | 3 | 1 | - | **4** |

| Examination Scheme | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **CA** | **MSE** | **ESE** | **TW** | **OR** | **OR & PR** | **Total** |
| **Theory** | | 20 | 30 | 50 | - | - | - | **100** |
| **Practical/Lab** | | - | - | - | 25 | - | 25 | **50** |
| **Grand Total** | | | | | | | | **150** |

| | |
|---|---|
| **Pre-Requisite Course(s)** | 25CE4PCC01 – Theoretical Computer Science |

# Course Objectives & Module overview

Course Objectives: This course introduces the fundamental concepts of system software and compiler design. Students will learn the various phases of a compiler, implement language processing tools, and apply code generation and optimization techniques for efficient program translation and execution.

Module 1: Introduction to System Software and Assembler

This module introduces the role of system software in program development and execution. It covers assemblers and the design of a two-pass assembler used for translating assembly language programs.

Module 2: Macro Processor, Linkers and Loaders

This module focuses on macro processing and program loading mechanisms. Students learn how macros are expanded and how loaders and linkers prepare programs for execution.

Module 3: Lexical Analysis

This module presents the first phase of a compiler, lexical analysis. It explains token recognition using finite automata and the design of lexical analyzers.

Module 4: Syntax and Semantic Analysis

This module covers parsing techniques used to verify program structure and meaning. It introduces context-free grammars, parser design, and semantic analysis methods.

Module 5: Intermediate Code Generation

This module discusses machine-independent program representations. Students learn different intermediate code forms and their role in compiler construction.

Module 6: Code Optimization and Code Generation

This module focuses on improving code efficiency and generating target code. It introduces optimization techniques, basic blocks, flow graphs, and code generation strategies.

Overall, the course equips computer engineering students with the knowledge and practical skills to analyze, design, and implement various phases of a compiler and system software, facilitating efficient program translation, optimization, and execution.

# Course Outcomes

| CO | Course Outcome |
|---|---|
| **CO1** | Recall the concepts of system software, assemblers, macro processors, loaders, linkers, and compiler phases. |
| **CO2** | Explain the design and working of assemblers, macro processors, lexical analyzers, parsers, and semantic analyzers. |
| **CO3** | Apply lexical analysis, parsing techniques, and LEX/YACC tools for language processing. |
| **CO4** | Analyze grammars, parsing methods, semantic rules, and intermediate code representations. |
| **CO5** | Evaluate code generation and optimization techniques for efficient program execution. |
| **CO6** | Design and implement compiler components including lexical analyzers, parsers, and code generators. |

# Syllabus

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| **1** | **Module 1: Introduction to System Software and Assembler** | | **07** |
| | *Recall and define concepts of system software. Explain functions of assemblers, compilers, interpreters, loaders, linkers, editors, and debuggers. Describe the design and working of a two-pass assembler.* | | |
| | **1.1** | Concept of System Software, Goals of system software, system program and system programming | |
| | **1.2** | Introduction to various system programs: Assembler, Macro processor, Loader, Linker, Compiler, Interpreter, Device Drivers, Operating System, Editors, Debuggers | |
| | **1.3** | Assembler: Elements of Assembly Language programming, Assembly scheme, Assembler Design: Two-pass assembler design, Data structures used | |
| | **Self-Learning Topics:** *Interpreters: Working and Applications of Language Interpreters* | | |
| **2** | **Module 2: Macro Processor, Linkers and Loaders** | | **06** |
| | *Recall macro definitions, macro calls, and macro expansion. Explain the design and operation of a two-pass macro processor. Describe the functions and types of loaders.* | | |
| | **2.1** | Macro definitions and calls, Macro expansion, Design of Two-pass macro processor, Data structures used | |
| | **2.2** | Loaders – Functions, Types (absolute, relocating, dynamic) | |
| | **Self-Learning Topics:** *Direct Linking Loader* | | |
| **3** | **Module 3: Lexical Analysis** | | **03** |
| | *Recall the role of lexical analysis in compiler design. Explain the use of finite state automata for token recognition. Describe the design and implementation of a lexical analyzer.* | | |
| | **3.1** | Role of Finite State Automata in Lexical Analysis | |
| | **3.2** | Analysis, Design of Lexical analyzer, Data structures used | |
| | **Self-Learning Topics:** *LEX Tool for Automatic Generation of Lexical Analyzers* | | |
| **4** | **Module 4: Syntax and Semantic Analysis** | | **14** |
| | *Explain the role of context-free grammars in syntax analysis. Distinguish between top-down and bottom-up parsing techniques. Describe semantic analysis and syntax-directed definitions.* | | |
| | **4.1** | Role of Context Free Grammar in Syntax analysis | |
| | **4.2** | Types of Parsers: Top-down parser – LL(1); Bottom-up parser – SR Parser, Operator precedence parser, SLR | |
| | **4.3** | Semantic Analysis, Syntax directed definitions | |
| | **Self-Learning Topics:** *LR(0), Parser Generators and Introduction to YACC* | | |
| **5** | **Module 5: Intermediate Code Generation** | | **07** |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | *Explain the need for intermediate code. Illustrate different intermediate code representations. Describe three-address code using triples, quadruples, and indirect triples.* | | |
| | **5.1** | Types of Intermediate codes: Syntax tree, Postfix notation | |
| | **5.2** | Three address codes: Triples and Quadruples, Indirect triple | |
| | **Self-Learning Topics:** *Directed Acyclic Graph, Abstract Syntax Trees (AST) and Their Applications in Compilers* | | |
| **6** | **Module 6: Code Optimization and Code Generation** | | **08** |
| | *Explain the need and sources of code optimization. Compare machine-dependent and machine-independent optimization techniques. Describe code generation using basic blocks and flow graphs.* | | |
| | **6.1** | Need and sources of optimization | |
| | **6.2** | Code optimization techniques: Machine Dependent and Machine Independent | |
| | **6.3** | Code Generation: Basic block and flow graph | |
| | **Self-Learning Topics:** *Just-In-Time (JIT) Compilation and Modern Optimization Techniques* | | |
| | | **TOTAL** | **45** |

# Laboratory Experiments (Suggested)

| No. | Title and Details |
|---|---|
| **1** | Implementation of Two-Pass Assembler<br>**Objective: To implement a two-pass assembler for translating assembly language programs into machine code.**<br>**Outcome: Identify and construct symbol tables, opcode tables, and location counters.** |
| **2** | Implementation of Lexical Analyzer<br>**Objective: To implement the lexical analysis phase of a compiler for token identification and classification.**<br>**Outcome: Identify tokens, keywords, identifiers, and operators from source code.** |
| **3** | Implementation of Top-Down Parser<br>**Objective: To implement a top-down parsing technique for syntax analysis of context-free grammars.**<br>**Outcome: Apply top-down parsing methods for grammar recognition.** |
| **4** | Implementation of Bottom-Up Parser<br>**Objective: To implement a bottom-up parser for analyzing the structure of source programs.**<br>**Outcome: Apply shift-reduce parsing techniques for syntax analysis.** |
| **5** | Implementation of Intermediate Code Generation Phase<br>**Objective: To generate machine-independent intermediate code representations from source programs.** |

| No. | Title and Details |
|---|---|
| | **Outcome: Generate three-address code for source programs.** |
| **6** | Implementation of Code Generation Phase<br>**Objective: To implement the code generation phase for translating intermediate code into target code.**<br>**Outcome: Generate target code from intermediate representations.** |
| **7** | Study and Implement Experiments on LEX and YACC<br>**Objective: To learn and apply LEX and YACC tools for automated lexical and syntax analysis.**<br>**Outcome: Develop lexical analyzers using LEX; Construct parsers using YACC.** |
| **8** | Recognize Valid Arithmetic Expressions Using YACC<br>**Objective: To develop a YACC-based parser for validating arithmetic expressions.**<br>**Outcome: Design grammar rules for arithmetic expressions and implement expression validation.** |

## Text Books


1. A. V. Aho, R. Shethi, Monica Lam, J.D. Ullman – Compilers: Principles, Techniques and Tools, Pearson Education, Second Edition
2. J. J. Donovan – Systems Programming, Tata McGraw-Hill, 1991
3. D. M. Dhamdhere – Compiler Construction, 2nd Edition, Macmillan Publications


## Reference Books


1. John R. Levine, Tony Mason & Doug Brown – Lex & YACC, O'Reilly, Second Edition
2. Leland L. Beck – System Software: An Introduction to System Programming, Pearson, Third Edition


## Useful Links

1. http://www.nptelvideos.in/2012/11/compiler-design.html
2. https://www.coursera.org/lecture/nand2tetris2/unit-4-1-syntax-analysis-5pC2Z

## Assessment Methodology – System Programming & Compiler Construction

| Type of Assessment | Assessment Tools / Marks Distribution |
|---|---|
| **CA – Theory (20 Marks)** | Certification: NPTEL (20 Marks)<br>OR<br>Any two Pedagogies (10 marks each):<br>MCQ/Class Test \|<br>Case study/Assignment<br>GATE based Assignment<br>Certification: Udemy/Coursera<br>Open Book Test<br>Working model/simulation |
| **MSE – Theory (30 Marks)** | All Questions are compulsory.<br>Q1 A or B – 10 marks<br>Q2 A or B – 10 marks \|<br>Q3 A or B – 10 marks. |

| Type of Assessment | Assessment Tools / Marks Distribution |
|---|---|
| | Each question A and B are based on the same CO.<br>MSE based on 50% syllabus. Time: 90 minutes. Total Marks: 30 |
| **ESE – Theory (50 Marks)** | All Questions are compulsory.<br>Q1-Q5, each A or B – 10 marks.<br>ESE: 30% MSE syllabus + 70% post-MSE syllabus.<br>Time: 120 minutes. Total Marks: 50 |
| **TW – Laboratory (25 Marks)** | Active Participation (Lab) = 5 marks<br>Laboratory Report = 10 marks<br>Laboratory Performance = 10 marks.<br>Based on performance and satisfactory completion of assigned laboratory work. |
| **PR – Laboratory (25 Marks)** | Practical examination based on experiments performed by the students during laboratory sessions. |

## 2. Artificial Intelligence

**Course Code: 25CE5PCC02 | Category: PCC**

| Course Code | Course Name | Teaching Scheme (Hrs./Week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | **L** | **P** | **T** | **L** | **P** | **T** | **Total** |
| **25CE5PCC02** | **Artificial Intelligence** | 3 | 2 | - | 3 | 1 | - | **4** |

| **Examination Scheme** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **CA** | **MSE** | **ESE** | **TW** | **OR** | **OR & PR** | **Total** |
| **Theory** | | 20 | 30 | 50 | - | - | - | **100** |
| **Lab** | | - | - | - | 25 | - | 25 | **50** |
| **Grand Total** | | | | | | | | **150** |

| | |
|---|---|
| **Pre-Requisite Course(s)** | 25FE2VSECO2: Object Oriented Programming using Python<br>25FE2PCC01: Data Structures<br>25CE3PCC02: Analysis of Algorithms<br>25CE4PCC004: Advanced Data structure and Algorithm |

# Course Objectives & Module overview

**Course Objective**:

**Module 1** : **Introduction to Artificial Intelligence and Intelligent Agents**

This module introduces the foundations of Artificial Intelligence, including its evolution, major applications, and different categories of AI systems. Students learn how intelligent agents perceive and interact with their environments using rational decision-making principles. The module also covers various agent architectures and environmental characteristics that influence agent behavior.

**Module 2** : **Problem-Solving Techniques in AI**

This module focuses on AI problem-solving through search and optimization techniques. Students study uninformed and informed search algorithms, heuristic-based problem solving, local optimization methods, adversarial search strategies used in game-playing, and constraint satisfaction techniques. Real-world CSP applications such as Sudoku solving, cryptarithmetic puzzles.

**Module 3** : **Knowledge Representation and Reasoning**

This module introduces methods for representing knowledge in intelligent systems. Students learn propositional and first-order logic, knowledge engineering principles, inference mechanisms, and reasoning strategies. The module also covers semantic networks and ontologies for structured knowledge representation, enabling intelligent reasoning and decision-making.

**Module 4** : **Fundamentals of Neural Networks**

This module provides the foundation of Artificial Neural Networks by examining biological inspiration, neuron models, network architectures, and activation functions. Students learn various learning rules, training methodologies, and different learning paradigms used in machine learning systems. The module establishes the theoretical basis for modern deep learning approaches.

**Module 5** : **Associative Memory Networks**

This module focuses on memory-based neural network models that store and retrieve patterns through associative mechanisms. Students study auto-associative and hetero-associative memory systems along with classical models such as Bidirectional Associative Memory (BAM) and Hopfield Networks. The module highlights the significance of associative memory in intelligent information retrieval and pattern recognition.

**Module 6** : **Large Language Models**

This module introduces the concepts and working principles of Large Language Models (LLMs) that power modern Generative AI systems. Students explore Transformer architecture, key design components, model training methodologies, and adaptation techniques used in contemporary LLMs. The module also includes case studies of leading LLMs and discusses their applications, capabilities, and evaluation approaches in real-world AI systems.

# Course Outcomes

| CO | Course Outcome |
|---|---|
| **CO1** | Recall and describe the fundamental concepts of Artificial Intelligence, intelligent agents, agent architectures, and their applications in real-world environments. |
| **CO2** | Explain search, optimization, adversarial search, and constraint satisfaction techniques to |

| CO | Course Outcome |
|---|---|
| | formulate and solve AI problems. |
| **CO3** | Apply knowledge representation and reasoning techniques using propositional logic, first-order logic, semantic networks, and ontologies to solve AI problems. |
| **CO4** | Analyze the architecture, learning paradigms, and training mechanisms of artificial neural networks for intelligent decision-making. |
| **CO5** | Assess the effectiveness of BAM and Hopfield networks in associative memory and pattern retrieval tasks. |
| **CO6** | Develop LLM-driven applications by applying suitable model architectures, training approaches, and prompting strategies for real-world Generative AI tasks. |

# Syllabus

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| **1** | **Module 1: Introduction to Artificial Intelligence and Intelligent Agents** | | **05** |
| | **1.1** | Introduction to AI: Definition, history, Types of AI and key applications, Turing Test | |
| | **1.2** | Agents and Environment: Definition, PEAS framework, Rational agents, Types of agents (reflex, goal-based, utility-based) and environment types | |
| | **Self-Learning Topics:** *Case studies of intelligent agents used in real-world systems (chatbots, recommendation systems, autonomous systems), Modern Intelligent Agents and Virtual Assistants, Multi-Agent Systems* | | |
| **2** | **Module 2: Problem-Solving Techniques in AI** | | **14** |
| | **2.1** | Uninformed Search: Depth-First Search, Breadth-First Search, Uniform Cost Search, Depth-Limited Search | |
| | **2.2** | Informed Search: Heuristic search, A* Search | |
| | **2.3** | Local Search and Optimization: Hill Climbing, Genetic Algorithms; Adversarial Search: Game Playing, Minimax Algorithm, Alpha-Beta Pruning | |
| | **2.4** | Constraint Satisfaction Problems: Cryptarithmetic problem, Sudoku Puzzle solving | |
| | **Self-Learning Topics:** Advanced Search Techniques: Bidirectional Search, AO* search. | | |
| **3** | **Module 3: Knowledge Representation and Reasoning** | | **09** |
| | **3.1** | **Knowledge Representation: Propositional Logic, Logical Agents.** | |
| | **3.2** | First-Order Logic: Syntax and Semantics, Knowledge Engineering in FOL, Inferences in FOL, Forward chaining, Backward chaining. | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | **3.3** | **Semantic Networks and Ontology: Concepts and Components, Applications in AI.** | |
| | **Self-Learning Topics:** *Retrieval-Augmented Generation (RAG)* | | |
| **4** | **Module 4: Fundamentals of Neural Networks** | | **07** |
| | **4.1** | Introduction: Biological Neural System, Artificial Neural Networks, *Neural Network Architecture*, McCulloch-Pitts Neuron, Activation Functions: Binary Step, Sigmoid, Tanh, ReLU (Introduction) | |
| | **4.2** | Learning Rules and Training :Perceptron, Delta learning rule, Backpropagation | |
| | **4.3** | Types of Learning : Supervised: Regression Algorithms (Linear Regression ), Classification Algorithms (K-Nearest Neighbors (KNN) ), Unsupervised:Clustering Algorithms (K-Means Clustering ), Association Rule Learning (Apriori Algorithm ) | |
| | **Self-Learning Topics:** *Recurrent Neural Networks (RNN), Convolutional Neural Networks (CNN), Transfer Learning, Explainable AI (XAI)* | | |
| **5** | **Module 5: Associative Memory Networks** | | **05** |
| | **5.1** | Introduction to Associative Memory, Auto-associative and Hetero-associative Memory Networks | |
| | **5.2** | Classical Memory Models : Bidirectional Associative Memory (BAM), Hopfield Network | |
| | **Self-Learning Topics:** *Applications of Associative Memory Networks, Modern Associative Memory in Generative AI, Agentic AI (Introduction)* | | |
| **6** | **Module 6: Large Language Models** | | **05** |
| | **6.1** | Introduction to Large Language Models, Transformer Architecture and LLM Design : Tokenization and Embedding Layers, Positional Encoding, Self-Attention and Multi-Head Attention, Feed-Forward Networks, LLM Architectural Parameters (Layers, Hidden Dimensions, Attention Heads, Context Window) | |
| | **6.2** | LLM Training Methodologies: Self-Supervised Learning, Next Token Prediction, Pre-training, Fine-tuning, Instruction Tuning, Reinforcement Learning from Human Feedback (RLHF) | |
| | **6.3** | Contemporary LLMs and Applications: Comparative Analysis of Popular LLM Families, LLM Applications in Conversational AI, Knowledge Discovery, Code Generation, and Content Creation, Generative AI Applications using LLMs | |
| | **Self-Learning Topics:** Agentic AI and LLM-Based Autonomous Agents, LLM Evaluation Metrics and Benchmarking | | |
| | | **TOTAL** | **45** |

# Laboratory Experiments (Minimum 8)

| No. | Title and Details |
|---|---|
| **1** | Case Study on AI Applications Published in IEEE/ACM/Springer or Other Prominent Journals.<br>**Objective:** To study and analyze a real-world Artificial Intelligence application published in a reputed research journal (IEEE, ACM, Springer, Elsevier, etc.).<br>**Outcome:** Identify the AI techniques, algorithms, datasets, and evaluation methods used in the selected case study. |
| **2** | Implementation Uninformed and Informed Search Algorithms.<br>**Objective:** Implement Uninformed Search Algorithms (Breadth-First Search, Depth-First Search, and Uniform Cost Search) and the Informed Search Algorithm (A* Search).<br>**Outcome:** Successful implementation of BFS, DFS, UCS, and A* search algorithms. |
| **3** | Implementation of Knowledge Representation using Propositional Logic and First-Order Logic (FOL) .<br>**Objective:**To represent knowledge using Propositional Logic and First-Order Logic.<br>**Outcome:** To identify and represent knowledge using logical expressions and perform logical inference using Propositional Logic and FOL |
| **4** | Design and Implementation of Semantic Networks and Ontology for Knowledge Representation<br>**Objective:** To model knowledge using Semantic Networks and Ontologies**.**<br>**Outcome:** To construct Semantic Networks and simple Ontologies for representing domain knowledge and understand their role in AI-based knowledge management and reasoning. |
| **5** | Implementation of Decision Tree or K-Means Clustering<br><br>Objective: To classify or cluster data using machine learning techniques.<br><br>Outcome: To apply machine learning algorithms for data analysis and prediction. |
| **6** | Implementation of Artificial Neuron and Activation Functions<br>**Objective:** To implement an artificial neuron model and compare the outputs of various activation functions for different input values.<br>**Outcome:** To understand the working of artificial neurons and analyze the behavior of Binary Step, Sigmoid, Tanh, and ReLU activation functions. |
| **7** | Implementation of a Feedforward Neural Network using Backpropagation<br>**Objective:** To understand the concepts of forward propagation, error calculation, and weight updates .<br>**Outcome:** To train a Feedforward Neural Network using the Backpropagation algorithm and evaluate its performance for simple prediction or classification tasks |
| **8** | Implementation of Auto-Associative and Hetero-Associative Memory Networks .<br>**Objective:**To implement associative memory models for storing and recalling patterns.<br>**Outcome:**To identify and implement associative memory networks and demonstrate the storage and retrieval of patterns. |
| **9** | Exploration of Prompt Engineering Techniques in Large Language Models<br><br>**Objective : *To investigate various prompt engineering techniques such as zero-shot, few-shot, and chain-of-thought prompting and assess their effectiveness in improving LLM responses.*** |

| No. | Title and Details |
|---|---|
| | **Outcome : To construct effective prompts for different AI tasks and critically evaluate the capabilities and limitations of Large Language Models in generating accurate and contextually relevant outputs.** |
| **10** | Implementation of a Generative AI Chatbot using a Large Language Model .<br><br>**Objective:**To evaluate the performance and capabilities of the LLM for text generation and conversational AI tasks.<br><br>**Outcome:**To build and evaluate a Generative AI application using a pre-trained Large Language Model (LLM). |
| **11** | **Ethical Evaluation and Responsible Use of Generative AI**<br><br>**Objective:**<br>To evaluate AI-generated outputs for fairness, bias, privacy, transparency, and responsible usage.<br><br>**Outcome:**<br>To identify ethical concerns in Generative AI applications and propose mitigation strategies. |

**Text Books:**


1. Russell, S. J., and Norvig, P., *Artificial Intelligence: A Modern Approach,* 4th Edition, Pearson Education, 2022.
2. S. Rajasekaran, and Vijayalakshmi Pai, G. A., *Neural Networks, Fuzzy Logic and Genetic Algorithms*, PHI Learning Pvt. Ltd., New Delhi, 2003.
3. N.P. Padhy., *Artificial Intelligence and Intelligent Systems*, Oxford University Press, 2005.
4. JacekM.Zurada "Introduction to Artificial Neural Systems" Jaico Publishing House, 2005.


