M-TECH: EMBEDDED SYSTEMS

Department of

ELECTRONICS AND COMMUNICATION ENGINEERING

MARRI LAXMAN REDDY INSTITUTE OF TECHNOLOGY AND MANAGEMENT

REGULATION: MTECH-R24

Contents

OVERVIEW

Outcome Based Education (OBE) forms the foundation of quality assurance in higher technical education, particularly in postgraduate programmes such as M.Tech. Unlike traditional education models that emphasize only syllabus coverage and content delivery, OBE emphasizes what students are expected to achieve by the end of the programme. It focuses on clearly defined, measurable outcomes and ensures that all teaching-learning activities contribute directly to achieving these outcomes.

Key Focus of OBE

- Clearly defined and measurable learning outcomes
- Alignment of teaching–learning activities with outcomes
- Continuous assessment and feedback
- Student-centric and competency-driven education

Role of Faculty in OBE

Faculty members function as:

- **Instructors** – delivering core concepts
- **Facilitators** – guiding active learning
- **Trainers** – developing professional and technical skills
- **Mentors** – supporting academic and research growth

OBE Framework – Levels of Outcomes

The OBE system is structured across four key levels:

1. Vision and Mission
2. Programme Educational Objectives (PEOs)
3. Programme Outcomes (POs)
4. Course Outcomes (COs)

- Advanced technical expertise
- Research and innovation capability
- Professional ethics and social responsibility
- Lifelong learning skills
- participation (students, faculty, alumni, industry)

- Transparent and measurable learning achievement
- Improved student engagement and ownership of learning
- Strong linkage between curriculum, assessment, and outcomes
- Continuous improvement through feedback and analysis
- Alignment with global engineering standards

In the OBE framework, faculty members may function as instructors, facilitators, trainers, or mentors, depending on the learning objectives and targeted outcomes. The approach promotes student-centered learning, continuous feedback, and systematic assessment to evaluate learning achievement.

Institutions offering M.Tech programmes adopt OBE to revise and refine curriculum design, assessment practices, and teaching methodologies based on feedback from various stakeholders such as students, faculty, alumni, employers, industry professionals, and recruiters. OBE ensures that learning is outcome-driven, dynamic, and aligned with global expectations.

Figure 1: OBE process

The four key levels of outcomes in the OBE framework are:

1. **Vision and Mission**
2. **Programme Educational Objectives (PEOs)**
3. **Programme Outcomes (POs)**
4. **Course Outcomes (COs)**

These outcomes reflect the competencies expected from M. Tech graduates, including technical expertise, research capability, innovation, professional ethics, and lifelong learning.

Why OBE for M. Tech Programmes?

1. Facilitates international recognition of qualifications.Enhances global employability and mobility
2. Produces highly skilled, innovative graduates with strong research abilities, professional ethics, and social responsibility.
3. Improves institutional reputation, visibility, and credibility among national and international stakeholders.
4. Enhances participation and ownership of learning among students, faculty, industry partners, and academic bodies.
5. Ensures graduates are prepared for leadership roles, advanced research, and technological advancements.

6. Helps M. Tech graduates achieve professional excellence and contribute meaningfully to industry, academia, and society.

   The NBA accreditation framework has undergone several refinements to improve the quality and global recognition of technical education:

   • 2013: Introduction of the first comprehensive OBE-based accreditation format aligned with Washington Accord graduate attributes.

   • 2017: Inclusion of CO–PO mapping, assessment tools, and continuous improvement metrics.

   • 2021: Integration of digital evidence, innovation, entrepreneurship, and sustainability indicators into the Self-Assessment Report (SAR).

   • 2024: Launch of Graduate Attributes and Professional Competencies, emphasizing knowledge attributes (K1–K6 levels), skills, and attitudes in accordance with international educational standards.

Key Features of Outcome Based Education

- Transparent and measurable learning achievement
- Improved student engagement and ownership of learning
- Strong linkage between curriculum, assessment, and outcomes
- Continuous improvement through feedback and analysis
- Alignment with global engineering standards
- About NBA Accreditation