**Reference Books:**


1. Saptarsi Goswami, A. K.Das, and A. Chakrabarti," *AI for Everyone: A Beginner's Handbook for*
2. *Artificial Intelligence"*, Pearson Education, 2024
3. D.L. Poole., and AlanK.Mackworth, "Artificial Intelligence: Foundations of Computational Agents" 3rd Edition, Cambridge University Press, 2023.
4. Hagan, Demuth, Beale,"*Neural Network Design"*, 2nd Edition, Martin Hagan, 2014.
5. Satish Kumar "*Neural Networks: A Classroom Approach*, 2nd Edition, McGraw-Hill Education, 2012.
6. Elaine Rich and Kevin Knight — "Artificial Intelligence", Third Edition, Tata McGraw-Hill Education Pvt. Ltd., 2008.


**Useful Links:Web Resources**

1. "CS50's Introduction to Artificial Intelligence with Python" (Harvard Online free)

2. AI For Everyone by Andrew Ng (Coursera)
3. https://nptel.ac.in/courses/106102220
4. https://nptel.ac.in/courses/106105079
5. https://thestempedia.com/blog/simple-ai-and-machine-learning-projects-forstudents-and-biginners/
6. https://nptel.ac.in/courses/106105078

## Assessment Methodology – Artificial Intelligence

| Type of Assessment | Assessment Tools / Marks Distribution |
|---|---|
| **CA – Theory (20 Marks)** | Certification: NPTEL (20 Marks)<br>OR<br>Any two Pedagogies (10 marks each):<br>MCQ/Class Test \|<br>Case study/Assignment<br>GATE based Assignment<br>Certification: Udemy/Coursera<br>Open Book Test<br>Working model/simulation |
| **MSE – Theory (30 Marks)** | All Questions are compulsory.<br>Q1 A or B – 10 marks<br>Q2 A or B – 10 marks \|<br>Q3 A or B – 10 marks.<br>Each question A and B based on same CO.<br>MSE based on 50% syllabus. Time: 90 minutes. Total Marks: 30 |
| **ESE – Theory (50 Marks)** | All Questions are compulsory.<br>Q1-Q5, each A or B – 10 marks.<br>ESE: 30% MSE syllabus + 70% post-MSE syllabus.<br>Time: 120 minutes. Total Marks: 50 |
| **TW – Laboratory (25 Marks)** | Active Participation (Lab) = 5 marks<br>Laboratory Report = 10 marks<br>Laboratory Performance = 10 marks.<br>Based on performance and satisfactory completion of assigned laboratory work. |
| **PR – Laboratory (25 Marks)** | Practical examination based on experiments performed by the students during laboratory sessions. |

## 3. Program Elective – PCE (Choose One)

# Cloud Computing

| Course Code | Course Name | Teaching Scheme (Hrs./Week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | P | T | L | P | T | Total |
| 25CE5PCE01 | Cloud Computing | 2 | 1 | - | 2 | 1 | - | 3 |

| Examination Scheme | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | CA | MSE | ESE | TW | OR | OR & PR | Total |
| Theory | | 20 | 30 | 50 | - | - | - | 100 |
| Lab | | - | - | - | 25 | - | 25 | 50 |
| Grand Total | | | | | | | | 150 |

| Pre-Requisite Course(s) | 25CE4PCC03: Computer Networks |
|---|---|

# Course Objectives & Module overview

**Course Objectives:**

The course "Cloud Computing" is designed to provide students with a comprehensive understanding of the fundamental concepts, technologies, and applications of cloud computing in modern engineering. In today's interconnected world, cloud computing plays a pivotal role in enabling scalable, on-demand access to computational resources, storage, and applications over the internet. Emphasis will be placed on understanding how cloud computing transforms traditional telecommunication systems by providing efficient resource management, virtualization, and high availability for network services.

**Module 1** This module introduces the basic concepts of cloud computing. Students learn about cloud characteristics such as on-demand access, scalability, resource pooling, and pay-as-you-go services. It covers cloud components, deployment models, benefits and challenges of cloud computing, and an overview of popular cloud platforms like AWS and Azure.

**Module 2** This module Introduces virtualization concepts, virtual machines, hypervisors, and containerization technologies, including Docker and its architecture.

**Module 3** This Module explains cloud service models such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), and Database as a Service (DaaS), along with their features, responsibilities, and real-world applications.

**Module 4** This Module focuses on cloud security mechanisms, identity and access management(IAM), encryption, firewalls, authentication, authorization, accounting (AAA), and Single Sign-On (SSO).

**Module 5** This Module Introduces distributed, parallel, grid, and quantum computing, highlighting their integration with cloud and emerging technologies like edge computing.

**Module 6** This module Covers deployment, monitoring, and management of cloud resources, including virtual machines, storage, networking, load balancing, auto-scaling, and serverless computing.

# Course Outcomes – Cloud Computing

| CO | Course Outcome |
|---|---|
| **CO1** | Recall and describe the fundamental concepts, characteristics, deployment models, and service models of cloud computing. (Remembering) |
| **CO2** | Explain virtualization, containerization, cloud service models, and security mechanisms used in cloud environments. (Understanding) |
| **CO3** | Apply cloud technologies to create, configure, and manage cloud resources and applications. (Applying) |
| **CO4** | Analyze cloud deployment models, virtualization approaches, and security solutions for various application requirements. (Analyzing) |
| **CO5** | Evaluate cloud platforms, monitoring tools, and security practices based on performance and scalability. (Evaluating) |
| **CO6** | Design, deploy, and demonstrate cloud-based applications by integrating multiple cloud services. (Creating) |

# Syllabus – Cloud Computing

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| **1** | **Module 1: Introduction to Cloud Computing** | | **05** |
| | *Understand fundamental concepts, characteristics, components, and deployment models of cloud computing.* | | |
| | **1.1** | Introduction to Cloud Computing, Cloud Computing Architecture, Cloud Characteristics, Cloud Computing Components, Cloud computing benefits and challenges | |
| | **1.2** | Cloud Deployment Models: Public, Private, Community, Hybrid | |
| | **1.3** | Introduction to popular cloud platforms: AWS, Azure | |
| | **Self-Learning Topics:** *Google Cloud Platform (GCP), Multi-cloud and Edge Computing* | | |
| **2** | **Module 2: Virtualization Concepts and Containerization** | | **06** |
| | *Understand the benefits of virtualization and evaluate virtualization and container technologies such as Hypervisors, KVM, Docker, and Kubernetes in cloud environments.* | | |
| | **2.1** | Introduction to Virtualization: Concepts, Benefits, and Design Requirements; Hypervisors and Virtual Machines; Hosted Virtualization | |
| | **2.2** | Type-1 and Type-2 Hypervisors, KVM (Kernel-based Virtual Machine) – KVM Architecture, Features and Advantages | |
| | **2.3** | Introduction to Kubernetes: Architecture, Pods, Nodes, Deployments, Services, Scaling and Load Balancing, Kubernetes vs Docker, Kubernetes in Cloud Platforms | |
| | **2.4** | Containerization Concepts: Containers vs Virtual Machines, Docker Architecture, Containers, and Basic Docker Operations | |
| | **Self-Learning Topics:** *Xen Architecture and KVM Virtualization* | | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| **3** | **Module 3: Cloud Computing Service Models** | | **05** |
| | *Understand and compare IaaS, PaaS, SaaS, and DBaaS with real-life examples.* | | |
| | **3.1** | Cloud Computing Web Services, Service Oriented Architecture (SOA) | |
| | **3.2** | Cloud Computing Service Models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), Database as a Service (DaaS) with Concepts and real life examples. | |
| | **3.3** | Cloud Computing service model comparison, Responsibilities in each service model | |
| | **Self-Learning Topics:** *Applications and use cases of cloud computing (e-commerce, healthcare, IoT)* | | |
| **4** | **Module 4: Security in Cloud Computing** | | **05** |
| | *Learn cloud security fundamentals including IAM, encryption, firewalls, and the AAA model.* | | |
| | **4.1** | Introduction to Cloud Security, Security Challenges and Threats in Cloud Computing, Data Encryption (Data at Rest and Data in Transit), Identity and Access Management (IAM), Cloud Storage Gateways, Cloud Firewalls and Security Groups | |
| | **4.2** | AAA (Authentication, Authorization, and Accounting) Model, Single Sign-On (SSO) for Clouds, Authentication Management in Clouds, Authorization Management in Clouds, Multi-Factor Authentication (MFA), Role-Based Access Control (RBAC). | |
| | **Self-Learning Topics:** *Security Compliance Standards, Cloud Security Best Practices* | | |
| **5** | **Module 5: Distributed and Emerging Computing Paradigms** | | **05** |
| | *Understand and compare parallel, grid, and quantum computing paradigms and their applications.* | | |
| | **5.1** | Introduction to Computing Paradigms: Evolution, Centralized vs Distributed vs Cloud, High-Performance Computing | |
| | **5.2** | Parallel Computing: Types of Parallelism, Shared/Distributed Memory Architectures, Applications | |
| | **5.3** | Grid Computing: Architecture, Resource Sharing, Scheduling, Grid vs Cloud, Applications | |
| | **5.4** | Quantum Computing: Fundamentals, Qubits, Superposition, Entanglement, Quantum Gates, Applications, Quantum Cloud Platforms | |
| | **Self-Learning Topics:** *Edge and Fog Computing* | | |
| **6** | **Module 6: Cloud Deployment and Resource Management** | | **04** |
| | *Deploy applications and manage virtual machines, storage, networking, and monitoring on cloud platforms.* | | |
| | **6.1** | Cloud Resource Provisioning: Creating and Managing VMs(virtual machine), Storage Services, Networking Services, Resource Configuration. | |
| | **6.2** | Application Deployment: Web App Deployment, Load Balancing, Auto | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | | Scaling, Serverless Computing (AWS Lambda, Azure Functions) | |
| | **Self-Learning Topics:** *DevOps Tools in Cloud Computing* | | |
| | | **TOTAL** | **30** |

## Suggested List of Experiments

| Sr. No. | Title of the Experiment |
|---|---|
| 1 | **Comparative Case study of Cloud-Based and Non-Cloud-Based Solutions for Real-World Applications.**<br>**Objective:** To understand the key differences between cloud-based and non-cloud-based solutions in real-world applications.<br>**Outcome:** Students will be able to compare cloud and non-cloud solutions and identify the most suitable approach for a given application. |
| 2 | **Implementation of Virtualization using Hypervisors.**<br>**Objective:** To install and configure Type-1/Type-2 hypervisors and create virtualized environments.<br>**Outcome:** Students will be able to implement virtualization and analyze hypervisor-based resource management. |
| 3 | **Creating and Managing Virtual Machines using Infrastructure as a service (IaaS).**<br>**Objective:** To understand the process of creating and managing virtual machines using Infrastructure as a Service (IaaS).<br>**Outcome:** Students will be able to create, configure, and manage virtual machines on a cloud platform using IaaS services. |
| 4 | **Docker Installation and Container Management.**<br>**Objective:** To install Docker and perform container creation, execution, and management operations.<br>**Outcome:** Students will be able to create and manage containerized applications using Docker. |
| 5 | **Implementation of Storage as a Service using AWS / Azure Storage.**<br>**Objective:** To create and configure cloud storage resources for storing and managing data.<br>**Outcome:** Students will be able to Create and configure storage services using AWS S3 or Azure Storage. and Manage cloud storage resources and perform data storage operations. |

| Sr. No. | Title of the Experiment |
|---|---|
| 6 | **Working with Cloud Storage and Database as a Service (DBaaS).**<br><br>**Objective:** To create and manage cloud storage and database services on AWS/Azure.<br><br>**Outcome:** Students will be able to utilize cloud storage and DBaaS services for application deployment. |
| 7 | **Deploying a Web Application using Platform as a Service (PaaS).**<br><br>**Objective:** To deploy a web application on a cloud platform using Platform as a Service (PaaS).<br><br>**Outcome:** Students will be able to host and manage web applications using cloud platform services. |
| 8 | **Configuring Identity and Access Management (IAM).**<br><br>**Objective:** To create users, roles, and access policies using cloud IAM services.<br><br>**Outcome:** Students will be able to implement authentication and authorization mechanisms in cloud environments. |
| 9 | **Implementing Cloud Security Services using Security as a Service (SaaS).**<br><br>**Objective:** To configure cloud firewalls, security groups, and data encryption mechanisms.<br><br>**Outcome:** Students will be able to secure cloud resources using standard cloud security practices. |
| 10 | **Monitoring and Managing Cloud Resources.**<br><br>**Objective:** To monitor cloud resources and application performance using AWS CloudWatch/Azure Monitor.<br><br>**Outcome:** Students will be able to track resource utilization and manage cloud services efficiently. |
| 12 | **Cloud Computing Mini-project**<br><br>**Objective:** To design and deploy a Web Application Hosted on a Public Cloud Platform incorporating IaaS, PaaS, DBaaS, Storage as a Service and Security as a Service.<br><br>**Outcome:** Students will be able to design a real-world cloud-based solution and integrate various cloud services.<br><br>**Note:** AWS/ Azure Tool is Mandatory for implementing all the cloud computing experiments. |

## Text Books – Cloud Computing


1. Bernard Golden – Amazon Web Services for Dummies, John Wiley & Sons
2. Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi – Mastering Cloud Computing, Tata McGraw-Hill Education
3. Gautam Shroff – Enterprise Cloud Computing: Technology, Architecture, Applications, Cambridge University Press, 2010.

## Reference Books:

1. Cloud Computing Black Book: Kailash Jayaswal, Jagannath Kallakurchi, Donald J. Houde, Dr. Deven Shah by Kogent Learning Solutions, Publisher: Dreamtech Press.

2. Cloud Computing Concepts Technology and Architecture - Erl second hand book online from Used Books Factory.

## Other Resources :

1. NPTEL Swayam Course on Cloud computing By Prof. Soumya Kanti Ghosh https://nptel.ac.in/courses/106/105/106105167/
2. Cloud Computing and Distributed Systems By Prof. Rajiv Misra https://onlinecourses.nptel.ac.in/noc22_cs18/preview
3. Google Cloud Computing Foundation Course https://nptel.ac.in/courses/106/105/106105223

# Assessment Methodology – Cloud Computing

| Type of Assessment | Assessment Tools / Marks Distribution |
|---|---|
| **CA – Theory (20 Marks)** | Certification: NPTEL (20 Marks)<br>OR<br>Any two Pedagogies (10 marks each):<br>MCQ/Class Test \|<br>Case study/Assignment<br>GATE based Assignment<br>Certification: Udemy/Coursera<br>Open Book Test<br>Working model/simulation |
| **MSE – Theory (30 Marks)** | All Questions are compulsory.<br>Q1 A or B – 10 marks<br>Q2 A or B – 10 marks \|<br>Q3 A or B – 10 marks.<br>Each question A and B are based on the same CO.<br>MSE based on 50% syllabus. Time: 90 minutes. Total Marks: 30 |
| **ESE – Theory (50 Marks)** | All Questions are compulsory.<br>Q1-Q5, each A or B – 10 marks.<br>ESE: 30% MSE syllabus + 70% post-MSE syllabus.<br>Time: 120 minutes. Total Marks: 50 |
| **TW – Laboratory (25 Marks)** | Active Participation (Lab) = 5 marks<br>Laboratory Report = 10 marks<br>Laboratory Performance = 10 marks.<br>Based on performance and satisfactory completion of assigned laboratory work. |
| **PR – Laboratory (25 Marks)** | Practical examination based on experiments performed by the students during laboratory sessions. |

# Cyber Security

| Course Code | Course Name | Teaching Scheme (Hrs./Week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | P | T | L | P | T | Total |
| 25CE5PCE12 | Cyber Security | 2 | 1 | - | 2 | 1 | - | 3 |

| Examination Scheme | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | CA | MSE | ESE | TW | OR | OR & PR | Total |
| Theory | | 20 | 30 | 50 | - | - | - | 100 |
| Tutorial | | - | - | - | 25 | 25 | - | 50 |
| Grand Total | | | | | | | | 150 |

| | |
|---|---|
| **Pre-Requisite Course(s)** | 25DBFE2VSEC02 - Object Oriented Programming using Python<br>25CE4PCC03 - Computer Network<br>25FE2BSC01-Fundamentals of Engineering Mathematics -II |

# Course Objectives & Module overview

**Course Objectives**: The Cryptography and System Security (CSS) course aims to provide students with basic understanding of cyber security concepts, cryptographic techniques, and secure communication methods. It helps students apply encryption, analyze security mechanisms like hash functions and digital signatures, and understand network security protocols. The course also focuses on evaluating and designing secure systems using tools such as firewalls and intrusion detection systems to protect against cyber threats.

**Module 1: Introduction to Cyber Security**

To understand the fundamental concepts of cyber security including security goals (CIA triad), cyber threats, vulnerabilities, risks, and common cyber attacks, and to analyze real-world cyber incidents in terms of CIA triad violations.

**Module 2:Operating System Security**

To understand and apply operating system security mechanisms such as authentication, access control, user account management, and system protection techniques to safeguard system resources and data from security threats.

**Module 3: Number Theory and Basic Cryptography**

To understand and apply fundamental number theory concepts such as divisibility, prime numbers, GCD, Euclidean algorithm, modular arithmetic, Fermat's theorem, and Euler's theorem, along with classical cryptographic techniques like substitution and transposition ciphers, to perform basic encryption and decryption for secure communication and problem-solving.