Benefits of Outcome-Based Education

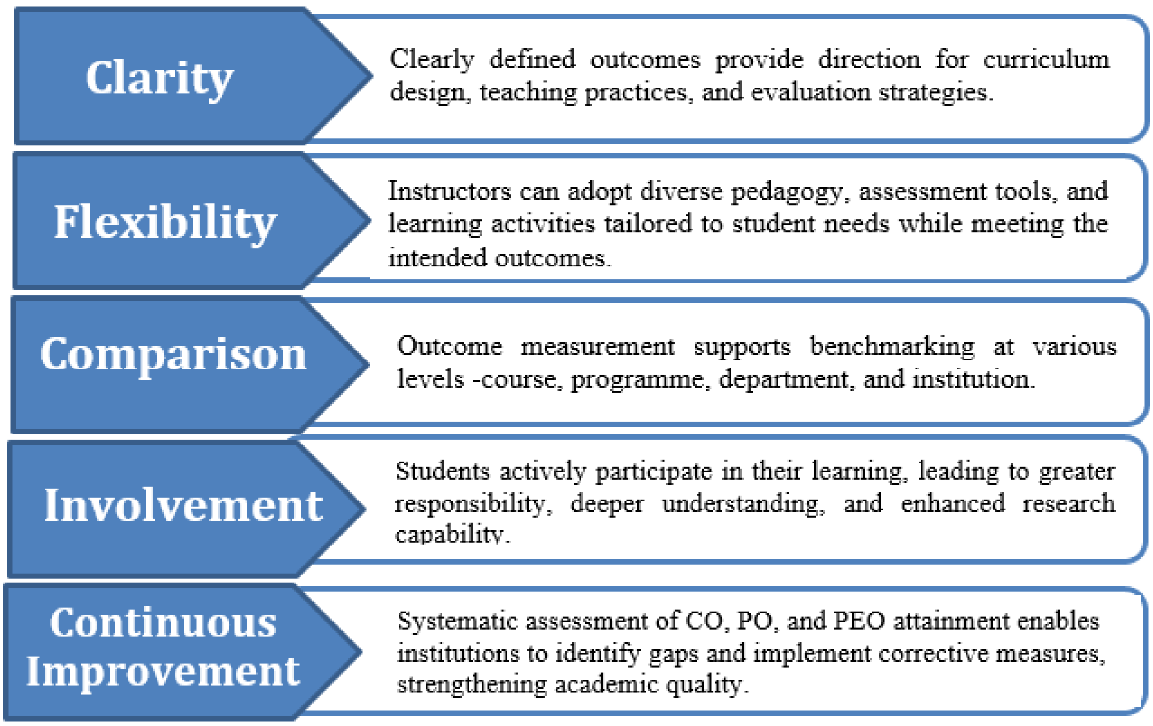

Figure 2: Benefits of Outcome Based Education

Outcome Based Education and Accreditation

India's adoption of Outcome-Based Education (OBE) represents a significant reform in the nation's higher technical education system. The transformation began gaining real momentum when India became a permanent signatory to the Washington Accord on 13 June 2014, a prestigious international agreement that recognizes engineering degree programmes based on the attainment of learning outcomes and graduate attributes. This global recognition demanded a shift from conventional, content-heavy teaching practices to a student-centric, measurable, and competency-oriented education system.

NBA formally introduced an OBE-based accreditation framework in 2013, encouraging institutions to redesign their curriculum delivery mechanisms. Under this framework, all engineering and technical programmes must clearly articulate Programme Educational Objectives (PEOs), Programme Outcomes (POs), and Course Outcomes (COs). Institutions are expected to adopt well-defined assessment strategies, evaluate attainment levels regularly, and maintain systematic documentation.

The implementation of OBE in India requires:

- Clear formulation of outcomes at all levels- course, programme, and graduate attributes.
- Appropriate mapping between COs, POs, and PEOs.
- Use of direct and indirect assessment tools to evaluate student performance.
- Data-driven analysis of attainment levels to identify strengths and weaknesses.
- Continuous improvement measures based on the attainment analysis and stakeholder feedback (students, faculty,alumni, industry, employers).
  Integration of modern pedagogies, industry practices, and technology-driven learning methods.

Through this outcome-based approach, Indian institutions aim to enhance not only academic knowledge but also the professional skills, ethical values, and problem-solving abilities of graduates. The emphasis on measurable outcomes ensures that students acquire competencies aligned with global engineering standards, enabling them to compete internationally and meet industry expectations effectively.

Thus, the adoption of OBE in India supported by NBA has significantly elevated the quality, transparency, and global credibility of technical education. It strengthens accountability, encourages innovation, and promotes continuous improvement, ultimately preparing graduates who are competent, employable, and capable of contributing to technological and societal development.

Vision, Mission, Philosophy & Core Values

1.1 Vision of the Institute

To be a globally recognized institution that fosters innovation, excellence, and leadership in education, research, and technology development, empowering students to create sustainable solutions for the advancement of society.

1.2 Mission of the Institute

- To foster a transformative learning environment that empowers students to excel in engineering, innovation, and leadership.
- To produce skilled, ethical, and socially responsible engineers who contribute to sustainable technological advancements and address global challenges.
- To shape future leaders through cutting-edge research, industry collaboration, and community engagement.

1.3 Quality Policy

- Ensure excellence in education through innovative teaching and continuous improvement.
- Promote ethical, skilled, and employable graduates who drive sustainable technologies.
- Encourage research, industry collaboration, and community engagement for societal benefit.

1.4 Philosophy

At Marri Laxman Reddy Institute of Technology and Management, we believe that the true essence of meaningful education lies in the pursuit of truth—one that removes ignorance and empowers individuals. Education is viewed not merely as the transfer of knowledge, but as a powerful instrument for liberation, empowerment, and societal transformation.
The essence of meaningful education lies in the pursuit of truth that dispels ignorance, and Marri Laxman Reddy Institute of Technology and Management firmly believes that education must serve as a tool for liberation and empowerment. Engineering education, encompassing all major fields of science and technology, plays a vital role in the advancement of society and the progress of civilization.

Guided by this philosophy, the Institute is committed to fostering scientific and technological development in harmony with natural and societal needs. It emphasizes rigorous research, advanced technical learning, and the cultivation of professional competence combined with strong ethical foundations. The Institute encourages collaboration with local communities and promotes global engagement to ensure that education remains socially relevant and responsible.

This holistic approach aims to transform students into complete individuals professionally skilled, ethically grounded, socially conscious, and capable of contributing meaningfully to the world.

Holistic Development Approach

- The Institute emphasizes:
- promoting scientific inquiry, technological innovation, and academic excellence aligned with societal and environmental needs.
- Rigorous research and advanced technical learning
- Development of professional competence with strong ethical values
- Harmony between technological growth, nature, and society
- Collaboration with local communities
- Active global engagement for socially relevant education
- Nurturing well-rounded, ethically grounded, and socially conscious professionals
- Preparing graduates for meaningful contributions to industry, academia, and societ

1.5 Core Values

Excellence:
All activities are conducted according to the highest international standards.

Integrity:
Adheres to the principles of honesty, trust worthiness, reliability, transparency and accountability.

Inclusiveness:
To show respect for ethics, cultural and religious diversity, and freedom of thought.

Figure 3: Core Values of OBE

Social Responsibility:
Promotes community engagement, environmental sustainability, and global citizenship. It also promotes awareness of, and support for, the needs and challenges of the local and global communities.

Innovation: Supports creative activities that approach challenges and issues from multiple perspectives in order to find solutions and advance knowledge.

1.6 OBE Implementation framework

Vision and Mission Statements
The Vision and Mission of the Institute and each Department are defined and reviewed to ensure alignment with institutional goals and societal needs

Program Educational Objectives (PEOs)
PEOs describe the career and professional achievements that graduates are expected to attain a few years after completing the program.
Program Outcomes (POs)
3 POs represent the graduate attributes as defined by the NBA, while 3 POs represent the discipline specific skills that students acquire during the program.
Identify Knowledge and Attitude Profiles (WKs)
The required knowledge, skills, and attitudes are mapped as per international engineering education standards.
Engineering Competencies (ECs)
Engineering competencies are identified based on the ability to solve complex engineering problems and perform complex engineering activities.
Course Outcomes (COs)
Each course specifies well-defined and measurable Course Outcomes, written **using** Bloom's Taxonomy action verbs to indicate the level of learning (Remember, Understand, Apply, Analyze, Evaluate, and Create).
Map Courses with POs
Each course outcome (CO) is mapped to relevant program outcomes (POs) to ensure alignment.
Map Topics with Course Outcomes
Every topic or module within a course is linked to one or more COs for structured delivery and assessment.
Prepare Course Lesson Plan and Schedule of Instruction
Lecture-wise lesson plans are prepared indicating learning objectives, teaching pedagogies, and assessment components.

Pedagogical Tools
Appropriate pedagogical tools are chosen for effective delivery of course outcomes such as case studies, group discussions, flipped classrooms, and problem-based learning.
Define Self-Learning and Team Work Activities
Activities like tutorials, practical sessions, seminars, projects, and assignments are designed to enhance self-learning and practical understanding.
Use of Learning Management System (LMS)
The Anvaya and Akshara Learning Management Portal is used for complete course management, including lesson plans, assessments, and feedback.
Assessment and Attainment Analysis
The OBE module in Anvaya is used to measure the attainment of each Course Outcome (CO) through both direct and indirect assessments.
Performance Tracking and Continuous Improvement Activities
Student performance is tracked continuously, and results are analyzed to identify strengths and areas for improvement..
Curriculum Gap Analysis
Gaps between curriculum outcomes and industry requirements are identified and bridged through additional learning modules, workshops, and expert lectures.
Program Outcome Attainment Review
PO attainment levels are compared for the past three academic years. Remedial actions are proposed and implemented based on the analysis.
Program Educational Objectives (PEO) Assessment
PEO attainment is assessed periodically using alumni feedback, employer surveys, and higher studies/placement data.

Vision, Mission & PEOs of the Department

2.1 Vision of the Department

To empower students to be skilled, competitive and dedicated Electronics and Communication Engineering by imparting advanced technical knowledge and ethical values, equipping them to play a key role in the planning and execution of the nation's infrastructure and development activities.

To provide quality technical education in Electronics and Communication Engineering through research, innovation, striving for global recognition in specified domain, leadership, and sustainable societal solutions.

2.2 Mission of the Department

M1: To create a transformative learning environment that empowers students in electronics and communication engineering, fostering excellence in technical skills and leadership.