**Module 4: Modern Cryptography Concepts**

To understand and apply modern cryptography concepts including symmetric and asymmetric encryption, block and stream ciphers, cryptographic hash functions, message authentication codes, digital signatures, and key management techniques to ensure secure communication and data protection.

**Module 5: Network Security and Risk Assessment**

To understand and apply network security concepts and risk assessment techniques including types of network attacks, security protocols, firewalls, intrusion detection systems, and risk identification and analysis methods to protect networks and evaluate security risks.

**Module 6: Ethical Hacking and System Security**

To understand and apply ethical hacking concepts, system vulnerabilities, and system security mechanisms including penetration testing basics, hacking phases, system hardening, patch management, backup and recovery, and security auditing to identify, analyze, and protect systems from cyber attacks.

Overall, the course equips computer science students with fundamental knowledge and practical skills in cyber security, cryptography, and system security to analyze threats, apply security mechanisms, and design secure computing systems for protecting data and networks.

# Course Outcomes – Cyber Security

| CO | Course Outcome |
|---|---|
| **CO1** | Recall the fundamental principles of Cyber Security and explain the CIA Triad, threats, vulnerabilities, and common cyber attacks. |
| **CO2** | Discuss the role of authentication methods, access control mechanisms, and common security threats in Operating System Security. |
| **CO3** | Apply number theory and classical cryptographic techniques to perform basic encryption and decryption operations. |
| **CO4** | Analyze symmetric, asymmetric, and hash-based cryptographic systems for secure communication |

| CO | Course Outcome |
|---|---|
| | and data integrity. |
| **CO5** | Evaluate network security mechanisms and risk assessment techniques to identify and reduce security risks in systems. |
| **CO6** | Design basic security solutions using ethical hacking concepts and system security mechanisms to protect systems from cyber threats. |

# Syllabus – Cyber Security

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| **1** | **Module 1: Introduction to Cyber Security** | | **03** |
| | *Understand fundamental concepts of cyber security including the CIA triad, cyber threats, vulnerabilities, and common attacks.* | | |
| | **1.1** | Fundamentals of Cyber Security, Need and Importance, Security Goals (CIA), Cyber Threats, Vulnerabilities and Risks, Types of Cyber Attacks (Malware, Phishing, Social Engineering, DoS/DDoS), Role of Cryptography | |
| | **Self-Learning Topics:** *Case Study: Analyze a real cyber attack and identify the breach in the CIA triad* | | |
| **2** | **Module 2: Operating System Security** | | **04** |
| | *Identify common OS threats and recall authentication and access control mechanisms.* | | |
| | **2.1** | OS Security Fundamentals: Threats and Vulnerabilities, Security Principles; Access Control: User Authentication, MFA, ACL, File/Directory Permissions | |
| | **2.2** | Malware and System Protection: Viruses, Worms, Trojans, Ransomware, Spyware, Detection and Prevention | |
| | **Self-Learning Topics:** *Comparative study of Password-based Authentication vs Multi-Factor Authentication (MFA)* | | |
| **3** | **Module 3: Number Theory and Basic Cryptography** | | **08** |
| | *Apply number theory concepts and classical cryptographic techniques for encrypting and decrypting messages.* | | |
| | **3.1** | Number Theory Foundations: Divisibility, Prime Numbers, GCD, Euclidean Algorithm, Modular Arithmetic, Fermat's Theorem, Euler's Theorem | |
| | **3.2** | Classical Cryptography: Symmetric Cipher Model, Caesar Cipher, Monoalphabetic, Playfair, Vigenere, Rail Fence, and Columnar Transposition Ciphers | |
| | **Self-Learning Topics:** *Encrypt a sentence using two classical ciphers and compare results* | | |
| **4** | **Module 4: Modern Cryptography Concepts** | | **10** |
| | *Differentiate symmetric and asymmetric cryptography and analyze digital signatures and authentication protocols.* | | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | **4.1** | Symmetric and Asymmetric Cryptography: DES, AES, RSA; Block Cipher vs Stream Cipher | |
| | **4.2** | Hash Functions and Message Digest: MD5, SHA family, applications | |
| | **4.3** | Digital Signature: Concept, generation and verification; Key Management: KDC, Diffie-Hellman, Kerberos | |
| | **Self-Learning Topics:** *Study of cryptography in online banking, email security, and secure websites* | | |
| **5** | **Module 5: Network Security and Risk Assessment** | | **02** |
| | *Evaluate the impact of network attacks and assess organizational risks with mitigation strategies.* | | |
| | **5.1** | Network Security Fundamentals: TCP/IP vulnerabilities, Packet Sniffing, ARP Spoofing, IP Spoofing, Port Scanning, DoS and DDoS | |
| | **5.2** | Security Mechanisms: Firewalls, IDS, IPS | |
| | **5.3** | Risk Assessment: Risk, Threat and Vulnerability concepts, Qualitative and Quantitative Risk Assessment, Mitigation Strategies | |
| | **Self-Learning Topics:** *Study a recent cyber attack and evaluate security measures that could reduce its impact* | | |
| **6** | **Module 6: Ethical Hacking and System Security** | | **03** |
| | *Design basic security approaches using ethical hacking and system security mechanisms.* | | |
| | **6.1** | Ethical Hacking Basics, Types of Hackers, Phases of Ethical Hacking, Vulnerability Assessment, Penetration Testing, Security Hardening and Monitoring | |
| | | **TOTAL** | **30** |

# Suggested List of Experiments

| S. No. | List of Experiments |
|---|---|
| 1 | **Module 1: Introduction to Cyber Security**<br>**Objectives:**<br>● To analyze the CIA triad (Confidentiality, Integrity, and Availability) in cyber security through real-world scenarios.<br>**Outcomes:**<br>● Students will be able to identify and analyze the impact of cyber attacks on the CIA triad in given situations.<br><br>**Experiment no 1 : CIA Triad Analysis** |

| | |
|---|---|
| 2 | **Module 2: Operating System Security**<br>• **Objectives:**<br>To perform and observe basic operating system security mechanisms such as authentication, access control (file permissions), and malware protection using system tools.<br>• **Outcomes:**<br>Students will be able to demonstrate and identify operating system security features including user authentication, file and directory permissions, and basic malware detection techniques.<br>**Experiment 2 : To observe and verify basic operating system security mechanisms such as authentication, access control, and malware protection features in a system.** |
| 3 | **Module 3:Number Theory and Basic Cryptography**<br>• **Objectives:**<br>To demonstrate the combined use of substitution and transposition techniques for securing messages.<br>• **Outcomes:**<br>**S**tudents will be able to encrypt and decrypt messages using a product cipher.<br>**Experiment 3: Design and Implementation of a Product Cipher using Substitution and Transposition Ciphers.** |
| 4 | Module 4: **Modern Cryptography Concepts**<br>• **Objectives:**<br>To understand the working of public key cryptography through RSA.<br>• **Outcomes:**<br>Students will be able to perform RSA-based encryption and decryption.<br>**Experiment 4:Implementation and analysis of RSA crypto system.** |
| 5 | **Module 4: Modern Cryptography Concepts**<br>• **Objectives:**<br>To demonstrate secure key establishment between communicating parties.<br>• **Outcomes:**<br>Students will be able to establish a shared secret key using the Diffie-Hellman algorithm.<br>**Experiment 5:Implementation of Diffie Hellman Key exchange algorithm.** |

| | |
|---|---|
| 6 | **Module 5: Network Security and Risk Assessment**<br><br>● **Objectives:**<br>To investigate network traffic and packet analysis techniques.<br><br>● **Outcomes:**<br>Students will be able to capture, filter, and analyze network packets using Wireshark.<br><br>**Experiment 6: Study of packet sniffer tools: wireshark,:**<br>**1. Download and install wireshark and capture icmp, tcp, and http packets in promiscuous mode.**<br>**2. Explore how the packets can be traced based on different filters.** |
| 7 | **Module 5: Network Security and Risk Assessment**<br><br>**Objectives:**<br>To explore various network scanning and host discovery techniques.<br><br>**Outcomes:**<br>Students will be able to identify open ports and gather network information using Nmap.<br><br>**Experiment no 7 :Download and install nmap. Use it with different options to scan open ports, perform OS fingerprinting, do a ping scan, tcp port scan, udp port scan, xmas scan** |
| 8 | **Module 2: Operating System Security**<br><br>**Objectives:**<br>To identify and analyze the impact of software vulnerabilities through buffer overflow attacks.<br><br>**Outcomes:**<br>Students will be able to identify and analyze buffer overflow vulnerabilities.<br><br>**Experiment 8: Simulate buffer overflow attack using Ollydbg, Splint, Cpp check** |
| 9 | **Module 5 : Network Security and Risk Assessment**<br><br>**Objectives:**<br>To evaluate system security risks by implementing a Python program using a predefined dataset and calculating risk scores based on likelihood and impact values.<br><br>**Outcomes:**<br>Students will be able to evaluate and classify security risks in a system using a Python-based predefined dataset approach without manual input.<br><br>**Experiment 9 :Risk Calculation and Assessment Using Python with Predefined Dataset** |

| | |
|---|---|
| 10 | **Module 6 : Ethical Hacking and System Security**<br><br>**Objectives:**<br>To design a basic ethical hacking framework for identifying system vulnerabilities and suggesting appropriate security measures. .<br><br>**Outcomes:**<br>Students will be able to design and present a simple ethical hacking model including phases of hacking and corresponding security countermeasures for a given system.<br><br>**Experiment 10 : Design of Basic Ethical Hacking Framework for a System** |
| Implementation of basic cryptographic algorithms, number theory concepts, and system security mechanisms using suitable programming approaches to reinforce theoretical concepts of cyber security and secure communication. | |

# Text Books – Cyber Security


1. William Stallings – Cryptography and Network Security: Principles and Practice, 6th Edition, Pearson Education, 2013
2. Behrouz A. Forouzan – Cryptography and Network Security, Tata McGraw-Hill
3. Behrouz A. Forouzan & Debdeep Mukhopadhyay, "Cryptography and Network Security" 3rd Edition, McGraw Hill


# Reference Books – Cyber Security


1. Atul Kahate, "Cryptography and Network Security", Tata McGraw-Hill Education, 2003.
2. Bruce Schneier, "Applied Cryptography, Protocols Algorithms and Source Code in C",Second Edition, Wiley.
3. Eric Cole, "Network Security Bible", Second Edition, Wiley, 2011.


### Useful Links

- https://nptel.ac.in/courses/106106222?utm_source=chatgpt.com
- https://owasp.org/www-project-top-ten/?utm_source=chatgpt.com
- https://cryptii.com/?utm_source=chatgpt.com
- https://www.cloudflare.com/learning/security/?utm_source=chatgpt.com

# Assessment Methodology – Cyber Security

| Type of Assessment | Assessment Tools / Marks Distribution |
|---|---|
| **CA – Theory (20 Marks)** | Certification: NPTEL (20 Marks)<br>OR<br>Any two Pedagogies (10 marks each):<br>MCQ/Class Test \|<br>Case study/Assignment<br>GATE based Assignment<br>Certification: Udemy/Coursera<br>Open Book Test |

| Type of Assessment | Assessment Tools / Marks Distribution |
|---|---|
| | Working model/simulation |
| **MSE – Theory (30 Marks)** | All Questions compulsory.<br>Q1 A or B – 10 marks<br>Q2 A or B – 10 marks \|<br>Q3 A or B – 10 marks.<br>Each question A and B based on same CO.<br>MSE based on 50% syllabus. Time: 90 minutes. Total Marks: 30 |
| **ESE – Theory (50 Marks)** | All Questions compulsory.<br>Q1-Q5, each A or B – 10 marks.<br>ESE: 30% MSE syllabus + 70% post-MSE syllabus.<br>Time: 120 minutes. Total Marks: 50 |
| **TW – Laboratory (25 Marks)** | Active Participation (Lab) = 5 marks<br>Laboratory Report = 10 marks<br>Laboratory Performance = 10 marks.<br>Based on performance and satisfactory completion of assigned laboratory work. |
| **OR– Laboratory (25 Marks)** | Oral examination based on experiments performed by the students during laboratory sessions. |

# Statistics for Machine Learning and Data Science

| Course Code | Course Name | Teaching Scheme (Hrs./Week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | P | T | L | P | T | Total |
| 25CE5PCE013 | Statistics for Machine Learning and Data Science | 2 | 2 | - | 2 | 1 | - | 3 |

| Examination Scheme | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | CA | MSE | ESE | TW | OR | OR & PR | Total |
| Theory | | 20 | 30 | 50 | - | - | - | 100 |
| Lab | | - | - | - | 25 | 25 | - | 50 |
| Grand Total | | | | | | | | 150 |

| | |
|---|---|
| **Pre-Requisite Course(s)** | 25FE1BSE01 – Engineering Mathematics 01<br>25FE2VSEC02 – Object Oriented Programming Using Python |

Course Objectives & Module overview

**Statistics for Machine Learning and Data Science** provides a comprehensive foundation in statistical methods and their applications in Data Science and Machine Learning. It introduces descriptive statistics, probability theory, sampling techniques, regression analysis, statistical estimation, and hypothesis testing. Students will learn how to collect, analyze, interpret, and draw inferences from data using statistical tools and techniques. The course emphasizes practical applications of statistics in predictive modeling, machine learning, and data-driven decision-making. By the end of the course, students will be able to apply statistical concepts to real-world datasets, evaluate machine learning models, and make informed decisions based on statistical evidence.

**Course Objectives:**

1.To introduce fundamental concepts of statistics, probability, and data analysis.
2.To develop understanding of statistical measures, probability laws, and inference techniques.
3.To apply statistical methods and regression models for data analysis.
4.To analyze relationships among variables using statistical and probabilistic techniques.
5.To evaluate statistical models and inference methods for decision making
6.To develop statistical solutions for Machine Learning and Data Science applications.

**Module 1**: This module introduces the fundamental concepts of statistics and their significance in data science and machine learning. Students will learn methods for organizing, summarizing, and visualizing data using statistical measures and graphical techniques. The module also covers measures of central tendency, dispersion, skewness, kurtosis, correlation, covariance, and distance metrics used in exploratory data analysis and feature selection.

**Module 2:** This module covers the foundations of probability theory and random variables. Students will learn probability laws, conditional probability, Bayes' theorem, Bayesian inference, and probability distributions. The module introduces discrete and continuous random variables, statistical independence, joint and conditional distributions, and commonly used probability distributions in machine learning applications.

**Module 3:** This module focuses on data collection methodologies and sampling techniques used in statistical studies. Students will understand population and sample concepts, census and sample surveys, probability and non-probability sampling methods, bootstrap sampling, sampling errors, and sampling distributions. The Law of Large Numbers and Central Limit Theorem are introduced as the foundation for statistical inference.

**Module 4:** This module introduces regression analysis as a tool for modeling relationships among variables and making predictions. Students will learn simple and multiple linear regression, model assumptions, significance testing, and model evaluation metrics such as $R^2$, MAE, MAPE, MSE, and RMSE. The module emphasizes the application of regression techniques in predictive analytics and machine learning.

**Module 5:** This module introduces statistical inference through estimation theory. Students will learn point estimation, properties of estimators, Method of Moments, Maximum Likelihood Estimation (MLE), confidence intervals, sample size determination, and applications of confidence intervals in model evaluation. The module highlights the role of estimation techniques in machine learning and statistical modeling.

**Module 6:** This module covers the principles of hypothesis testing and statistical decision-making. Students will study standard statistical distributions, formulation of null and alternative hypotheses, Type I and Type II errors, Neyman-Pearson lemma, Most Powerful (MP) tests, and Uniformly Most Powerful (UMP) tests. The module emphasizes the use of hypothesis testing techniques in machine learning experiments, model comparison, and data-driven decision-making.

# Course Outcomes – Statistics for ML & DS

| CO | Course Outcome |
|---|---|
| **CO1** | **Recall** the fundamental concepts of statistics, probability, data collection methods, sampling techniques, and statistical distributions used in data science and machine learning (Remembering) |
| **CO2** | **Explain** descriptive statistical measures, probability concepts, random variables, sampling distributions, and regression principles for data analysis. (Understanding) |
| **CO3** | **Apply** probability laws, sampling methods, estimation techniques, confidence intervals, and regression models to solve data science and machine learning problems. (Applying) |
| **CO4** | **Analyze** relationships among variables using correlation analysis, probability models, simple and multiple regression techniques, and statistical tests. (Analyzing) |
| **CO5** | **Evaluate** estimators, confidence intervals, regression models, and hypothesis testing procedures for statistical inference and decision-making. **(**Evaluating) |
| **CO6** | **Design** and develop data-driven solutions by integrating statistical analysis, predictive modeling, estimation, and hypothesis testing techniques for real-world machine learning applications. (Creating) |

# Syllabus – Statistics for ML & DS

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| **1** | **Module 1: Descriptive Statistics and Data Representation** | | **03** |
| | After completing this module, students will be able to recall the fundamental concepts of statistics, data classification, descriptive statistical measures, and data visualization techniques used in data analysis. | | |
| | 1.1 | Functions, importance, uses and limitations of Statistics. | |
| | 1.2 | **Data Classification and Visualization:** Statistical data– classification, tabulation, descriptive statistics:central tendency, dispersion, skewness, kurtosis. , diagrammatic and graphical representation of data;histograms, boxplots, scatter plots, pair plots. | |
| | 1.3 | Statistical Measures: Expectation, Variance, Covariance, correlation, confounding, correlation matrices and their properties.Distance measures: Euclidean, Manhattan, Cosine,Introduction to Feature Selection using Correlation , | |
| | **Self-Learning Topics:** Exploratory Data Analysis (EDA), Outlier Detection Methods, Data Preprocessing Concepts | | |
| **2** | **Module 2: Probability and Random Variables** | | **05** |
| | After completing this module, students will be able to explain probability concepts, random variables, statistical independence, and probability distributions for modeling uncertainty in data-driven applications. | | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | 2.1 | **Fundamentals of Probability:** Experiment, Sample Space and Events, Types of Events, Simple and Compound Events, Mutually Exclusive Events, Exhaustive Events, Independent and Dependent Events, Conditional Probability, Baye's Theorem, Bayesian Inference (Prior, Posterior, Likelihood) ,Applications of Probability in Data Science and Machine Learning. | |
| | 2.2 | **Random Variables and Statistical Independence:** Concept of Random Variable, Discrete and Continuous Random Variables, Statistical Independence. | |
| | 2.3 | Multivariate Probability Distributions: Joint, Marginal and Conditional Distributions of Two-Dimensional Random Variables. | |
| | 2.4 | Probability Distributions:Probability Mass Function (PMF),Probability Density Function (PDF),Cumulative Distribution Function (CDF),Binomial distribution,Poisson distribution,Uniform distribution,Normal distribution. | |
| | **Self-Learning Topics**: Introduction to Information Theory (Entropy), Probabilistic Graphical Models, Applications of Bayesian Networks. | | |
| **3** | **Module 3: Data Collection & Sampling Methods** | | **04** |
| | After completing this module, students will be able to apply appropriate data collection methods, sampling techniques, and sampling distribution concepts for statistical analysis and inference. | | |
| | 3.1 | **Data Sources and Collection Techniques:** Primary and Secondary Data, Sources of Data, Methods of Data Collection. | |
| | 3.2 | Sampling Concepts and Methods: Population and Sample,Census & Sample methods –Methods of sampling, Probability Sampling and Non-Probability Sampling Techniques: Simple Random, Stratified, Cluster, Bootstrap Sampling Techniques and Applications ,Sampling and Non-Sampling Errors. | |
| | 3.3 | Theory of Sampling Distributions: Sampling Distribution of Means, Law of Large Numbers and Central Limit Theorem. | |
| | **Self-Learning Topics**: Missing Data Mechanisms, Data Bias and Fairness, Resampling Techniques | | |
| **4** | **Module 4: Regression Analysis and Predictive Modeling** | | **10** |
| | After completing this module, students will be able to analyze relationships among variables and evaluate regression models using statistical and predictive performance measures. | | |
| | 4.1 | Correlation and Dependence Analysis. | |
| | 4.2 | Fundamentals of Linear Regression: Mathematical and Statistical Equations, Simple Linear Regression, Meaning of Intercept and Slope. | |
| | 4.3 | Regression Model Evaluation: Error Term, Assumptions of Regression, Measures of Model Fit: $R^2$, MAE, MAPE, MSE, RMSE, Adjusted $R^2$. | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | 4.4 | Multiple Regression and Significance Testing: Multiple Linear Regression Model, Partial Regression Coefficients, Testing Significance overall significance of Overall fit of the model, Testing for Individual Regression Coefficients | |
| | **Self-Learning Topics:** Introduction to Logistic Regression, Overfitting and Underfitting | | |
| **5** | **Module 5: Statistical Inference and Estimation** | | **04** |
| | After completing this module, students will be able to evaluate estimators, confidence intervals, and statistical inference methods for estimating population parameters and assessing model reliability. | | |
| | 5.1 | Random sample, Parametric point estimation unbiasedness and consistence, Method of Moments and Maximum Likelihood Estimation (MLE). | |
| | 5.2 | Sample Size Determination and Model Evaluation: Confidence Intervals for Variance, Sample Size Determination and Applications of Confidence Intervals in Model Performance Evaluation. | |
| | **Self-Learning Topics**:Introduction to Statistical Learning Theory and applications | | |
| **6** | **Module 6: Tests of hypotheses** | | **04** |
| | After completing this module, students will be able to design and implement statistical decision-making frameworks by applying hypothesis testing techniques and statistical distributions to solve real-world data science and machine learning problems. | | |
| | 6.1 | **Standard Statistical Distributions:** Population Distribution, Z-Distribution, Student's t-Distribution, Chi-Square Distribution and F-Distribution. | |
| | 6.2 | Null and Alternative hypotheses. Types of errors. Neyman-Pearson lemma MP and UMP tests. | |
| | **Self-Learning Topics:**Non-Parametric Tests, Multiple Hypothesis Testing, | | |
| | | **TOTAL** | **30** |