M2: To drive innovation through research, deliver a transformative education grounded in ethical principles, and nurture the development of professionals

M3: Encourage professional development to address complex technical challenges and engage in innovation with creativity, leadership, ethics, and social awareness.

2.3 Program Educational Objectives (PEOs)

Program Educational Objectives (PEOs) are defined by the Head of the Department in consultation with various stakeholders such as industry experts, employers, alumni, and students. PEOs represent the department's commitment to prospective students, outlining what graduates are expected to achieve few years after completing the program. Since assessing long-term professional achievements is challenging in the Indian context, the NBA has not made PEO assessment mandatory, and assessors generally do not evaluate it during accreditation. PEOs may be framed from different perspectives such as career advancement, technical competence, ethical conduct, and societal contribution. While drafting PEOs, technical jargon should be avoided, as these statements must be easily understandable to aspiring students and other stakeholders. Typically, three to five well-defined PEOs are recommended for any program.

PEO1

To achieve professional success in the embedded systems domanins by applying technical knowledge in academic, industry and entrepreneurial roles.

PEO2

To excel in research and innovation through deep understanding of industrial needs and emerging technologies for developing real-world solutions.

PEO3

To improve knowledge and skills for career growth by upholding integrity and embracing lifelong learning globally.

PEO4

To exhibit leadership, professionalism, and communication skills in multidisciplinary towards the sustainable development.

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Program Outcomes (POs)

3. Program Outcomes (POs)

A Program Outcome (PO) is broad in scope and describes what a student is expected to achieve at the end of the program. Program Outcomes (POs) should be specific, measurable, and achievable.

Out of the six POs, three are defined by the NBA and are common to all institutions in India, remaining three are program-specific, framed by the department to reflect specialization in Structural Engineering. For Postgraduate Programs POs descriptions are generally aligned with national standards

PO1
Research/ investigation

Independently carry out research /investigation and development work to solve practical problems

PO2
Report Preparation

Write and present a substantial technical report/document to solve practical problems

PO3
Domain Mastery

Demonstrate a degree of mastery over the area in Embedded Systems

PO4
Application of Engineering Principles

Acquire and apply engineering principles to design embedded systems and processes that address complex real-world problems.

PO5
Design and

Use modern tools to conduct experiments, apply technical skills, and develop solutions for societal challenges and sustainable development.

PO6
Lifelong Learning and Professional Development

Recognize the value of lifelong learning and proactively engage in ongoing professional development by embracing and integrating emerging technologies.

NBA-Defined Common POs

1. Research/ investigation
2. Report Preparation
3. Domain Mastery

Department Defined Program Outcomes

4. Application of Engineering Principles
5. Modern Tools & Societal Impact
6. Lifelong Learning & Adaptability

3.1 Relation between the Program Educational Objectives and the POs

The relationship between Program Educational Objectives (PEOs) and Program Outcomes (POs) is essential, as it ensures that the long-term goals of the program are systematically aligned with measurable outcomes attained by students during the course of study. Establishing this alignment helps the department verify that the curriculum, teaching-learning processes, assessments, and continuous improvement practices are effectively preparing graduates for professional careers, higher education, lifelong learning, and societal contribution. The broad correlation between the PEOs and POs is presented in Figure 4**.**