# Laboratory Experiments – Statistics for ML & DS (Minimum 10)

| No. | Title and Details |
|---|---|
| **1** | **Aim: To perform descriptive statistical analysis and visualize data using graphical techniques.**<br>**Objective: Compute descriptive statistical measures (central tendency, dispersion, skewness, kurtosis) and visualize data using histograms, boxplots, scatter plots, and pair plots.**<br>**Outcome: Students will be able to summarize datasets and interpret statistical characteristics using visualization tools.** |
| **2** | **Aim: To analyze relationships among variables using statistical and distance measures.**<br>**Objective: Quantify relationships using covariance and correlation; compute distance metrics for similarity analysis.**<br>**Outcome: Students will be able to measure dependence and similarity among variables in datasets.** |

| No. | Title and Details |
|---|---|
| 3 | **Aim: To understand and implement basic probability concepts and event relationships.**<br>**Objective: Apply probability rules, conditional probability, and Bayes' theorem to decision-making scenarios.**<br>**Outcome: Students will be able to solve probability problems and interpret uncertainty in data-driven applications.** |
| 4 | **Aim: To analyze multivariate probability distributions.**<br>**Objective: Compute joint, marginal, and conditional probabilities from multivariate datasets.**<br>**Outcome: Students will be able to model probabilistic relationships among multiple variables.** |
| 5 | **Aim: To generate and analyze discrete and continuous probability distributions.**<br>**Objective: Study the behavior of random variables through PMF, PDF, and CDF visualizations.**<br>**Outcome: Students will be able to identify appropriate probability models for different data scenarios.** |
| 6 | **Aim: To study different sampling methods and evaluate sampling errors.**<br>**Objective: Implement various sampling methods and compare sample statistics with population characteristics.**<br>**Outcome: Students will be able to select suitable sampling techniques for data collection and analysis.** |
| 7 | **Aim:To demonstrate sampling distributions and the Central Limit Theorem through simulation.**<br>**Objective:To study sampling distributions through repeated random sampling experiments and verify the Law of Large Numbers and Central Limit Theorem using simulations. Outcome:Students will be able to explain the foundation of statistical inference using simulations.** |
| 8 | **Aim:To develop a predictive model using simple linear regression.**<br>**Objective:To develop a simple linear regression model for analyzing relationships between variables and interpret regression coefficients to evaluate prediction performance. Outcome:Students will be able to predict outcomes and interpret linear relationships between variables.** |
| 9 | **Aim:To build and evaluate multiple linear regression models.**<br>**Objective:To construct multiple linear regression models using multiple predictor variables and assess model performance using statistical and error-based evaluation metrics.**<br>**Outcome:Students will be able to assess model performance and identify influential predictors.** |
| 10 | **Aim:To estimate population parameters and construct confidence intervals.**<br>**Objective:To estimate population parameters using point and interval estimation techniques and construct confidence intervals and apply maximum likelihood estimation methods. Outcome:Students will be able to evaluate uncertainty associated with parameter estimates.** |
| 11 | **Aim:To study hypothesis testing concepts and analyze Type I and Type II errors using statistical distributions.**<br>**Objective: To formulate null and alternative hypotheses for statistical decision-making problems and determine critical regions and decision rules using Z, t, Chi-Square, and F distributions.** |

| No. | Title and Details |
|---|---|
| | **Outcome:Students will be able to formulate statistical hypotheses, interpret decision rules, and evaluate the effects of Type I and Type II errors in statistical inference.** |

## Text Books – Statistics for ML & DS


1. Agarwal, B.L. (2006) – Basic Statistics, Wiley Eastern Ltd., New Delhi
2. Gupta, S. P. (2011) – Statistical Methods, Sultan Chand & Sons, New Delhi
3. Hogg, R.V. and Craig, A.T. (2006) – An Introduction to Mathematical Statistics, Amerind Publications
4. Miller & Freund – Probability and Statistics for Engineers, 9th Edition


## Reference Books – Statistics for ML & DS


1. Arora, P.N., Sumeet Arora, S. Arora (2007) – Comprehensive Statistical Methods, Sultan Chand, New Delhi
2. Montgomery, D.C., Peck, E.A., & Vining, G.G. (2003) – Introduction to Linear Regression Analysis, John Wiley and Sons
3. Mood, A.M., Graybill, F.A., and Boes, D.C. (1985) – Introduction to the Theory of Statistics, McGraw-Hill


## Useful Links – Statistics for ML & DS

1. https://onlinecourses-archive.nptel.ac.in/noc19_ma08/preview
2. https://onlinecourses-archive.nptel.ac.in/noc18_ma22/preview

### Assessment Methodology – Statistics for ML & DS

| Type of Assessment | Assessment Tools / Marks Distribution |
|---|---|
| **CA – Theory (20 Marks)** | Certification: NPTEL (20 Marks)<br>OR<br>Any two Pedagogies (10 marks each):<br>MCQ/Class Test \|<br>Case study/Assignment<br>GATE based Assignment<br>Certification: Udemy/Coursera<br>Open Book Test<br>Working model/simulation |
| **MSE – Theory (30 Marks)** | All Questions compulsory.<br>Q1 A or B – 10 marks<br>Q2 A or B – 10 marks \|<br>Q3 A or B – 10 marks.<br>Each question A and B based on same CO.<br>MSE based on 50% syllabus. Time: 90 minutes. Total Marks: 30 |
| **ESE – Theory (50 Marks)** | All Questions compulsory.<br>Q1-Q5, each A or B – 10 marks.<br>ESE: 30% MSE syllabus + 70% post-MSE syllabus.<br>Time: 120 minutes. Total Marks: 50 |
| **TW – Laboratory (25 Marks)** | Active Participation (Lab) = 5 marks<br>Laboratory Report = 10 marks<br>Laboratory Performance = 10 marks.<br>Based on performance and satisfactory completion of assigned laboratory |

| Type of Assessment | Assessment Tools / Marks Distribution |
|---|---|
| | work. |
| **OR – Laboratory (25 Marks)** | Oral examination based on experiments performed by the students during laboratory sessions. |

## Professional Communication Skills

**Course Code: 25CE5AEC02 | Category: AEC (Ability Enhancement Course)**

| Course Code | Course Name | Teaching Scheme (Hrs./Week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | P | T | L | P | T | Total |
| 25CE5AEC02 | Professional Communication Skills | 2+2 | - | - | 2 | - | - | 2 |

| Examination Scheme | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | CA | MSE | ESE | TW | OR | OR & PR | Total |
| Theory | | - | - | - | 50 | - | - | 50 |
| Pre-Requisite Course(s) | 25FEAEC01 – Effective Communication Skills | | | | | | | |

# Course Objectives and Module Overview

**Course Objectives:**

This course is designed to develop professional communication competencies required in academic, technical, corporate, and global workplace environments. The course focuses on enhancing verbal, written, interpersonal, digital, and presentation communication skills essential for engineering graduates and professionals. Students will develop the ability to communicate effectively in professional settings through technical writing, presentations, group discussions, workplace interactions, and digital communication platforms.

The course also emphasizes leadership communication, critical thinking, emotional intelligence, corporate etiquette, teamwork, and interview readiness. Practical activities such as mock interviews, presentations, group discussions, report writing, and roleplay simulations provide experiential learning opportunities to prepare students for placements, internships, entrepreneurship, and professional careers.

The course integrates modern communication practices including AI-assisted communication tools, digital collaboration platforms, professional networking, and global workplace communication standards to ensure industry relevance and employability readiness.

**Module 1** This module develops advanced professional communication competencies required in workplace and corporate environments. It focuses on persuasive communication, negotiation skills, emotional intelligence, workplace ethics, and cross-cultural communication. Students will learn to communicate strategically, handle professional interactions effectively, and resolve workplace conflicts through appropriate communication practices.

**Module 2** This module emphasizes professional writing skills required for technical and corporate communication. Students will learn technical report writing, proposal drafting, executive summaries, research documentation, professional emails, meeting documentation, and AI-assisted writing practices used in industry and academic environments

**Module 3** This module develops professional speaking and interpersonal communication abilities. It focuses on presentations, group discussions, panel discussions, interview communication, storytelling techniques, and corporate meeting simulations. Students will strengthen public speaking confidence, teamwork communication, and leadership interaction skills.

**Module 4** This module introduces modern digital communication platforms and AI-based communication tools used in professional environments. Students will learn professional networking, digital etiquette, prompt engineering basics, AI-assisted content generation, online collaboration, and personal branding strategies for digital workplace communication.

**Module 5** This module prepares students for internships, placements, and professional careers through resume building, portfolio development, interview preparation, corporate professionalism, and workplace communication practices. Students will gain confidence in handling HR, technical, behavioral, and stress interviews effectively.

**Module 6** This module focuses on leadership communication, innovation pitching, entrepreneurship communication, design thinking, crisis communication, and multicultural workplace interaction. Students will develop the communication competencies required for leadership roles, global collaboration, and future workplace environments.

# Course Outcomes

| CO | Course Outcome |
|---|---|
| **CO1** | Define the fundamentals of professional, technical, digital, and workplace communication. (Remembering) |
| **CO2** | Explain communication models, professional ethics, corporate communication practices, and workplace interaction strategies. (Understanding) |
| **CO3** | Apply verbal, written, presentation, and digital communication skills in academic, technical, and professional contexts. (Applying) |

| CO | Course Outcome |
|---|---|
| **CO4** | Analyze workplace communication situations, group discussions, negotiation scenarios, and professional challenges to identify suitable communication strategies. (Analyzing) |
| **CO5** | Evaluate leadership communication, ethical communication practices, and cross-cultural workplace interactions in professional environments. (Evaluating) |
| **CO6** | Create technical reports, business documents, presentations, resumes, portfolios, and AI-assisted communication content for industry readiness. (Creating) |

# Syllabus

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| **1** | **Module 1: Advanced Professional Communication** | | **06** |
| | *Define advanced workplace communication concepts and models. Analyze workplace communication scenarios and conflict situations. Demonstrate emotional intelligence and ethical communication practices.* | | |
| | **1.1** | Fundamentals of Professional Communication: Types of professional communication, Barriers to communication, Principles of effective communication | |
| | **1.2** | Workplace Communication Skills: Formal and informal workplace communication, Internal and external communication, Corporate communication structure, Professional interaction techniques | |
| | **1.3** | Persuasive Communication and Influencing Skills: Persuasion techniques, Negotiation communication, Influencing strategies, Assertive communication | |
| | **1.4** | Emotional Intelligence, Interpersonal Skills and Professional Etiquettes: Ethical communication practices, Professional behavior and etiquette, Corporate responsibility in communication, Confidentiality and professionalism | |
| | **Self-Learning Topics:** *Watch corporate communication videos and prepare observation report* | | |
| **2** | **Module 2: Technical and Business Writing** | | **08** |
| | *Draft technical reports, proposals, and executive summaries professionally. Prepare professional emails, meeting agendas, and minutes. Apply concise and structured business writing principles.* | | |
| | **2.1** | Technical Report Writing: Structure of technical reports, Formal writing style, Data presentation techniques, Report formatting standards | |
| | **2.2** | Business Correspondence: Professional email writing, Business letters and memos, Escalation and response mails, Corporate communication drafting | |
| | **2.3** | Technical Proposal Writing: Proposal writing structure, Writing executive summaries, Parts of a technical proposal, Documentation standards | |
| | **2.4** | Business Meeting Documentation: Notice and agenda preparation, Writing meeting minutes, Documentation practices, Official communication records, Conducting business meetings | |
| | **2.5** | AI-Assisted Writing Tools: AI tools for professional writing, Content | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | | refinement techniques, Grammar and style checking tools, Ethical use of AI in documentation | |
| | **Self-Learning Topics:** *Create documentation using AI tools* | | |
| **3** | **Module 3: Corporate Speaking & Group Communication** | | **06** |
| | *Deliver professional and impactful presentations confidently. Participate effectively in group discussions, panel discussions, and meetings. Demonstrate leadership and teamwork communication skills.* | | |
| | **3.1** | Professional Presentation Skills: Presentation structure, Visual aids and slide design, Voice modulation and body language, Audience engagement techniques | |
| | **3.2** | Group Discussions: GD strategies and participation, Analytical and critical discussion skills, Leadership during discussions, Professional interaction techniques | |
| | **3.3** | Team Communication and Collaboration: Team interaction methods, Collaborative communication, Workplace coordination, Communication in projects | |
| | **3.4** | Storytelling and Persuasive Speaking: Storytelling techniques, Persuasive presentation methods, Corporate storytelling, Influencing audience perception | |
| | **3.5** | Interview Communication Mastery: HR interview communication, Technical interview interaction, Behavioral interview handling, Mock interview practice | |
| | **Self-Learning Topics:** *Record and analyze personal presentation videos* | | |
| **4** | **Module 4: Digital Communication & AI Tools** | | **06** |
| | *Use professional digital communication platforms effectively. Build professional online profiles and digital presence. Apply AI tools for presentations, reports, and communication tasks.* | | |
| | **4.1** | Digital Communication Platforms: Professional communication tools, Email and virtual communication, Online collaboration platforms, Digital workplace communication | |
| | **4.2** | LinkedIn and Professional Networking: LinkedIn profile optimization, Professional networking strategies, Building online professional identity, Networking etiquette | |
| | **4.3** | AI Tools for Communication: AI tools for presentations, AI-assisted report writing, Communication automation tools, Productivity enhancement using AI | |
| | **4.4** | Digital Etiquette and Cyber Professionalism: Online professional behavior, Cyber ethics and safety, Responsible digital communication, Professional conduct in virtual environments | |
| | **4.5** | Personal Branding and Online Reputation: Personal branding strategies, Online presence management, Digital reputation building, Professional portfolio creation | |
| | **Self-Learning Topics:** *Build personal online portfolio* | | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| **5** | **Module 5: Placement and Career Readiness** | | **06** |
| | *Prepare ATS-friendly resumes and professional portfolios. Demonstrate effective communication during HR and technical interviews. Apply the STAR method while answering interview questions.* | | |
| | **5.1** | Resume and Portfolio Development: Resume writing techniques, ATS-friendly resume preparation, Cover letters, Portfolio building methods, Career documentation standards | |
| | **5.2** | Placement Communication Skills: Internship communication, Placement interaction strategies, Corporate communication readiness, Professional self-introduction | |
| | **5.3** | HR and Technical Interviews: HR interview preparation, Technical interview handling, Stress interview techniques, Behavioral interview strategies, STAR method for structured responses | |
| | **5.4** | Corporate Professionalism: Workplace expectations, Professional ethics and conduct, Office communication etiquette, Time and task communication | |
| | **5.5** | Career Growth and Workplace Readiness: Career planning communication, Workplace adaptability, Professional relationship management, Industry communication practices | |
| | **Self-Learning Topics:** *Watch placement interview sessions and prepare reflection report* | | |
| **6** | **Module 6: Leadership, Innovation & Global Workplace Skills** | | **04** |
| | *Demonstrate leadership and innovation communication skills. Present entrepreneurial and technical ideas effectively. Handle crisis communication situations professionally.* | | |
| | **6.1** | Leadership Communication: Leadership communication styles, Motivational communication, Decision-making communication, Team leadership interaction | |
| | **6.2** | Innovation and Entrepreneurial Communication: Startup pitching techniques, Entrepreneurial communication, Innovation presentations, Business idea communication | |
| | **6.3** | Crisis Communication and Media Handling: Crisis management communication, Media interaction basics, Reputation management, Emergency communication strategies | |
| | **6.4** | Future Workplace Skills and Industry 5.0 Communication: Future communication trends, Human-AI workplace collaboration, Smart workplace communication, Industry 5.0 professional competencies | |
| | **Self-Learning Topics:** *Study successful startup presentations* | | |
| | | **TOTAL** | **36** |

# Suggested List of Activities

| No. | Title and Details |
|---|---|
| **1** | Mock GD 1 |

| No. | Title and Details |
|---|---|
| | **Objective: To develop students' ability to participate actively and effectively in group discussions.**<br>**Outcome: Students will be able to present opinions logically and contribute meaningful ideas during group discussions.** |
| **2** | Business Meeting Simulation<br>**Objective: To train students in professional communication and collaboration during formal business meetings.**<br>**Outcome: Students will be able to participate professionally in meetings and demonstrate meeting etiquette.** |
| **3** | Mock GD 2<br>**Objective: To enhance students' confidence and communication skills in group discussion settings.**<br>**Outcome: Students will be able to articulate viewpoints confidently and engage constructively in discussions.** |
| **4** | Presentation on Interpersonal Skills<br>**Objective: To develop students' presentation and interpersonal communication skills.**<br>**Outcome: Students will be able to organize and deliver structured presentations with effective verbal and non-verbal communication.** |
| **5** | Mock Interviews<br>**Objective: To prepare students for professional interviews through practice and self-assessment.**<br>**Outcome: Students will be able to answer interview questions confidently and communicate their strengths effectively.** |
| **6** | Creation of LinkedIn Profile<br>**Objective: To guide students in building a professional online presence for career opportunities.**<br>**Outcome: Students will be able to create a professional LinkedIn profile showcasing qualifications, achievements, and career interests.** |
| **7** | Debate on Emerging Technologies<br>**Objective: To encourage critical thinking and effective public speaking through debate activities.**<br>**Outcome: Students will be able to express arguments logically and defend viewpoints confidently.** |
| **8** | Pitching a Startup Idea<br>**Objective: To enable students to present innovative business ideas persuasively and professionally.**<br>**Outcome: Students will be able to explain a startup idea clearly, justify its feasibility, and deliver an effective pitch presentation.** |
| **9** | Final Group Discussion<br>**Objective: To assess overall group discussion and communication skills.**<br>**Outcome: Students will be able to participate confidently and demonstrate collaborative communication skills.** |
| **10** | Final Presentation on Project<br>**Objective: To develop students' ability to present project work in a structured and** |

| No. | Title and Details |
|---|---|
| | **professional manner.**<br>**Outcome: Students will be able to deliver organized project presentations with clarity and effective audience engagement.** |

## Text Books

1. Business Communication Today – Bovee & Thill
2. Technical Communication – Meenakshi Raman

## Reference Books

1. HBR Guide to Persuasive Presentations
2. Crucial Conversations – Patterson et al.
3. The Quick and Easy Way to Effective Speaking – Dale Carnegie

## Assessment Methodology

| Type of Assessment | Assessment Tools / Marks Distribution |
|---|---|
| **Term Work (50 Marks)** | Active Participation (Lab) = 05 marks \| Assignments = 10 marks \| Activities = 10 marks. Based on performance and satisfactory completion of all activities. |
| **Internal Oral (25 Marks)** | Book Report = 05 marks \| Presentation = 10 marks \| Final Group Discussion = 10 marks |

## Research Methodology

**Course Code: 25CE5ELC | Category: ELC (Elective Learning Course)**

| Course Code | Course Name | Teaching Scheme (Hrs./Week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | P | T | L | P | T | Total |
| 25CE5ELC | Research Methodology | 2 | - | - | 2 | - | - | 2 |

| Examination Scheme | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | CA | MSE | ESE | TW | OR | OR & PR | Total |
| Theory | | - | - | - | 50 | - | - | 50 |
| Pre-Requisite Course(s) | 25FE1BSE01 – Engineering Mathematics 01 | | | | | | | |

# Course Objectives & Module overview

**Course Objectives:**

This course introduces engineering students to the principles and practices of scientific research. It covers problem identification, literature review, research design, experimental methods, data analysis, technical writing, research ethics, and intellectual property rights. The course equips students with the skills required to undertake research projects, publish technical papers, and pursue innovation in engineering.

The objectives of this course are as follows:

1. Understand the fundamentals and methodologies of engineering research.
2. Formulate research problems and develop appropriate research designs.
3. Apply experimental, computational, and analytical methods in engineering investigations.
4. Analyze and interpret research data using statistical techniques.
5. Develop technical writing and presentation skills for dissemination of research findings.
6. Understand research ethics, intellectual property rights, and publication practices.

**Module 1** introduces the fundamentals of engineering research, including its purpose, significance, and role in technological innovation. It covers the research process, scientific inquiry, and various types of research such as basic, applied, experimental, and computational research. Students will gain an understanding of how research contributes to solving engineering problems and advancing technology.

**Module 2** focuses on identifying research problems and conducting effective literature reviews. It introduces techniques for searching, evaluating, and synthesizing scholarly literature to identify research gaps and formulate research objectives, questions, and hypotheses. Students will develop the ability to define meaningful engineering research problems based on existing knowledge and emerging challenges.

**Module 3** introduces the principles of research design and methodology used in engineering research. It covers the selection of appropriate research approaches, methods, and procedures for conducting systematic investigations. Students will learn to design research studies, develop experimental plans, select data collection methods, and ensure the reliability and validity of research outcomes.

**Module 4** focuses on methods of data collection, organization, and analysis in engineering research. It introduces primary and secondary data sources, sampling techniques, and statistical tools used for data interpretation. Students will learn to apply descriptive and inferential statistics to analyze research data, draw meaningful conclusions, and support evidence-based decision-making.

**Module 5** introduces the ethical, legal, and professional aspects of engineering research. It covers research integrity, plagiarism, intellectual property rights (IPR), patents, copyrights, and scholarly publishing practices. Students will gain an understanding of ethical research conduct, protection of research outcomes, and the process of publishing technical papers in journals and conferences.

**Module 6** focuses on the effective communication of research findings through technical writing and professional presentations. It covers the preparation of research papers, technical reports, theses, and research proposals, along with citation and referencing practices.

## Course Outcomes

| CO | Course Outcome |
|---|---|
| **CO1** | Explain the fundamental concepts, types, and processes of research in engineering and technology. |
| **CO2** | Identify research problems, formulate objectives and hypotheses, and conduct a comprehensive literature review using scientific databases. |
| **CO3** | Design appropriate research methodologies, experiments, and data collection procedures for engineering investigations. |
| **CO4** | Apply statistical and analytical techniques to collect, process, analyze, and interpret research data. |
| **CO5** | Demonstrate awareness of research ethics, plagiarism, intellectual property rights (IPR), and publication practices. |
| **CO6** | Prepare and present research proposals, technical reports, dissertations, and research papers in a professional format. |

## Syllabus

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| **1** | **Module 1: Introduction to Engineering Research Concepts and Types of Research** | | **04** |
| | *After completing this module, students will understand the fundamentals and scope of engineering research.* | | |
| | **1.1** | Meaning, objectives, and significance of research; Types of research: Basic, Applied, Experimental, Computational, Action research; Characteristics of good research, Research process and scientific method, Engineering research challenges and opportunities | |
| | **Self-Learning Topics:** *Emerging Research Paradigms, Research Impact Assessment, Global Research Trends, AI in Engineering Research, Technology Transfer* | | |
| **2** | **Module 2: Literature Review and Research Problem Formulation** | | **04** |
| | *After completing this module, students will be able to formulate research problems and conduct literature reviews.* | | |
| | **2.1** | Identification of research problems, Selection of research topics, Research objectives and questions, Hypothesis formulation, Research gap identification, Sources of technical literature, Literature survey techniques, Citation and referencing methods, Use of digital databases and search engines | |
| | **Self-Learning Topics:** *Research Question Development Frameworks, AI-Assisted Literature Reviews, Critical Analysis of Research Papers* | | |
| **3** | **Module 3: Research Design and Methodology** | | **08** |
| | *After completing this module, students will be able to design suitable methodologies for engineering research.* | | |
| | **3.1** | Research design concepts, Quantitative and qualitative research methods, Experimental research design, Survey methods, Case study approach, Modeling and simulation-based research, Variables and measurement scales, Reliability and validity | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | **Self-Learning Topics:** *Bibliometric Analysis, AI-Assisted Research* | | |
| **4** | **Module 4: Data Collection and Statistical Analysis** | | **06** |
| | *After completing this module, students will be able to collect and analyze engineering data.* | | |
| | **4.1** | Sources of data, Primary and secondary data, Sampling methods, Questionnaire design, Data coding and classification, Descriptive statistics, Probability distributions, Hypothesis testing, Correlation and regression analysis, ANOVA | |
| | **Self-Learning Topics:** *Data Ethics and Privacy, Open Data Repositories, Uncertainty Analysis, Perform exploratory analysis on an open dataset* | | |
| **5** | **Module 5: Research Ethics, IPR, and Technical Publications** | | **04** |
| | *After completing this module, students will understand ethical and legal aspects of research.* | | |
| | **5.1** | Research ethics, Plagiarism and academic integrity, Ethical issues in engineering research, Intellectual Property Rights (IPR), Patents, copyrights, trademarks, Patent search and filing basics, Journal publications and conferences, Peer-review process | |
| | **Self-Learning Topics:** *Responsible Conduct of Research, Ethics in Emerging Technologies, Open Science Practices, Predatory Publishing, Research Visibility and Scholarly Identity* | | |
| **6** | **Module 6: Technical Writing and Research Presentation** | | **04** |
| | *After completing this module, students will be able to communicate research findings effectively.* | | |
| | **6.1** | Scientific Writing, Research proposal writing and Funding Agencies, Thesis and dissertation preparation, Writing journal papers, Preparation of tables, figures, and references (IEEE, APA, MLA, Chicago, Harvard, Vancouver styles), Use of Reference Management Tools (Zotero, Mendeley, EndNote), Responding to Reviewers Comments, Research Communication through Blogs and social media | |
| | **Self-Learning Topics:** *Graphical Abstracts and Infographics, Digital Tools for Academic Writing, Peer Review and Manuscript Revision* | | |
| | | **TOTAL** | **30** |

# Text Books


1. Creswell, J.W. & Creswell, J.D. – Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 6th Edition, SAGE Publications, 2023
2. Kothari, C. R. & Garg, G. – Research Methodology: Methods and Techniques, 5th Edition, New Age International Publishers, 2024
3. Ganesan, R. – Research Methodology for Engineers, MJP Publishers, 2024


# Useful Links

1. https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_ge66

2. https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_ge79
3. https://ocw.mit.edu/courses/esd-932-engineering-ethics-spring-2006/
4. own Business

## Assessment Methodology

| Type of Assessment | Assessment Tools / Marks Distribution |
|---|---|
| **Term Work (50 Marks)** | Any two individual pedagogy assignments (10 marks each):<br>Literature Review Assignment<br>Statistical Analysis Using Software<br>Patent Search Activity.<br>Group activity/tasks (10 marks each):<br>Technical Paper Review and Presentation<br>Research Problem Identification Exercise<br>Research Proposal Preparation |

## Community Engagement Project III – Innovation, Research and Product Engineering

| Course Code | Course Name | Teaching Scheme (Hrs./Week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | P | T | L | P | T | Total |
| **25CE4CEP03** | **Community Engagement Project III – Innovation, Research and Product Engineering** | - | 1 | - | - | 1 | - | **1** |

| Examination Scheme | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | CA | MSE | ESE | TW | OR | PR | Total |
| **Theory** | | - | - | - | 25 | 25 | - | **50** |

| | |
|---|---|
| **Pre-Requisite Courses** | 25CE4CEP01 – Mini Project I (Design Thinking Fundamentals)<br>25CE4CEP02 – Mini Project II (Solution Development and Testing) |

## Course Objectives & Overview

This course represents the culmination of a three-semester experiential learning journey, building upon 25CE4CEP01 – Mini Project I (Design Thinking Fundamentals) and 25CE4CEP02 – Mini Project II (Solution Development and Testing). Students are expected to transform validated ideas, prototypes, and challenge statements into impactful engineering solutions addressing industrial, societal, sustainability, research, entrepreneurship, and national innovation needs. Projects may originate from initiatives such as Smart India Hackathon (SIH), ISRO, government departments, industry collaborations, Sustainable Development Goals (SDGs), startup concepts, research problems, or community challenges.

The course emphasizes engineering innovation, solution maturity, experimentation, validation, deployment, and effective communication of outcomes. Students apply modern engineering practices, including software development, cloud deployment, DevOps, AI-assisted tools, testing methodologies, research techniques, and professional documentation, to develop, evaluate, and showcase deployable solutions with measurable impact.

Course Objectives (COs) – 5 Points

- To identify and analyze real-world problems from industrial, societal, research, or entrepreneurial domains and formulate clear project objectives, scope, and success criteria.
- To design innovative and feasible solutions by developing suitable architectures, selecting appropriate technologies, and planning validation and deployment strategies.
- To develop and implement project solutions using modern engineering practices, software tools, version control systems, APIs, cloud services, and AI-assisted technologies.
- To evaluate and validate project outcomes through systematic testing, performance analysis, user feedback, and assessment of scalability, sustainability, and impact.
- To effectively communicate and demonstrate project results through technical documentation, research reports, presentations, pitch decks, and professional project deployment or showcasing.

## Course Outcomes

| CO | Course Outcome |
|---|---|
| **CO1** | Identify and justify a significant industrial, societal, research, sustainability, or innovation challenge for solution development. (Remembering) |
| **CO2** | Interpret stakeholder requirements, literature findings, domain constraints, and problem-specific opportunities. (Understanding) |
| **CO3** | Apply appropriate engineering, research, and project management methodologies to develop innovative solutions. (Applying) |
| **CO4** | Analyze system performance, user feedback, experimental results, and feasibility constraints to improve solution quality. (Analyzing) |
| **CO5** | Evaluate the impact, scalability, sustainability, novelty, and effectiveness of the proposed solution. (Evaluating) |
| **CO6** | Develop and demonstrate a deployable product, research prototype, competition-ready solution, or innovation artifact with professional documentation and presentation. (Creating) |

## Syllabus

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| **1** | **Project Identification and Problem Framing** | | **06** |
| | *After completing this module, students will be able to: Identify real-world, industrial, societal, or research challenges; Formulate project objectives and scope; Establish measurable success criteria; Define project deliverables.* | | |
| | | Problem sources: SIH, ISRO, SDGs, industry, startups, community. Problem analysis, feasibility assessment, stakeholder identification. Project planning, milestones, risk identification. | |
| | **Deliverable** | Project Proposal: Problem statement, objectives, literature review, project plan | |
| **2** | **Solution Design and Technical Planning** | | **06** |
| | *After completing this module, students will be able to: Design solution architecture; Select suitable technologies and methodologies; Plan validation and testing strategies; Estimate resources and deployment requirements.* | | |
| | | Solution architecture and workflow design. Technology selection and validation strategy. Resource estimation and deployment planning. | |
| | **Deliverable** | Design Document: Architecture, workflow, technology stack, testing strategy | |
| **3** | **Development, Experimentation and Engineering Practices** | | **08** |
| | *After completing this module, students will be able to: Develop solution components; Apply software engineering practices; Integrate external services and tools; Manage project versions and releases.* | | |
| | | Core solution development and integration. Version control, documentation, engineering practices. AI-assisted tools, cloud services, APIs. | |
| | **Deliverable** | Working Prototype: Source code repository, implementation progress, demo | |
| **4** | **Testing, Validation and Impact Assessment** | | **06** |
| | *After completing this module, students will be able to: Validate developed solutions; Measure performance and effectiveness; Assess user acceptance and impact; Improve solution quality through iteration.* | | |
| | | Functional, usability, performance, and security testing. Experimental validation and benchmarking. Impact, scalability, and sustainability assessment. | |
| | **Deliverable** | Validation Report: Test results, user feedback, performance/impact analysis | |
| **5** | **Product Deployment, Research Communication and Pitching** | | **04** |
| | *After completing this module, students will be able to: Deploy or demonstrate solutions professionally; Prepare research and technical documentation; Communicate innovation outcomes effectively; Present solutions to academic, industry, or competition panels.* | | |
| | | Deployment and demonstration. Research paper and technical | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | | report preparation. Pitch deck and presentation techniques. | |
| | **Deliverable** | Final Submission Package: Technical report, presentation, deployed solution/prototype, research paper/pitch deck/SIH submission | |

## Suggested Project Categories

- Smart India Hackathon (SIH) Problem Statements
- ISRO / Government Innovation Challenges
- Sustainable Development Goal (SDG) Projects
- Research and Innovation Projects
- Product Engineering and Startup Ideas
- AI and Data-Driven Applications
- Human-Machine Interaction Solutions
- Cloud-Based Applications
- Community and Social Impact Projects
- Industry-Sponsored Projects

## Assessment Criteria

- Problem significance and relevance
- Technical depth and innovation
- Application of engineering/research methodologies
- Quality of implementation or experimentation
- Validation and impact assessment
- Deployment or demonstration readiness
- Research paper and documentation quality
- Presentation and pitching effectiveness
- Teamwork and project management
- Individual contribution and professional conduct

## Text Books


1. Tim Brown – Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, Harper Business, 2009
2. Harold Kerzner – Innovation Project Management: Methods, Case Studies, and Tools for Managing Innovation Projects, Wiley, 2nd Edition, 2023
3. Gerard O'Regan – Guide to Software Project Management, Springer, 2025
4. Jeanne Liedtka, Randy Salzman, Daisy Azer – Design Thinking for the Greater Good: Innovation in the Social Sector, Columbia University Press, 2017


## Reference Books


1. Jim Highsmith – Agile Project Management: Creating Innovative Products, Addison-Wesley
2. Roger L. Martin – The Design of Business: Why Design Thinking is the Next Competitive Advantage, Harvard Business Review Press
3. Frederick P. Brooks Jr. – The Mythical Man-Month: Essays on Software Engineering, Addison-Wesley
4. David Kelley and Tom Kelley – Creative Confidence: Unleashing the Creative Potential Within Us All, Crown Business

## Useful Links

1. Smart India Hackathon (SIH) Official Portal: https://www.sih.gov.in
2. ISRO Capacity Building and Student Programmes: https://www.isro.gov.in/CapacityBuilding.html
3. United Nations Sustainable Development Goals (SDGs): https://sdgs.un.org/goals
4. Stanford d.school Resources and Design Tools: https://dschool.stanford.edu/resources
5. IDEO Design Thinking Resources: https://designthinking.ideo.com/resources
6. GitHub Student Developer Resources: https://education.github.com/students
7. IEEE Author Center and Paper Templates: https://journals.ieeeauthorcenter.ieee.org

## Assessment Methodology

| Type of Assessment | Assessment Tools / Marks Distribution |
|---|---|
| **TW (25 Marks)** | Active Participation (Lab) = 05 marks \| Project Report = 10 marks \| Progress Presentations (Minimum 2) & Demonstration = 10 marks |
| **PR (25 Marks)** | Practical examination based on experiments performed by the students during laboratory sessions. |

# Multidisciplinary Minor (MDM) Courses:

## IoT System Design

| Course Code | Course Name | Teaching Scheme (Hrs. / Week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25ET5MDM01 | IoT System Design | L | P | T | L | P | T | Total |
| | | 3 | 2 | - | 3 | 1 | - | 4 |
| | | Examination Scheme | | | | | | |
| | | | CA | MSE | ESE | TW | OR | PR | Total |
| | | Theory | 20 | 30 | 50 | - | - | - | 100 |
| | | Lab | - | - | - | 25 | - | - | 25 |

| Pre-Requisite Courses: | |
|---|---|
| | 25FE1BSC01: Engineering Physics |
| | 25FE1VSEC01: C Programming |
| | 25FE1ESC02: Basic Electrical and Digital Electronics |
| | 25ET4MDM01: Embedded Systems |
| | 25ET4MDM02: Sensor Technology |

**Course and Module Overview:**

This course gives students a complete guide to building smart, connected systems using the Internet of Things (IoT). It is highly useful for Computer Science (Comp) and Information Technology (IT) students because it teaches them how to collect big data, use cloud platforms like ThingSpeak, and manage network protocols like MQTT. These students will learn to write code that safely connects hardware to web servers and handles data visualization. Mechanical (Mech) students will benefit greatly because modern machinery, factories, and vehicles rely heavily on smart sensors and automatic actuators to run smoothly. They will learn how to read physical values like temperature or motion and turn them into digital data to automate tasks. By bringing these fields together, the course allows Comp and IT students to understand physical machine parts, while Mech students learn how to make their mechanical designs smart and connected. Everyone will gain hands-on skills in prototyping with Arduino and Raspberry Pi, which are highly valued in smart manufacturing and automation jobs. Ultimately, this course helps students from different fields work together to design, build, and secure real-world smart systems.

**Module 1** introduces the fundamental concepts of the Internet of Things (IoT), including its architecture, components, and characteristics. It also explains the differences between M2M and IoT systems and introduces Cloud, Fog, and Edge computing paradigms used in IoT applications.

**Module 2** focuses on popular IoT development platforms such as Arduino, NodeMCU, and Raspberry Pi. Students learn to interface sensors and actuators with microcontrollers and develop basic programs for data acquisition and device control.

**Module 3** covers common wireless communication technologies used in IoT, including Wi-Fi,

| Course Code | Course Name | Teaching Scheme (Hrs. / Week) | Credits Assigned |
|---|---|---|---|

Bluetooth, ZigBee, and LoRaWAN. It also introduces IoT communication protocols such as MQTT and CoAP and compares them with traditional HTTP communication.