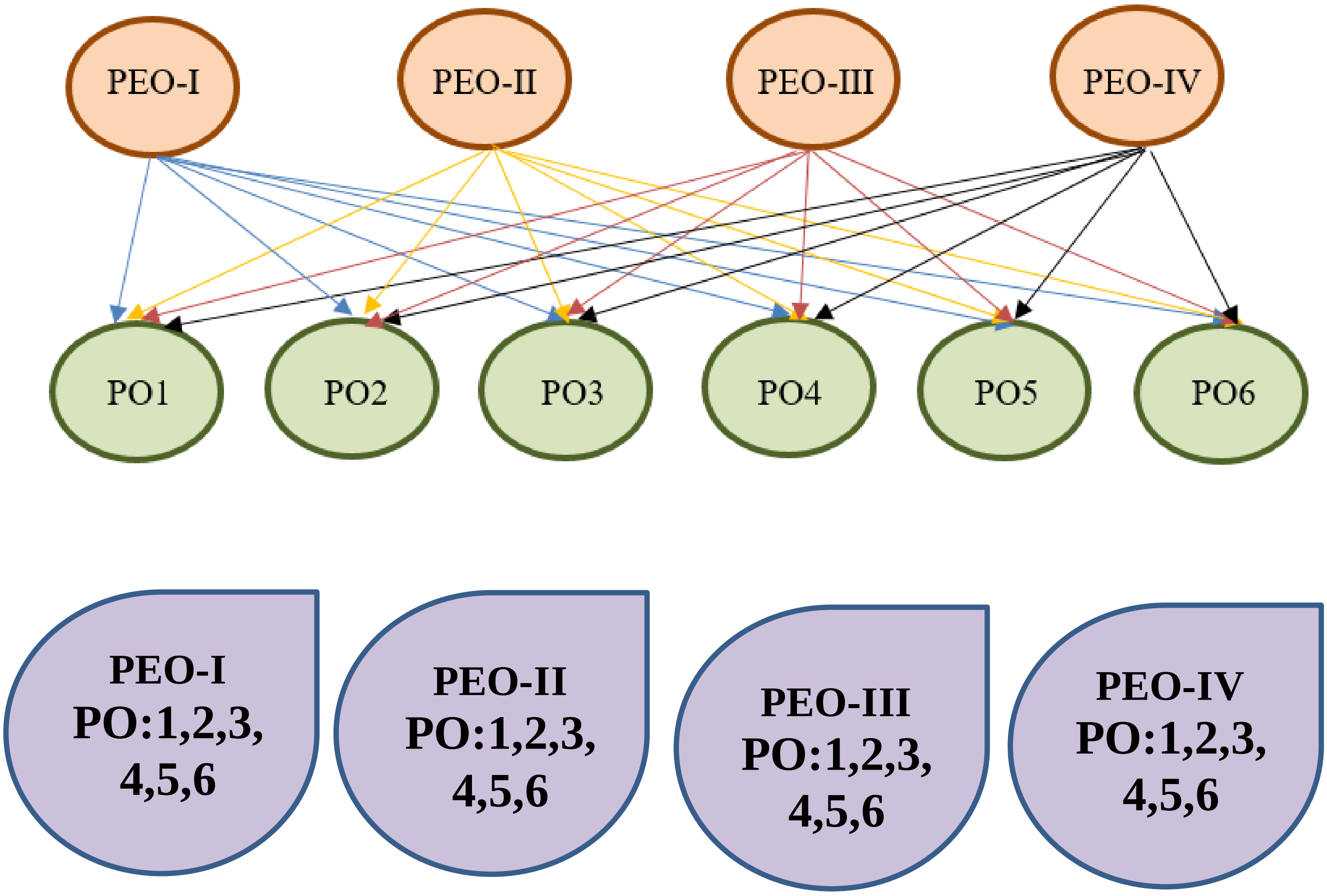
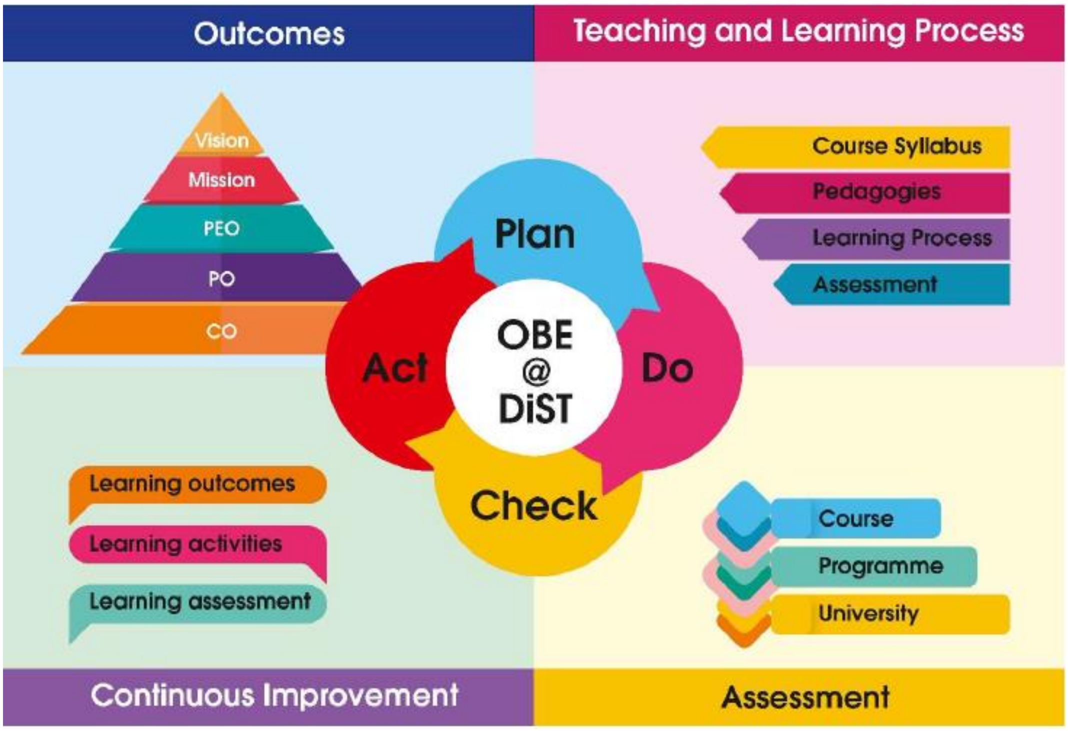


Figure 4: Correlation between the PEOs and the Pos



The detailed mapping illustrating the extent to which each Program Outcome contributes to the attainment of the Program Educational Objectives is shown in Table 1.

Table 1. Relation between the Program Educational Objectives and the POs

PEO's→ ↓PO's		**(1) Professional Excellence**	**(2) Research and Industry Awareness**	**(3) Career growth & lifelong learning**	**(4) Leadership in Sustainable development**
PO1	An ability to independently carry out research /investigation and development work to solve practical problems	2	3	2	1
PO2	An ability to write and present a substantial technical report/document	3	2	1	2
PO3	Students should be able to demonstrate a degree of mastery in Embedded Systems	3	3	2	1
PO4	Acquire and apply engineering principles to design embedded systems and processes that address complex real-world problems.	3	3	2	2

PO5	Use modern tools to conduct experiments, apply technical skills, and develop solutions for societal challenges and sustainable development.	2	2	2	3
PO6	Recognize the value of lifelong learning and proactively engage in ongoing professional development by embracing and integrating emerging technologies.	2	2	3	2

Objectives Key : 3 = High; 2 = Medium; 1 = Low

Note: PO assessment is carried out through both direct and indirect assessment procedures.

Direct Assessment is conducted through:

- Continuous Internal Assessment (CIA),
- Semester-end examinations.

Indirect Assessment is carried out through:

- Program Exit Surveys from graduating students,
- Alumni Surveys, and
- Employer/Employment Surveys.

About Blooms Taxonomy

4.1 What is Bloom's Taxonomy?

Bloom's Taxonomy is widely recognized as the global language of education. It is extensively used by educators for framing Course Outcomes, as it offers a well-defined hierarchical structure along with a comprehensive list of measurable action verbs. This structured approach helps ensure clarity, consistency, and alignment between learning objectives, teaching strategies, and assessment methods. A concise overview of the revised Bloom's Taxonomy of critical thinking, proposed by Anderson and Krathwohl, is presented in the figure below.

Bloom's Taxonomy provides a structured classification of learning stages, progressing from the simple recall of facts to the creation of new ideas based on acquired knowledge. The taxonomy is built on the understanding that learning is a sequential and hierarchical process. A learner must first remember key facts before they can understand a concept; only after gaining understanding can they apply the knowledge in real-life situations. Originally introduced as a conceptual framework, Bloom's Taxonomy is now often represented as a pyramid to visually express this progression. At the base of the pyramid lies Knowledge (Remembering), followed by Comprehension**,** Application**,** Analysis**,** Synthesis, and finally Evaluation at the top. Each level depends on mastery of the preceding one, emphasizing that effective learning requires moving step-by-step through these cognitive stages to achieve higher-order thinking skills.

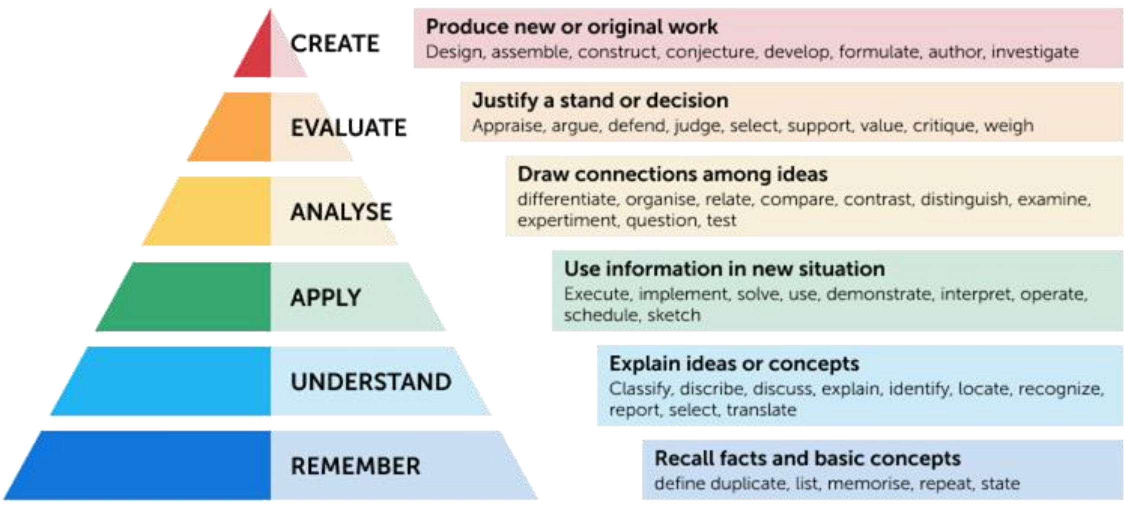


Figure 5: Blooms Taxonomy

4.2 Bloom's Taxonomy (Original and Revised)

Bloom's Taxonomy is a foundational framework for classifying educational learning objectives. First introduced in 1956 by Benjamin Bloom and his colleagues Max Englehart, Edward Furst, Walter Hill, and David Krathwohl in the book Taxonomy of Educational *Objectives*, the original taxonomy organized cognitive skills into six hierarchical levels: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation**.** Its primary purpose was to provide educators with a common terminology and systematic approach for designing curriculum, formulating learning outcomes, and developing assessment methods. Although initially designed for use in higher education, it quickly gained acceptance across all educational sectors, from school education to professional and corporate training, becoming one of the world's most widely used instructional design models.