**Module 4** explains the role of cloud computing in IoT systems and demonstrates how sensor data can be transmitted, stored, and visualized using cloud platforms such as ThingSpeak. Students also learn to create dashboards and configure simple automated alerts.

**Module 5** introduces the security challenges associated with IoT devices and networks. It covers fundamental security practices such as authentication, encryption, password management, and firmware updates to protect IoT systems from common threats.

**Module 6** presents the complete workflow of an IoT system, from data collection to cloud-based analytics and decision-making. It explores real-world applications of IoT in smart homes, healthcare monitoring, and intelligent transportation systems through practical case studies.

| | | |
|---|---|---|
| **Course Outcomes (COs)** | **After successful completion of the course, the students will be able to:** | |
| | CO1 | State the basic differences between standard Machine-to-Machine (M2M) communication and cloud, fog, or edge computing. (Remembering) |
| | CO2 | Describe the pin outs and features of development boards like Arduino Uno, NodeMCU, and Raspberry Pi. (Understanding) |
| | CO3 | Construct simple Arduino IDE sketches to read data from sensors and trigger physical actuators like relays. (Applying) |
| | CO4 | Differentiate between HTTP and lightweight protocols like MQTT to see which is best for small devices. (Analyzing) |
| | CO5 | Assess cloud logging data charts on ThingSpeak to judge if a system requires an automatic IFTTT alert. (Evaluating) |
| | CO6 | Build a step-by-step IoT case study application that connects physical sensors to a functional web dashboard. (Creating) |

**Syllabus:**

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| 1 | | **Introduction to IoT Basics** | **07** |
| | | After completing this module, students will be able to:<br>• Define what IoT is and identify its basic structural building blocks.<br>• Explain the main differences between standard Machine-to-Machine (M2M) communication and IoT. | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | • Understand the basic concepts of Cloud, Fog, and Edge computing. | | |
| | 1.1 | Definition, characteristics, and basic components of an IoT system. Physical and logical design of IoT. | |
| | 1.2 | Difference between M2M (Machine to Machine) and IoT. Introduction to Cloud computing, Fog computing, and Edge computing in IoT. | |
| | **Self-Learning Topics:** Basic real-world examples of IoT like Smart Homes and Smart Agriculture. | | |
| **2** | **IoT Hardware and Prototyping (Arduino & Raspberry Pi)** | | **08** |
| | After completing this module, students will be able to:<br>• Differentiate between common IoT development boards like Arduino Uno, NodeMCU, and Raspberry Pi.<br>• Connect common sensors (Temperature, Motion, and Gas) and actuators (Relays, Motors) to a microcontroller.<br>• Write simple Arduino IDE sketches to read sensor data and control outputs. | | |
| | 2.1 | Introduction to popular IoT boards: Arduino Uno, NodeMCU (ESP8266/ESP32), and Raspberry Pi pin outs and features. | |
| | 2.2 | Interfacing Sensors: DHT11 (Temperature & Humidity), PIR (Motion Sensor), Ultrasonic (Distance), and MQ-2 (Gas/Smoke Sensor). | |
| | 2.3 | Interfacing Actuators: Relays (for switching AC home appliances), LEDs, Buzzers, and Servo Motors. | |
| | 2.4 | Programming Basics: Writing, compiling, and uploading basic C/C++ code using the Arduino IDE. | |
| | **Self-Learning Topics**: Understanding the "Blink" and "Serial Monitor" examples in Arduino IDE. | | |
| **3** | **Wireless Technologies and IoT Protocols** | | **08** |
| | After completing this module, students will be able to:<br>• Identify common wireless technologies used in IoT and their basic ranges (Wi-Fi, Bluetooth, ZigBee, LoRa).<br>• Explain how the MQTT protocol works using the Publish-Subscribe model.<br>• Compare HTTP protocol with lightweight IoT protocols like MQTT and CoAP. | | |
| | 3.1 | Overview of IoT connectivity: Wi-Fi, Bluetooth/BLE, ZigBee, and LoRaWAN (Basic features, range, and use cases). | |
| | 3.2 | Introduction to IoT Application Protocols: MQTT (Publish/Subscribe, Broker, Client concept) and CoAP (Request/Response). | |
| | 3.3 | Comparison between HTTP and MQTT protocols for small devices. | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | 3.4 | Overview of IoT connectivity: Wi-Fi, Bluetooth/BLE, ZigBee, and LoRaWAN (Basic features, range, and use cases). | |
| | **Self-Learning Topics**: Study how a wireless Wi-Fi router connects IoT devices to the internet. | | |
| **4** | **Cloud Platforms for IoT** | | **08** |
| | After completing this module, students will be able to:<br>• Send sensor data from an IoT board to a free cloud platform over Wi-Fi.<br>• Create online dashboards with graphs to view live data remotely on a phone or laptop.<br>• Set up simple automatic alerts (like an email notification when temperature crosses a limit). | | |
| | 4.1 | Introduction to IoT Cloud platforms: Why do we need the cloud? Overview of free platforms like ThingSpeak, Introduction to cloud-based AIoT and ML model trainings | |
| | 4.2 | Real-time analytics & dashboards: Sending sensor data to ThingSpeak channels using API keys, monitoring and observability | |
| | 4.3 | Data Visualization: Creating online charts, gauges, and graphs. Setting up simple triggers (e.g., using IFTTT for email alerts). | |
| | **Self-Learning Topics**: Creating a free account on ThingSpeak and exploring its public channels. | | |
| **5** | **AIoT Security & Privacy** | | **08** |
| | After completing this module, students will be able to:<br>• Identify the common security risks and attack points in a simple IoT setup.<br>• Understand the basic importance of passwords, encryption, and secure updates for smart devices. | | |
| | 5.1 | Introduction to IoT security challenges: Security challenges in AI-enabled IoT systems, Device and Edge Security, Securing AI models & data, Privacy in sensor-driven systems | |
| | 5.2 | Regulatory considerations: Compliance & Regulatory considerations, Ethical AI in IoT systems | |
| | **Self-Learning Topics**: Reading about famous IoT cyberattacks (like the Mirai Botnet) in plain language. | | |
| **6** | **IoT Applications and Case Studies** | | **07** |
| | After completing this module, students will be able to:<br>• Explain the step-by-step working mechanism of a complete IoT system.<br>• Discuss how IoT is transforming industries like healthcare, home automation, and city planning. | | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | 6.1 | Step-by-step design of an IoT project: From sensor data collection to cloud storage. | |
| | 6.2 | Real-world Applications: Smart Home Automation (Lights/Fans control). | |
| | 6.3 | Smart Health Monitoring (Pulse/Heart rate tracking), and Smart Traffic Management. | |
| | **Self-Learning Topics**: Finding a simple DIY IoT project tutorial on Hackster.io and summarizing it. Writing report on various case studies. | | |
| | **Total** | | **45** |

**Suggested List of Experiments:**

| Experiment No. | Title of the Experiment |
|---|---|
| 1 | **To design and configure a basic IoT network in Cisco Packet Tracer**<br>**Learning Objective:** To design, connect, and configure a functional IoT network topology in Cisco Packet Tracer by integrating smart sensors and actuators with a central Home Gateway or IoT Server, establishing secure IP and wireless connectivity, and implementing automation rules for device control.<br>**Learning Outcome:** The ability to successfully deploy and troubleshoot an automated IoT network simulation, enabling remote control of end devices through a management interface while verifying seamless end-to-end data communication |
| 2 | **To design and simulate Home Automation IoT System**<br>**Learning Objective:** To design and build an interconnected Smart Home network topology in Cisco Packet Tracer by bridging environmental sensors and actuators through a central Home Gateway and wireless router, defining logical conditions to automate indoor climate, lighting, and security appliance reactions.<br>**Learning Outcome:** The ability to successfully evaluate and validate an automated smart residential ecosystem by executing remote device monitoring via management interfaces, troubleshooting dynamic IP allocations and wireless credential mismatches, and demonstrating functional logic rules that turn data inputs into physical actuator responses. |
| 3 | **Sensor Interfacing and Serial Monitoring**<br>**Learning Objective:** To interface environmental sensors like the DHT11 (Temperature & Humidity) or MQ-2 (Gas) with an Arduino Uno/NodeMCU board using the Arduino IDE.<br>**Learning Outcome**: Write, compile, and upload sketches to read analog/digital sensor inputs and view real-time data on the Serial Monitor. |
| 4 | **Actuator Control and Relay Interfacing**<br>**Learning Objective:** To interface high-power actuators like AC home appliances via Relays, LEDs, and Buzzers with an IoT development board. |

| Experiment No. | Title of the Experiment |
|---|---|
| | **Learning Outcome**: Develop an Arduino IDE program to trigger physical actuators based on specific sensory threshold inputs. |
| 5 | **Wireless Connectivity Setup and Wi-Fi Configuration**<br>**Learning Objective:** To configure a NodeMCU (ESP8266/ESP32) board to scan and connect to local wireless networks using local Wi-Fi router parameters.<br>**Learning Outcome:** Establish a stable local wireless link and verify the device network configurations and IP assignment. |
| 6 | **MQTT Publish-Subscribe Communication Modeling**<br>**Learning Objective:** To implement lightweight application protocol communication using the MQTT Publish-Subscribe model via an external MQTT Broker.<br>**Learning Outcome:** Create an MQTT client to publish sensor payloads and subscribe to control topics, comparing it against heavy HTTP transactions. |
| 7 | **Cloud Data Logging on ThingSpeak**<br>**Learning Objective: T**o upload real-time sensor data packets from an internet-connected NodeMCU board to a free cloud platform over Wi-Fi using Write API keys.<br>**Learning Outcome:** Configure remote IoT data streaming channels on ThingSpeak to systematically store long-term sensor logs. |
| 8 | **Cloud Visualization Dashboards and Web Alerts**<br>**Learning Objective:** To construct online charts, gauges, and visualization widgets on an IoT platform and set up automated email/SMS alerts via IFTTT triggers.<br>**Learning Outcome:** Create a functional web dashboard for remote monitoring and trigger emergency notifications when a sensor value breaches safety limits. |
| 9 | **Device Authentication and Firmware Protection**<br>**Learning Objective:** To study the implementation of basic security practices including strong device passwords, authentication keys, and encrypted payloads.<br>**Learning Outcome:** Build a secure connection script that rejects unauthenticated communication requests and protects the node from physical tampering vulnerabilities. |
| 10 | **Secure Firmware Updates and Vulnerability Assessment**<br>**Learning Objective:** To understand the importance of regular firmware updates and analyze common security attack points like the Mirai Botnet framework.<br>**Learning Outcome:** Perform a simulated remote secure firmware update (OTA) and identify open vulnerabilities in an unpatched IoT device node. |
| 11 | **Local Storage Data Logging**<br>**Learning Objective:** To log sensor data locally on an SPI-based MicroSD card module during network connection or internet dropouts.<br>**Learning Outcome:** Implement a backup storage architecture that prevents data loss when the primary Wi-Fi cloud connection fails. |
| 12 | **Bluetooth Low Energy (BLE) Beacon Advertisement**<br>**Learning Objective**: To configure an ESP32 micro-controller as a Bluetooth Low Energy (BLE) beacon to broadcast custom data packets.<br>**Learning Outcome:** Transmit environment parameters over BLE and read them |

| Experiment No. | Title of the Experiment |
|---|---|
| | successfully using a mobile phone application. |
| 13 | **Ultrasonic Distance Measurement and Buzzer Alert System**<br>**Learning Objective:** To interface an HC-SR04 ultrasonic distance sensor to calculate object proximity and trigger physical audio alerts.<br>**Learning Outcome:** Write an algorithmic loop to map distance values into changing frequency alarm outputs using microcontrollers. |
| 14 | **Edge-Based Data Filtering and Threshold Processing**<br>**Learning Objective:** To filter noisy raw sensor data directly at the edge node using a simple moving average filters before transmission.<br>**Learning Outcome:** Reduce network bandwidth usage by transmitting data only when significant parameter variations breach pre-set limits. |
| 15 | **CoAP Protocol Request-Response Implementation**<br>**Learning Objective:** To study the lightweight Constrained Application Protocol (CoAP) using a request-response communication model on a local server.<br>**Learning Outcome:** Create a CoAP client node to read resources from an IoT sensor device with low network overhead. |

**Suggested Course Project Areas**

1. Smart Home Automation and Appliance Control System
2. IoT-Based Smart Agriculture and Soil Moisture Monitor
3. Remote Patient Health Telemetry Station (Pulse & Temperature)
4. Smart Weather Station with Cloud Logging (ThingSpeak)
5. IoT Smoke & Gas Leakage Detector with IFTTT Email Alerts
6. Smart Waste Management and Garbage Bin Level Tracker
7. Intruder Detection System with PIR Sensor and MQTT Alerts

**Textbooks**


1. Internet of Things (IoT), S.K. Kataria & Sons, Dr. Rajiv Chopra, 1st Edition (2022).
2. The Internet of Things: Enabling Technologies, Platforms, and Use Cases, CRC Press, Pethuru Raj and Anupama C. Raman, 1st Edition (2022).
3. Internet of Things, Oxford University Press India, Dr. Surya Durbha and Dr. Jyoti Joglekar, 1st Edition (2019).
4. Internet of Things (IoT): Principles, Paradigms and Applications of IoT, BPB Publications, Dr. Kamlesh Lakhwani, Dr. Hemant Kumar Gianey, Joseph Kofi Wireko, and Kamal Kant Hiran, 1st Edition (2020).


**Reference Books**


1. Internet of Things A to Z: Technologies and Applications, Wiley-IEEE Press, Qusay F. Hassan, 2nd Edition (2026).
2. The Internet of Things, MIT Press, Samuel Greengard, Revised and Updated Edition (2021).

3. Wireless Networks and Industrial IoT: Applications, Challenges and Enablers, Springer International Publishing, Nurul Huda Mahmood, Nikolaj Marchenko, Mikael Gidlund, and Petar Popovski, 1st Edition (2020).
4. Industry 4.0 and Industrial IoT, Amazon Digital Services, Dr. Ashutosh Kumar Dubey and Prof. (Dr.) S. B. Choraddi, 1st Edition (2023).

**Assessment Methodology:**

| Type of Assessment | Assessment Tools |
|---|---|
| **Continuous Assessment (CA) (20 Marks)** | Certification: NPTEL (20 Marks) (Approved by instructor)<br>**OR**<br>Any 02 Pedagogies (10 marks each)<br>• MCQ /Class Test<br>• Case study/Assignment<br>• GATE based Assignment<br>• Certification Udemy/Coursera (Approved by instructor)<br>• Open Book Test<br>• Working model / Simulation of a course-based concept. |
| **Mid Semester Examination (MSE) (30 Marks)** | Question Paper Pattern is as follows:<br><br>All Questions are compulsory.<br>• Q1 A or B - 10 marks<br>• Q2 A or B - 10 marks<br>• Q3 A or B - 10 marks<br>• For each question, A and B should be based on the same CO.<br>• MSE should be based on 50% syllabus.<br>• Time: 90 minutes (1 hour 30 minutes) |
| **End Semester Examination (ESE) (50 Marks)** | Question Paper Pattern is as follows:<br><br>All Questions are compulsory.<br>• Q1 A or B - 10 marks<br>• Q2 A or B - 10 marks<br>• Q3 A or B - 10 marks<br>• Q4 A or B - 10 marks<br>• Q5 A or B - 10 marks<br>• For each question, A and B should be based on the same CO.<br>• ESE should be based on 30% syllabus of MSE and 70% syllabus after MSE.<br>• Time: 120 minutes (02 hours)<br>Total Marks: 50 |
| **Term Work (25 Marks)** | • Active Participation (Lab) = 05 marks<br>• Laboratory Journal /Mini Project = 10 marks<br>• Laboratory Performance = 10 marks<br><br>Based on the performance & satisfactory completion of minimum 10 experiments. |

**Data Acquisition and Industrial Monitoring**

| Course Code | Course Name | Teaching Scheme (Hrs. / Week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25ET5MDM02 | Data Acquisition and Industrial Monitoring | **L** | **P** | **T** | **L** | **P** | **T** | **Total** |
| | | 3 | 2 | - | 3 | 1 | - | **4** |
| | | **Examination Scheme** | | | | | | |
| | | | **CA** | **MSE** | **ESE** | **TW** | **OR** | **PR** | **Total** |
| | | **Theory** | 20 | 30 | 50 | - | - | - | **100** |
| | | **Lab** | - | - | - | 25 | - | - | **25** |

| | |
|---|---|
| **Pre-Requisite Courses:** | 25FE1BSC01: Engineering Physics |
| | 25FE1VSEC01: C Programming |
| | 25FE1ESC02: Basic Electrical and Digital Electronics |
| | 25ET4MDM01: Embedded Systems |
| | 25ET4MDM02: Sensor Technology |

**Course and Module Overview:**

This course builds upon Sensor Technology and focuses on acquisition, conditioning, processing, visualization and interfacing of sensor data in modern engineering systems. The course is designed for Mechanical, Computer and Information Technology students and emphasizes interdisciplinary applications in Industry 4.0, robotics, automation, smart manufacturing, predictive maintenance and intelligent monitoring systems

**Module 1** introduces the fundamentals of measurement systems, instrumentation, and sensor technologies used in engineering applications. It covers the operating principles of conventional and smart sensors, along with their static and dynamic performance characteristics. Students will learn calibration techniques, error analysis methods, and the role of sensors in mechanical, IT, and computer-based systems. The module also provides an introduction to virtual instrumentation for modern measurement and monitoring applications.

**Module 2** focuses on the acquisition and conditioning of analog and digital signals for accurate measurement and processing. It covers instrumentation amplifiers, Wheatstone bridge circuits, filtering techniques, and methods for reducing noise and interference. Students will understand how signal conditioning improves data quality and reliability in engineering systems. The module also introduces programmable gain amplifiers used in modern instrumentation applications.

**Module 3** introduces the principles and architecture of data acquisition systems used for collecting and converting real-world signals into digital data. Topics include sampling theory, sample-and-hold circuits, ADCs, DACs, and data logging systems. Students will learn how data is acquired, processed, and stored in modern measurement systems. An overview of industrial SCADA systems is also provided for self-learning.

**Module 4** explores the integration of sensors and data acquisition systems with embedded platforms. It covers microcontroller-based acquisition systems and widely used communication protocols such

as UART, I2C, SPI, and CAN bus. Students will gain knowledge of reliable data exchange between embedded devices and peripheral systems. The module also introduces the Modbus protocol used in industrial automation.

**Module 5** focuses on processing, analyzing, and visualizing sensor-generated data for meaningful interpretation. It includes data preprocessing, statistical analysis, filtering methods, and feature extraction techniques. Students will learn how to transform raw sensor data into useful information and present it effectively using Python-based visualization tools. The module also provides a foundation for applying machine learning techniques to sensor data.

**Module 6** introduces intelligent engineering systems and emerging Industry 4.0 technologies. It covers Cyber-Physical Systems, Digital Twin concepts, predictive maintenance, machine condition monitoring, and smart manufacturing practices. Students will understand how advanced sensing, data analytics, and automation contribute to intelligent industrial operations. The module also explores future trends and emerging intelligent engineering systems through self-learning.

| | | |
|---|---|---|
| **Course Outcomes (COs)** | **After successful completion of the course, the students will be able to:** | |
| | CO1 | Define measurement systems, sensors and signal acquisition principles. (Remembering) |
| | CO2 | Explain signal conditioning circuits, data acquisition architectures and conversion techniques. (Understanding) |
| | CO3 | Implement sensor interfacing and communication protocols, using embedded platforms. (Applying) |
| | CO4 | Analyze acquired sensor data using processing and visualization techniques. (Applying) |
| | CO5 | Evaluate intelligent monitoring solutions for engineering applications. (Evaluating) |
| | CO6 | Design integrated sensor-based intelligent systems for real-world applications. (Creating) |

**Syllabus:**

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| 1 | | **Sensors and Measurement Systems** | 04 |
| | | After completing this module, students will be able to:<br>• Explain the fundamentals of measurement systems, instrumentation, and sensor technologies.<br>• Differentiate between conventional sensors and smart sensors based on their characteristics and applications.<br>• Analyse the static and dynamic performance characteristics of sensors and measurement systems and study calibration of sensors. | |
| | 1.1 | **Introduction to Measurement Systems and Instrumentation:** Functional elements, classification, and performance of measurement systems and instrumentation. | |
| | 1.2 | **Review of Sensors and Introduction to Smart Sensors:** Classification, operating principles, characteristics, and applications of conventional and smart sensors. | |
| | 1.3 | **Study of Static and Dynamic Characteristics of Sensors**: Static characteristics (accuracy, precision, sensitivity, linearity) and dynamic characteristics (response time, fidelity, time constant) of sensors. | |
| | 1.4 | **Calibration Techniques and Error Analysis in Measurement Systems:** Calibration methods, measurement errors, uncertainty, and techniques for improving measurement accuracy. | |
| | | **Self-Learning Topics:** Introduction to virtual instrumentation. | |
| 2 | | **Signal Acquisition and Conditioning** | 08 |
| | | After completing this module, students will be able to:<br>• Differentiate between analog and digital signals used in measurement systems.<br>• Analyze the operation of instrumentation amplifiers and Wheatstone bridge circuits.<br>• Design and apply active and passive filters for signal conditioning.<br>• Implement noise reduction and shielding techniques to improve signal quality. | |
| | 2.1 | Fundamentals of Analog and Digital Signals and their types | |
| | 2.2 | Instrumentation Amplifier: Requirements, Characteristics and Working, Interfacing with Sensors. | |
| | 2.3 | Wheatstone Bridge: Principle, Balanced and Unbalanced Bridge, Derivation and applications. | |
| | 2.4 | Active and Passive Filters: Need for Filtering in Measurement Systems, Low-pass, High-pass, Band-pass, Active Filters using Operational Amplifiers, Selection of Filters for Sensor Applications | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | 2.5 | Techniques for Noise Reduction and Signal Shielding: Sources of Noise as EMI and RFI, Grounding and Shielding Techniques, Differential Signal Transmission, Signal Isolation and Best Practices for Reliable Measurements | |
| | **Self-Learning Topics**: Introduction to Programmable Gain Amplifiers. | | |
| **3** | **Sensor Data Acquisition System** | | **12** |
| | After completing this module, students will be able to:<br>• Explain the principles of signal sampling and data acquisition.<br>• Compare different types of ADCs and DACs based on their characteristics and applications.<br>• Analyse the role of sample-and-hold circuits in data acquisition systems.<br>• Evaluate the architecture and operation of data loggers and DAQ systems. | | |
| | 3.1 | **Principles of Sampling and Data Acquisition:** Analog and Digital Data Acquisition, Sampling Theorem and Aliasing, Sampling Rate, Resolution, and Quantization, Overview of Data Acquisition Systems. | |
| | 3.2 | **Sample-and-Hold Circuits:** Need for Sample-and-Hold Circuits, Working Principle and Block Diagram, Acquisition Time, Hold Time, and Aperture Time, Applications in Data Acquisition Systems. | |
| | 3.3 | **Data Converters:** Fundamentals of ADCs and DACs, Types of ADCs: Flash, Successive Approximation (SAR), Types of DACs: Binary Weighted and R-2R Ladder, Performance Parameters: Resolution, Accuracy, Conversion Time and Settling time. | |
| | 3.4 | **Data Loggers and DAQ Systems:** Architecture and Components of DAQ Systems, Data Loggers: Features and Working, DAQ Hardware and Software, Industrial Applications of DAQ Systems. | |
| | 3.5 | **Industrial SCADA Systems:** Introduction to SCADA, Basic SCADA Architecture (Sensors, RTU/PLC, HMI, Communication Network), Functions of SCADA in Industrial Monitoring and Control, Applications of SCADA in Manufacturing, Power, Water Treatment, and Process Industries. | |
| | **Self-Learning Topics**: Overview of Industrial SCADA system. | | |
| **4** | **Embedded Interfacing and Communication** | | **06** |
| | After completing this module, students will be able to:<br>• Develop basic microcontroller-based data acquisition and interfacing systems.<br>• Explain the working principles of UART, I²C, and SPI communication protocols.<br>• Analyse CAN bus communication for industrial and automotive | | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | | applications.<br>• Select appropriate communication protocols for embedded system applications. | |
| | 4.1 | **Development of Microcontroller-Based Data Acquisition Systems:** Introduction to microcontroller-based sensor interfacing and data acquisition. Basic architecture for acquiring, processing, and transmitting sensor data. | |
| | 4.2 | **Fundamentals of UART Communication Protocol:** Overview of UART communication, frame format, and asynchronous data transmission. Applications in embedded systems and sensor interfacing | |
| | 4.3 | **Fundamentals of $I^2C$ and SPI Communication Protocols:** Communication methods, master-slave architecture, comparison and typical applications in embedded systems. | |
| | 4.4 | **CAN Bus Fundamentals:** CAN bus architecture and message-based communication. | |
| | **Self-Learning Topics**: Introduction to the Modbus protocol. | | |
| **5** | **Sensor Data Processing and Visualization** | | **08** |
| | After completing this module, students will be able to:<br>• Apply preprocessing techniques to improve the quality of sensor data.<br>• Perform statistical analysis and filtering of acquired data.<br>• Extract meaningful features from sensor signals for further analysis.<br>• Create effective data visualizations using Python-based tools. | | |
| | 5.1 | **Data Preprocessing Techniques for Sensor Signals:** Handling missing values, noise removal, normalization, and smoothing techniques for improving sensor data quality. | |
| | 5.2 | **Statistical Analysis of Acquired Sensor Data:** Descriptive statistics, trend analysis, data distribution, and interpretation of sensor measurements. | |
| | 5.3 | **Application of Filtering Techniques for Signal Enhancement:** Moving average, median, and low-pass filtering techniques for reducing noise and enhancing sensor signals. | |
| | 5.4 | **Feature Extraction from Sensor Data:** Extraction of basic time-domain features such as mean, maximum, minimum, standard deviation, and peak values from sensor signals. | |
| | 5.5 | **Data Visualization using Python Libraries:** Visualization of sensor data using **Matplotlib**, **Pandas**, and **Plotly** through line plots, bar charts, scatter plots, and time-series graphs. | |
| | **Self-Learning Topics**: Introduction to Machine Learning for sensor data analysis. | | |
| **6** | **Sensor Applications in Industrial Automation** | | **07** |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | After completing this module, students will be able to:<br>• Explain the role of sensors in industrial automation and smart monitoring systems.<br>• Analyse sensor-based automation solutions in automotive, healthcare, agriculture, and environmental applications.<br>• Evaluate the performance of sensor-based monitoring systems through industrial case studies.<br>• Recommend appropriate sensors for different industrial automation applications. | | |
| | 6.1 | Introduction to Sensor-Based Industrial Automation and Smart Monitoring Systems | |
| | 6.2 | **Automotive Applications:** Vehicle safety systems, Tire Pressure Monitoring System (TPMS), Parking Assistance, Engine Monitoring, Autonomous Vehicle Sensors | |
| | 6.3 | **Healthcare Applications:** Patient Monitoring Systems, Wearable Health Sensors, Smart Medical Devices, Remote Health Monitoring | |
| | 6.4 | **Agricultural Applications:** Smart Irrigation Systems, Soil Moisture Mon Automation, Crop Health Monitoring using IoT Sensors | |
| | 6.5 | **Environmental & Industrial Case Studies:** Air and Water Quality M Monitoring Systems, Smart Waste Management, Smart Street I Automation Case Studies (Conveyor Belt Monitoring, Tank Level Moni & Pressure Monitoring in Process Industries, Elevator Monitoring System | |
| | **Self-Learning Topics**: Emerging Trends in Intelligent Engineering Systems. | | |
| | | **Total** | **45** |

**Suggested List of Tasks/Experiments:**

| Task No. | Title of Task/Experiment |
|---|---|
| **1** | **Sensor Calibration**<br>**Learning Objective:** To understand sensor calibration procedures and evaluate measurement accuracy.<br>**Learning Outcome:** Calibrate a sensor and determine measurement errors and accuracy. |
| **2** | **Temperature Sensor Interfacing**<br>**Learning Objective:** To study the interfacing of temperature sensors with a data acquisition system.<br>**Learning Outcome:** Acquire and interpret temperature data using suitable interfacing techniques. |
| **3** | **Pressure Sensor Interfacing**<br>**Learning Objective:** To understand pressure measurement and sensor characteristics.<br>**Learning Outcome:** Interface a pressure sensor and acquire pressure data for analysis. |

| Task No. | Title of Task/Experiment |
|---|---|
| 4 | **Instrumentation Amplifier Design**<br>**Learning Objective:** To design signal conditioning circuits for low-level sensor signals.<br>**Learning Outcome:** Design and test instrumentation amplifier circuits for sensor applications. |
| 5 | **Filter Implementation**<br>**Learning Objective:** To implement filtering techniques for signal conditioning.<br>**Learning Outcome:** Apply analog and digital filters to improve signal quality. |
| 6 | **ADC Interfacing**<br>**Learning Objective:** To understand analog-to-digital conversion and data acquisition.<br>**Learning Outcome:** Interface ADC modules and acquire digital sensor data. |
| 7 | **DAC Interfacing**<br>**Learning Objective:** To study digital-to-analog conversion techniques.<br>**Learning Outcome:** Generate analog outputs using DAC interfacing methods. |
| 8 | **UART Communication**<br>**Learning Objective:** To establish serial communication between embedded devices.<br>**Learning Outcome:** Implement UART communication for reliable data transfer. |
| 9 | **I2C Communication**<br>**Learning Objective:** To study multi-device communication using I2C protocol.<br>**Learning Outcome:** Interface sensors and peripherals using I2C communication. |
| 10 | **SPI Communication**<br>**Learning Objective:** To understand high-speed serial communication using SPI protocol.<br>**Learning Outcome:** Implement SPI communication between embedded systems. |
| 11 | **Data Logger Development**<br>**Learning Objective:** To develop a system for recording and storing sensor data.<br>**Learning Outcome:** Design and implement a basic sensor data logger. |
| 12 | **Sensor Data Acquisition using ESP32**<br>**Learning Objective:** To acquire real-time sensor data using ESP32.<br>**Learning Outcome:** Develop an ESP32-based sensor acquisition system. |
| 13 | **Sensor Data Visualization using Python**<br>**Learning Objective:** To visualize acquired sensor data using Python tools.<br>**Learning Outcome:** Generate plots and dashboards for sensor data analysis. |
| 14 | **Condition Monitoring System**<br>**Learning Objective:** To monitor machine or process conditions using sensor data.<br>**Learning Outcome:** Analyze sensor data for condition monitoring applications. |
| 15 | **Mini Project Demonstration**<br>**Learning Objective:** To integrate course concepts into a practical engineering application.<br>**Learning Outcome:** Develop and demonstrate a sensor-based intelligent monitoring system. |

**Suggested List of Application:**

1. Machine Health Monitoring System
2. Industrial Data Logger
3. Vibration Monitoring System
4. Environmental Monitoring Station
5. Smart Energy Monitoring System
6. Predictive Maintenance Prototype
7. Multi-Sensor Acquisition Platform

**Text Books:**


1. Ramon Pallas-Areny, Sensors and Signal Conditioning.
2. D.V.S. Murthy, Transducers and Instrumentation.
3. H.S. Kalsi, Electronic Instrumentation.
4. A.K. Sawhney, Electrical and Electronic Measurements.


**Reference Books:**


1. John G. Webster, Measurement, Instrumentation and Sensors Handbook.
2. Nathan Ida, Sensors, Actuators and their Interfaces.
3. Robert H. Bishop, Mechatronics Handbook.
4. Behzad Razavi, Fundamentals of Microelectronics.


**Assessment Methodology:**

| **Type of Assessment** | **Assessment Tools** |
|---|---|
| **Continuous Assessment (CA) (20 Marks)** | Certification: NPTEL (20 Marks) (Approved by instructor)<br>**OR**<br>Any 02 Pedagogies (10 marks each)<br>● MCQ /Class Test<br>● Case study/Assignment<br>● GATE based Assignment<br>● Certification Udemy/Coursera (Approved by instructor)<br>● Open Book Test<br>● Working model / Simulation of a course-based concept. |

| Type of Assessment | Assessment Tools |
|---|---|
| **Mid Semester Examination (MSE) (30 Marks)** | Question Paper Pattern is as follows:<br><br>All Questions are compulsory.<br>● Q1 A or B - 10 marks<br>● Q2 A or B - 10 marks<br>● Q3 A or B - 10 marks<br>● For each question, A and B should be based on the same CO.<br>● MSE should be based on 50% syllabus.<br>● Time: 90 minutes (1 hour 30 minutes) |
| **End Semester Examination (ESE) (50 Marks)** | Question Paper Pattern is as follows:<br><br>All Questions are compulsory.<br>● Q1 A or B - 10 marks<br>● Q2 A or B - 10 marks<br>● Q3 A or B - 10 marks<br>● Q4 A or B - 10 marks<br>● Q5 A or B - 10 marks<br>● For each question, A and B should be based on the same CO.<br>● ESE should be based on 30% syllabus of MSE and 70% syllabus after MSE.<br>● Time: 120 minutes (02 hours)<br>Total Marks: 50 |
| **Term Work (25 Marks)** | ● Active Participation (Lab) = 05 marks<br>● Laboratory Journal/Mini Project/Case Study = 10 marks<br>● Laboratory Performance = 10 marks<br>Based on the performance & satisfactory completion of minimum 10 experiments. |

**Quality Engineering**

| Course Code | Course Name | Teaching Scheme (Hrs. / Week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25ME5MDM01 | Quality Engineering | L | P | T | L | P | T | Total |
| | | 3 | 2 | - | 3 | 1 | - | 4 |
| | | Examination Scheme | | | | | | |
| | | | CA | MSE | ESE | TW | OR | PR | Total |
| | | Theory | 20 | 30 | 50 | - | - | - | 100 |
| | | Lab | - | - | - | 25 | - | - | 25 |
| Pre-Requisite Courses: | Manufacturing Processes | | | | | | | |

| Course Code | Course Name | Teaching Scheme (Hrs. / Week) | Credits Assigned |
|---|---|---|---|

**Course and Module Overview:**

Quality Engineering introduces the principles, tools, and techniques used to achieve and sustain quality in products, processes, and services. The course covers Total Quality Management (TQM), Statistical Quality Control (SQC), Reliability Engineering, Quality Function Deployment (QFD), Lean Six Sigma, and Quality Management Systems. It emphasizes continuous improvement, customer satisfaction, process optimization, and reliability in manufacturing, software, IT, and communication systems.

**Module 1: Total Quality Management (TQM)**

This module introduces the concepts, principles, and philosophies of Total Quality Management. It focuses on customer satisfaction, continuous improvement, quality costs, and the contributions of leading quality gurus in achieving organizational excellence.

**Module 2: Statistical Quality Control and Process Capability**

This module covers statistical techniques used for monitoring and controlling process quality. It includes control charts, process capability analysis, and applications of statistical quality control in manufacturing, software, and electronic systems.

**Module 3: Acceptance Sampling and Reliability Engineering**

This module introduces acceptance sampling methods and reliability concepts used to evaluate product quality and system performance. It also covers reliability analysis of engineering systems and their applications across different domains.

**Module 4: Quality Improvement Tools and Techniques**

This module focuses on the practical tools used for quality improvement and problem-solving. Students learn the seven basic quality tools, root cause analysis, Kaizen, 5S, and Poka-Yoke techniques for continuous process improvement.

**Module 5: Design for Quality and Quality Function Deployment**

This module emphasizes customer-focused product and service development. It covers Voice of Customer (VOC), Quality Function Deployment (QFD), House of Quality, and design approaches that improve quality during product development.

**Module 6: Lean Six Sigma and Quality Management Systems**

This module introduces modern quality improvement methodologies such as Lean Manufacturing and Six Sigma. It also covers ISO 9001 Quality Management Systems, quality audits, and best practices for

achieving operational excellence and continuous improvement.

| | | |
|---|---|---|
| **Course Outcomes (COs)** | **After successful completion of the course, the students will be able to:** | |
| | CO1 | Recall the fundamental concepts, philosophies, and terminology associated with quality engineering and TQM. (Remember) |
| | CO2 | Explain quality management principles, statistical quality control techniques, and quality improvement methodologies. (Understand) |
| | CO3 | Apply quality engineering tools for process monitoring, process capability analysis, reliability assessment, and quality improvement. (Applye) |
| | CO4 | Analyze process performance, quality problems, customer requirements, and system reliability using appropriate quality techniques. (Analyze) |
| | CO5 | Evaluate manufacturing, software, IT service, and communication system processes using quality engineering principles and improvement methodologies. (Evaluate) |
| | CO6 | Develop quality-focused solutions using TQM, QFD, Lean Six Sigma, reliability engineering, and quality management systems. (Create) |