In 2001, the taxonomy was revised by a group led by David Krathwohl and Lorin Anderson to better align with contemporary educational practices and the need for measurable learning outcomes. The revised taxonomy replaced the original noun-based categories with action-oriented verbs and repositioned the highest levels, resulting in the cognitive stages: Remember, Understand, Apply, Analyze, Evaluate, and Create**.** The revision also defined specific cognitive processes associated with each level, such as recognizing, recalling, interpreting, applying, critiquing, and generating. This updated, action-focused structure is particularly well suited for Outcome-Based Education (OBE)**,** as it enables institutions to clearly articulate, observe, and assess learning outcomes with precision and consistency.

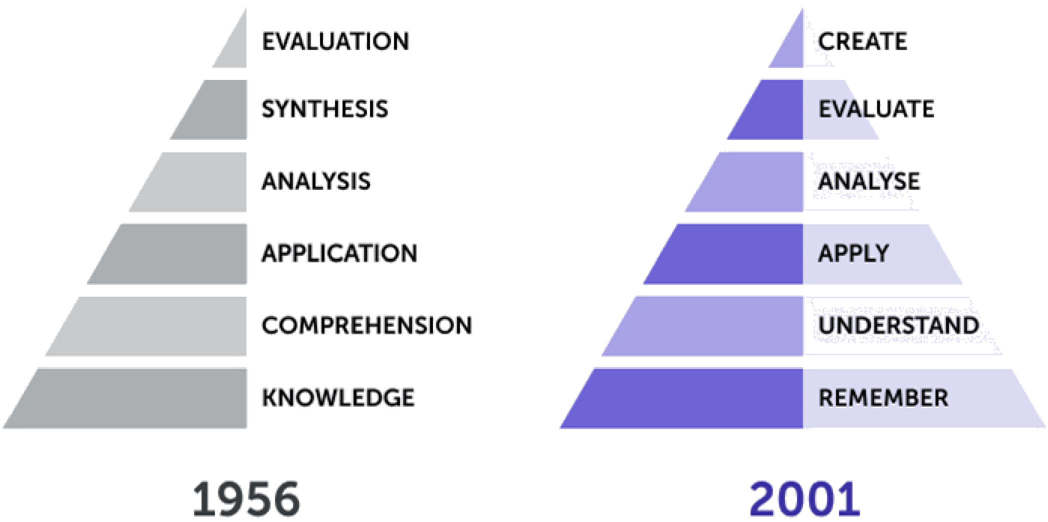


Figure 6: Blooms Taxonomy (Original and Revised)

4.3 Incorporating Critical Thinking Skills into Course Outcome Statements

In Outcome-Based Education (OBE), Course Outcomes (COs) must reflect the development of cognitive abilities at every level, ensuring that students gradually build the capacity to think clearly, logically, and independently. Critical thinking is not restricted to any single stage of Bloom's Taxonomy; rather, it develops progressively across all six levels from Remember to Create. Each level contributes uniquely to strengthening learners' ability to interpret information, solve problems, and make informed decisions.

At the foundational levels of Remember and Understand, learners begin critical thinking by recalling essential concepts, explaining ideas, identifying relationships, and interpreting information. These skills create the base for more advanced reasoning. As students move to *Apply*, they demonstrate critical thinking by using concepts in relevant situations, choosing appropriate methods, and drawing meaningful conclusions from their actions.

As learning deepens through *Analyze, Evaluate,* and *Create,* students continue to refine their critical thinking through breaking down information, comparing alternatives, validating solutions, and generating new ideas. These stages help learners handle complex tasks, make justified decisions, and approach problems with a systematic mindset.

To effectively incorporate critical thinking into CO statements, instructors should use action verbs from all levels of Bloom's Taxonomy. Verbs such as identify, describe, explain, apply, differentiate, justify, and create provide clarity and measurability, ensuring proper alignment of teaching, learning, and assessment.

Integrating critical thinking skills across all levels of COs fosters holistic learning, enhances problem-solving ability, and prepares students for professional practice, research, and lifelong learning. This comprehensive approach ensures that critical thinking is nurtured continuously throughout the curriculum.

4.4. Definitions of the different levels of thinking skills in Bloom's taxonomy:

Remember

This is the foundation of learning, where students recall basic information such as facts, definitions, formulas, events, and important concepts.

Students may be asked to:

- Recall definitions or key terms from a chapter
- List steps in a process
- Identify important dates, people, or events
- Recognize symbols, diagrams, or formulas

This level includes recognizing and recalling information from memory.

Understand

At this level, students demonstrate that they comprehend the meaning of what they have learned. They should be able to explain ideas in their own words or interpret information.