**Syllabus:**

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| 1 | **Total Quality Management** | | 08 |
| | After completing this module, students will be able to:<br>• Explain the fundamental concepts, principles, and philosophies of Total Quality Management and the contributions of quality gurus.<br>• Describe the role of customer satisfaction, quality costs, and continuous improvement in achieving organizational excellence | | |
| | 1.1 | Evolution and importance of quality.<br>Dimensions of quality in products and services.<br>Contributions of Deming, Juran, Crosby, Ishikawa, and Taguchi.<br>Principles of Total Quality Management. | |
| | 1.2 | Customer focus and customer satisfaction.<br>Employee involvement and teamwork.<br>Continuous improvement philosophy. | |
| | 1.3 | Cost of Quality.<br>Applications of TQM in manufacturing, software industries, IT services, and telecom sectors. | |
| | **Self-Learning Topics**: Study of Quality Management Practices in a Leading Organization (e.g., Toyota, Tata Motors, Infosys, TCS, Samsung, etc.) | | |
| 2 | **Statistical Quality Control and Process Capability** | | 08 |
| | After completing this module, students will be able to:<br>• Explain process variation and the application of control charts for monitoring process performance.<br>• Calculate and interpret process capability indices for assessing process quality and performance. | | |
| | 2.1 | Process variation and quality characteristics.<br>Statistical concepts for quality control. | |
| | 2.2 | Control Charts:<br>$\bar{X}$ Chart, R Chart, p Chart, np Chart, c Chart, u Chart<br>Process Capability Analysis.<br>Process Capability Indices (Cp and Cpk). | |
| | 2.3 | Applications of SPC in manufacturing, software defect monitoring, network performance monitoring, and electronics manufacturing. | |
| | **Self-Learning Topics:** Applications of Statistical Process Control (SPC) in Manufacturing, Software Development, and Network Performance Monitoring. | | |
| 3 | **Acceptance Sampling and Reliability Engineering** | | |

| | | | |
|---|---|---|---|
| | After completing this module, students will be able to:<br>• Apply acceptance sampling concepts and OC curves for quality inspection and decision-making.<br>• Analyze the reliability characteristics of engineering systems using reliability concepts and models. | | **07** |
| | 3.1 | Fundamentals of acceptance sampling.<br>Single sampling plans.<br>Producer's Risk and Consumer's Risk.<br>Operating Characteristic (OC) Curve. | |
| | 3.2 | Reliability concepts and terminology.<br>Failure rate and reliability function.<br>Bath Tub Curve.<br>Reliability of series and parallel systems.<br>Reliability applications in mechanical systems, computer hardware, communication systems, and embedded systems. | |
| | **Self-Learning Topics**: Reliability Analysis of Consumer Products, Computer Hardware, and Communication Systems. | | |
| **4** | **Quality Improvement Tools and Techniques** | | **08** |
| | After completing this module, students will be able to:<br>• Utilize basic quality tools to identify and investigate quality-related problems.<br>• Analyze process improvement opportunities using root cause analysis, Kaizen, 5S, and Poka-Yoke techniques. | | |
| | 4.1 | Seven Basic Quality Tools:<br>Check Sheet<br>Histogram<br>Pareto Chart<br>Cause-and-Effect Diagram<br>Scatter Diagram<br>Control Chart<br>Flow Chart | |
| | 4.2 | Root Cause Analysis.<br>Kaizen.<br>5S Methodology.<br>Poka-Yoke (Mistake Proofing).<br>Applications in manufacturing, software quality improvement, IT services, and electronics industries. | |
| | **Self-Learning Topics**: Case Study on the Implementation of Kaizen, 5S, or Poka-Yoke in Industrial or Service Organizations. | | |
| **5** | **Design for Quality and Quality Function Deployment** | | **07** |
| | After completing this module, students will be able to: | | |

| | | | |
|---|---|---|---|
| | • Explain customer requirements and the methodology of Quality Function Deployment (QFD).<br>• Analyze customer needs and translate them into engineering specifications using the House of Quality. | | |
| | 5.1 | Voice of Customer (VOC).<br>Customer requirements and expectations.<br>Quality Function Deployment (QFD).<br>House of Quality. | |
| | 5.2 | Design for Manufacturability (DFM).<br>Design for Assembly (DFA).<br>Taguchi Quality Loss Function.<br>Applications in product design, software development, consumer electronics, and communication devices. | |
| | **Self-Learning Topics**: Development of a House of Quality (QFD) for a Product, Mobile Application, or Service System. | | |
| **6** | **Lean Six Sigma and Quality Management Systems** | | **07** |
| | After completing this module, students will be able to:<br>• Analyze equipment performance using reliability, availability, maintainability, MTBF, and MTTR concepts.<br>• Examine modern maintenance management practices such as TPM, CMMS, Industry 4.0, and predictive maintenance. | | |
| | 6.1 | Lean Manufacturing concepts.<br>Waste identification and elimination.<br>Introduction to Six Sigma.<br>DMAIC Methodology.<br>Quality Management Systems (QMS). | |
| | 6.2 | ISO 9001 requirements and documentation.<br>Quality Audits.<br>Quality practices in manufacturing, software quality assurance, IT services, and telecom industries. | |
| | **Self-Learning Topics**: Case Study on Lean Six Sigma and ISO 9001 Implementation in Manufacturing, IT, or Telecom Industries. | | |
| | **Total** | | **45** |

**Suggested List of Experiments:**

| Experiment No. | Title of Experiment/Task |
|---|---|
| **1** | **Study of Quality Dimensions and Quality Costs Using Industrial Case Studies.**<br>**Learning Objective:** To understand the dimensions of quality and the impact of quality costs on organizational performance.<br>**Learning Outcome:** Students will be able to identify quality dimensions and classify quality costs in industrial applications. |
| **2** | **Analysis of Quality Philosophies of Deming, Juran, Crosby, Ishikawa, and Taguchi.**<br>**Learning Objective:** To study the contributions of quality gurus and their role in quality management practices.<br>**Learning Outcome:** Students will be able to explain and compare various quality philosophies for organizational excellence. |
| **3** | **Construction and Interpretation of $\bar{X}$ and R Control Charts.**<br>**Learning Objective:** To learn the application of variable control charts for monitoring process performance.<br>**Learning Outcome:** Students will be able to construct and interpret $\bar{X}$ and R control charts for process control. |
| **4** | **Machinery Servicing (Greasing, Oiling, Cleaning, Inspection).**<br>**Learning Objective:** To understand routine servicing procedures required for efficient machine operation.<br>**Learning Outcome:** Students will be able to perform basic machine servicing activities and assess their importance in preventive maintenance. |
| **5** | **Construction of Attribute Control Charts (p, np, c and u Charts)**<br>**Learning Objective:** To understand the use of attribute control charts for quality monitoring and analysis.<br>**Learning Outcome:** Students will be able to select and apply appropriate attribute control charts for different quality characteristics. |
| **6** | **Design of Acceptance Sampling Plans and OC Curve Analysis.**<br>**Learning Objective:** To study acceptance sampling techniques used in quality inspection and decision-making.<br>**Learning Outcome:** Students will be able to design sampling plans and analyze OC curves for quality acceptance decisions. |
| **7** | **Reliability Analysis of Series and Parallel Systems.**<br>**Learning Objective:** To understand reliability concepts and methods for evaluating system reliability.<br>**Learning Outcome:** Students will be able to determine the reliability of simple engineering systems and configurations. |
| **8** | **Application of Pareto Analysis and Cause-and-Effect Diagrams for Problem Solving.**<br>**Learning Objective:** To identify and analyse major causes of quality problems using |

| | |
|---|---|
| | basic quality tools.<br>**Learning Outcome:** Students will be able to perform root cause analysis and prioritize corrective actions. |
| **9** | **Implementation Study of 5S and Kaizen in Manufacturing or Service Systems.**<br>**Learning Objective:** To understand the principles of workplace organization and continuous improvement.<br>**Learning Outcome:** Students will be able to apply 5S and Kaizen methodologies for process and workplace improvement. |
| **10** | **Development of a House of Quality (QFD) for a Selected Product or Service.**<br>**Learning Objective:** To translate customer requirements into engineering specifications using QFD.<br>**Learning Outcome:** Students will be able to develop a House of Quality for customer-focused product or service design. |
| **11** | **Lean Waste Identification and Six Sigma DMAIC Case Study.**<br>**Learning Objective:** To study Lean and Six Sigma methodologies for quality and process improvement.<br>**Learning Outcome:** Students will be able to identify process waste and apply DMAIC methodology to solve quality-related problems. |
| **12** | **Mini Project on Quality Improvement for a Manufacturing Process, Software Application, IT Service, or Communication System.**<br>**Learning Objective:** To integrate quality engineering tools and techniques for solving real-world quality challenges**.**<br>**Learning Outcome:** Students will be able to develop and present a quality improvement solution using appropriate quality engineering methodologies. |

**Text Books:**


1. Total Quality Management – N. V. R. Naidu and K. M. Babu, New Age International Publishers, Latest Edition.
2. Statistical Quality Control – M. Mahajan, Dhanpat Rai Publications, Latest Edition.
3. Quality Planning and Analysis – J. M. Juran and F. M. Gryna, McGraw Hill Education, 5th Edition.


**Reference Books:**


5. Total Quality Management – Dale H. Besterfield, Pearson Education, 4th Edition.
6. Introduction to Statistical Quality Control – Douglas C. Montgomery, Wiley India, 8th Edition.
7. Quality Engineering Using Robust Design – Madhav S. Phadke, Pearson Education, Latest Edition.
8. Managing for Total Quality – N. V. R. Naidu and K. M. Babu, New Age International Publishers, Latest Edition.
9. Reliability Engineering – E. Balagurusamy, Tata McGraw Hill, Latest Edition.
10. The Certified Quality Engineer Handbook – Connie M. Borror, ASQ Quality Press, 5th Edition.

**Assessment Methodology:**

| Type of Assessment | Assessment Tools |
|---|---|
| **Continuous Assessment (CA) (20 Marks)** | Certification: NPTEL (20 Marks) (Approved by instructor)<br>**OR**<br>Any 02 Pedagogies (10 marks each)<br>• MCQ /Class Test<br>• Case study/Assignment<br>• GATE based Assignment<br>• Certification Udemy/Coursera (Approved by instructor)<br>• Open Book Test<br>• Working model / Simulation of a course-based concept. |
| **Mid Semester Examination (MSE) (30 Marks)** | Question Paper Pattern is as follows:<br><br>All Questions are compulsory.<br>• Q1 A or B - 10 marks<br>• Q2 A or B - 10 marks<br>• Q3 A or B - 10 marks<br>• For each question, A and B should be based on the same CO.<br>• MSE should be based on 50% syllabus.<br>• Time: 90 minutes (1 hour 30 minutes) |
| **End Semester Examination (ESE) (50 Marks)** | Question Paper Pattern is as follows:<br><br>All Questions are compulsory.<br>• Q1 A or B - 10 marks<br>• Q2 A or B - 10 marks<br>• Q3 A or B - 10 marks<br>• Q4 A or B - 10 marks<br>• Q5 A or B - 10 marks<br>• For each question, A and B should be based on the same CO.<br>• ESE should be based on 30% syllabus of MSE and 70% syllabus after MSE.<br>• Time: 120 minutes (02 hours)<br>Total Marks: 50 |
| **Term Work (25 Marks)** | • Active Participation (Lab) = 05 marks<br>• Laboratory Report / Journal = 10 marks<br>• Laboratory Performance = 10 marks<br>Based on the performance & satisfactory completion of minimum 8 experiments. |

**Industrial Automation**

| Course Code | Course Name | Teaching Scheme (Hrs. / Week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25ME5MDM02 | Industrial Automation | L | P | T | L | P | T | Total |
| | | 3 | 2 | - | 3 | 1 | - | 4 |
| | | Examination Scheme | | | | | | |
| | | | CA | MSE | ESE | TW | OR | PR | Total |
| | | Theory | 20 | 30 | 50 | - | - | - | 100 |
| | | Lab | - | - | - | 25 | - | - | 25 |

| Pre-Requisite Courses: | - |
|---|---|

**Course and Module Overview:**

Industrial Automation focuses on the technologies and systems used to automate manufacturing and industrial processes for improved productivity, quality, flexibility, and safety. The course covers automation fundamentals, sensors and actuators, programmable controllers, CNC and flexible manufacturing systems, Product Lifecycle Management (PLM), SCADA systems, Cyber-Physical Systems (CPS), and Industrial Internet of Things (IIoT). Students gain an understanding of modern automation technologies used in smart factories and Industry 4.0 environments.

**Module 1: Introduction to Automation in Industry**

This module introduces the basic concepts of industrial automation and manufacturing system organization. It covers mechanization, automated production systems, and group technology concepts used for improving manufacturing efficiency.

**Module 2: Sensors, Actuators and Controllers**

This module introduces sensing and actuation devices used in automated systems. It also provides basic knowledge of PLCs and microcontrollers used for process monitoring and control.

**Module 3: Levels of Automation**

This module focuses on different levels of manufacturing automation ranging from NC machines to CIM. It introduces flexible manufacturing concepts and integrated production systems.

**Module 4: Product Lifecycle Management**

This module introduces PLM concepts and their role in managing products throughout their lifecycle. It also covers quality and lean manufacturing tools used for process improvement.

**Module 5: SCADA Systems**

This module introduces SCADA systems used for industrial monitoring and control. Students learn about system architecture, communication networks, HMI, and supervisory control applications.

**Module 6: CPS and Industrial Internet of Things (IIoT)**

This module introduces Industry 4.0 technologies including CPS, IIoT, Digital Twins, cloud-based monitoring, and intelligent maintenance systems used in smart manufacturing environments.

| Course Outcomes (COs) | After successful completion of the course, the students will be able to: | |
|---|---|---|
| | CO1 | Recall the fundamental concepts, terminology, and technologies used in industrial automation systems. (Remember) |
| | CO2 | Explain the principles and functions of automation components, manufacturing systems, and industrial control technologies. (Understand) |
| | CO3 | Apply automation tools and technologies such as PLCs, CNC systems, SCADA, and IIoT for industrial applications. (Apply) |
| | CO4 | Analyze automated manufacturing systems, control architectures, and industrial communication networks for improved productivity. (Analyze) |
| | CO5 | Evaluate suitable automation solutions and Industry 4.0 technologies for specific industrial applications. (Evaluate) |
| | CO6 | Develop basic automation strategies integrating sensors, controllers, SCADA, and IIoT technologies for smart manufacturing systems. (Create) |

**Syllabus:**

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| 1 | **Introduction to Automation in Industry** | | 07 |
| | After completing this module, students will be able to:<br>• Explain the concepts of mechanization, automation, and material handling systems used in manufacturing industries.<br>• Describe group technology, part families, and classification techniques used in production planning. | | |
| | 1.1 | Mechanization and Automation.<br>Material Handling Systems.<br>Hard Automation and Transfer Lines. | |
| | 1.2 | Group Technology.<br>Part Families.<br>Part Classification and Coding. | |
| | **Self-Learning Topics**: Applications of Automation in Automotive, Electronics, and Process Industries. | | |
| 2 | **Sensors, Actuators and Controllers** | | 07 |
| | After completing this module, students will be able to:<br>• Explain the operating principles and applications of industrial sensors and actuators.<br>• Describe the architecture and functions of PLCs and microcontrollers used in automation systems. | | |

| Module No. | Unit No. | Topics | Hours |
|---|---|---|---|
| | 2.1 | Touch and Non-Touch Sensors.<br>Digital and Analog Sensors.<br>Linear and Rotary Actuators. | |
| | 2.2 | Fluid Power and Electrical Actuators.<br>Introduction to PLC.<br>Microcontroller Architecture and Modules. | |
| | **Self-Learning Topics** Emerging Smart Sensors and Industrial Microcontroller Applications. | | |
| **3** | **Levels of Automation** | | **07** |
| | After completing this module, students will be able to:<br>• Explain the working principles of NC, CNC, and DNC systems used in automated manufacturing.<br>• Analyze the role of FMS and CIM in achieving manufacturing flexibility and productivity. | | |
| | 3.1 | NC, CNC and DNC Systems.<br>CNC Machining (3-Axis). | |
| | 3.2 | Flexible Manufacturing Systems (FMS).<br>FMS Components, Layouts and Equipment.<br>Introduction to Computer Integrated Manufacturing (CIM). | |
| | **Self-Learning Topics**: Smart Manufacturing and Industry 4.0 Applications in CNC-Based Production Systems. | | |
| **4** | **Product Lifecycle Management (PLM)** | | **08** |
| | After completing this module, students will be able to:<br>• Explain the phases and benefits of Product Lifecycle Management in modern industries.<br>• Apply lean and quality improvement concepts such as Kanban, JIT, and Ishikawa techniques for process optimization. | | |
| | 4.1 | Product Lifecycle Management Concepts.<br>Key Phases of PLM.<br>Benefits of PLM. | |
| | 4.2 | Kanban System.<br>Just-in-Time (JIT).<br>Ishikawa and Juran Quality Techniques.<br>Introduction to PLM Software Tools (SAP and Similar Platforms). | |
| | **Self-Learning Topics**: Case Study of PLM Implementation in Manufacturing Organizations. | | |
| **5** | **SCADA Systems** | | **08** |

| | | | |
|---|---|---|---|
| | 3.2 | Flexible Manufacturing Systems (FMS).<br>FMS Components, Layouts and Equipment.<br>Introduction to Computer Integrated Manufacturing (CIM). | |
| | After completing this module, students will be able to:<br>• Explain the architecture and components of SCADA systems used in industrial automation.<br>• Analyze the role of PLC integration, HMI, and communication networks in remote monitoring and control. | | |
| | 5.1 | Introduction to SCADA.<br>Supervisory Computers.<br>Remote Terminal Units (RTUs).<br>PLC Integration. | |
| | 5.2 | Communication Infrastructure.<br>Human Machine Interface (HMI).<br>Alarm Handling.<br>Remote Monitoring and Control. | |
| | **Self-Learning Topics**: SCADA Applications in Power Plants, Water Treatment Systems, and Smart Factories. | | |
| **6** | **CPS and Industrial Internet of Things (IIoT)** | | **08** |
| | After completing this module, students will be able to:<br>• Explain the architecture and working principles of CPS, IIoT, and Digital Twin technologies.<br>• Analyze cloud-based monitoring and intelligent maintenance systems used in smart manufacturing. | | |
| | 6.1 | Introduction to CPS Architecture.<br>IIoT Architecture.<br>Digital Twins.<br>Cloud Communication. | |
| | 6.2 | Data Acquisition Using IIoT.<br>Intelligent Monitoring Systems.<br>Predictive Maintenance Applications. | |
| | **Self-Learning Topics**: Digital Twin and IIoT Applications in Smart Manufacturing and Predictive Maintenance. | | |
| | **Total** | | **45** |

## Course Vertical: Open Elective Course (OE): 02 Credits

| Course Code | Course Name | Teaching Scheme (Hrs. / Week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | **L** | **P** | **T** | **L** | **P** | **T** | **Total** |
| **25IL5OEXX** | **Open Elective Course** [#] ([#] Refer to the list of Courses) | 2 | - | - | 2 | - | - | **2** |
| | | **Examination Scheme** | | | | | | |
| | | | **CA** | **ESE** | **TW** | **OR** | **PR** | **Total** |
| | | **Theory** | 20 | 30 | **-** | - | **-** | **50** |

### List Of Open Electives (OE) Courses [#] (02 Credits)

Students are required to **enroll in any one of the NPTEL Open Elective courses from the list of approved courses circulated by the Institute**. Enrolment in courses outside this approved list will not be considered for the Open Elective requirement.

| Serial No. | Course Code | Name of Open Elective Courses (OE) |
|---|---|---|
| 01 | 25IL5OE01 | Energy Economics and Policy |
| 02 | 25IL5OE02 | Economic Environment and Business Strategy |
| 03 | 25IL5OE03 | Ethics in Engineering Practice |
| 04 | 25IL5OE04 | Intellectual Property, Rights and Competition Law |
| 05 | 25IL5OE05 | Principle of Human Resource Management |
| 06 | 25IL5OE07 | Patent Search for Engineers and Lawyers |
| 07 | 25IL5OE08 | Developing Soft Skills and Personality |
| 08 | 25IL5OE09 | Mastering Speaking and Presentation Skills |
| 09 | 25IL5OE10 | Soft Skill Development |
| 10 | 25IL5OE11 | Any other course with the approval of Principal |

***** *For Open Elective Courses, online NPTEL courses approved by Institute*

## Assessment Methodology:

The assessment for the Open Elective course shall be carried out as follows:

1. **Continuous Assessment (CA)**

- Students shall complete and submit all the weekly NPTEL assignments as per the schedule prescribed by NPTEL.
- The marks obtained in the NPTEL assignments shall be considered for the **Continuous Assessment (CA)** component.

- The assignment marks shall be **scaled to 20 marks** for the purpose of awarding the CA marks.

**2. End Semester Examination (ESE)**

- Students shall register for and appear in the **NPTEL certification examination** for the Open Elective course in which they have enrolled.
- The marks obtained in the NPTEL certification examination shall be treated as the **End Semester Examination (ESE)** marks for the course.

**3. Grade Incentive**

- Students who **successfully qualify in the NPTEL certification examination** shall be awarded **one grade higher** than the grade earned based on their overall performance in the course, subject to the Institute's grading regulations.

| Total Marks Obtained (%) | DBIT Grade | Incentive Grade for NPTEL Certification | Performance |
|---|---|---|---|
| >=90 | O | O | Outstanding |
| >=80 and <90 | A+ | O | Excellent |
| >=70 and <80 | A | A+ | Very Good |
| >=60 and <70 | B+ | A | Good |
| >=55 and <60 | B | B+ | Fair |
| >=50 and <55 | C | B | Average |
| >=40 and <50 | D | C | Pass |
| <40 | F | No incentive grade | Fail |

**4. Students Not Appearing for the NPTEL Examination**

- Students who **do not appear** for the NPTEL certification examination shall be required to appear for the **college-conducted End Semester Examination** for the same Open Elective course.
- In such cases, the student **shall not be eligible for the one-grade incentive**, and the final grade shall be awarded based on the marks obtained in the college End Semester Examination together with the Continuous Assessment marks.