Examples of tasks include:

- Explaining the concept behind
- Summarizing a topic, or lesson
- Classifying types of phenomena, materials, or data
- Interpreting graphs, charts, and diagrams
- Comparing two theories or methods
- Drawing conclusions from a given situation

Key processes include interpreting, summarizing, inferring, comparing, and explaining.

Apply

Students use their knowledge in practical or new situations. This requires using learned concepts, formulas, rules, or methods in real-life or academic problems.

Example activities:

- Solving numerical problems using a learned formula
- Applying a scientific principle in a lab experiment
- Using a learned method to analyze a case study
- Implementing a procedure to complete a task

This level includes executing (using knowledge in familiar contexts) and implementing (using it in new contexts).

Analyze

This level focuses on breaking information into parts to understand how they relate, identify patterns, and examine underlying structures.

Students may be asked to:

- Analyze data to identify trends
- Distinguish relevant information from irrelevant details
- Break down a concept into components
- Examine causes and effects in a situation
- Compare different solutions or viewpoints

Key processes involve differentiating, organizing, and attributing.

Evaluate

Students make judgments based on criteria, standards, or evidence. This level requires critical thinking and reasoned decision-making.

Examples include:

- Justifying the selection of a method or solution
- Critiquing an experiment or an argument
- Assessing the effectiveness of a process or design
- Checking the validity or accuracy of data and conclusions

This level involves checking and critiquing using logical reasoning.

Create

The highest level, where students generate new ideas, products, or processes by combining knowledge and skills creatively.

Students may:

- Design a model, project, or experiment
- Develop a new solution to a problem
- Construct a plan, report, or prototype
- Produce original work such as a research project or presentation

Key processes include generating, planning, and producing.

4.5 List of Action Words Related to Critical Thinking Skills

Here is a list of action words that can be used when creating the expected student learning outcomes related to critical thinking skills in a course. These terms are organized according to the different levels of higher-order thinking skills contained in Anderson and Krathwohl's (2001) revised version of Bloom's taxonomy.

Here is the revised Bloom's document with action verbs, which we frequently refer to while writing COs for our courses.

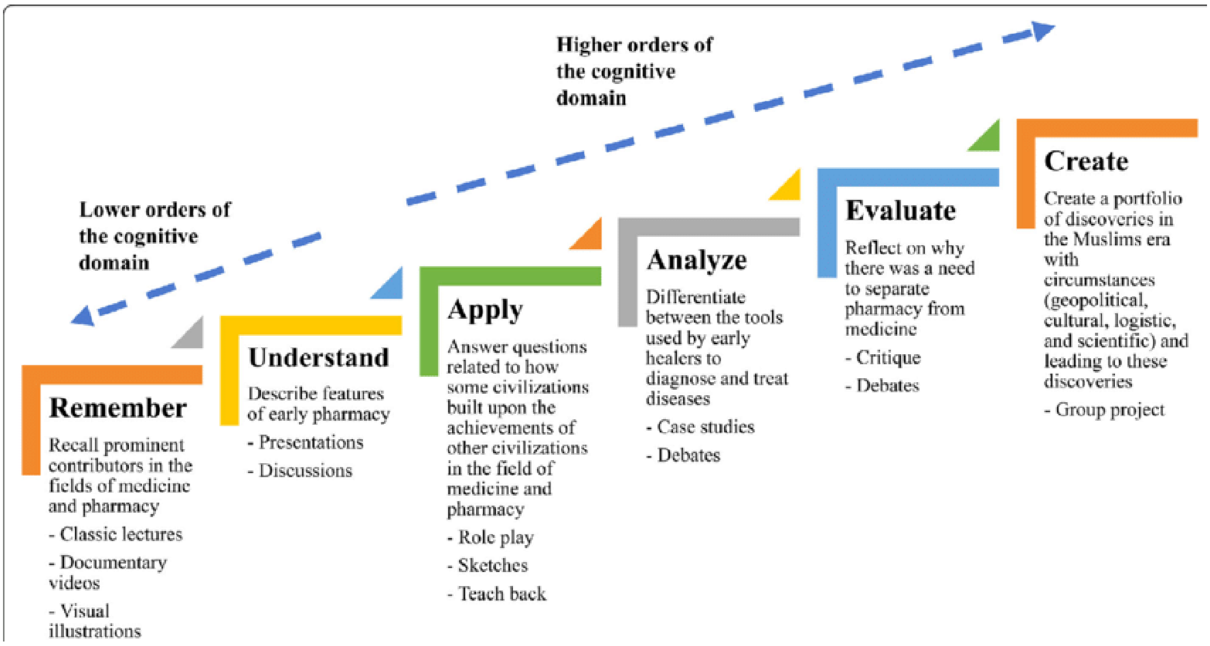


Figure 7: The cognitive process dimensions – categories

The Knowledge Dimension of the revised Bloom's Taxonomy classifies knowledge into Factual, Conceptual, Procedural, and Meta-cognitive categories.

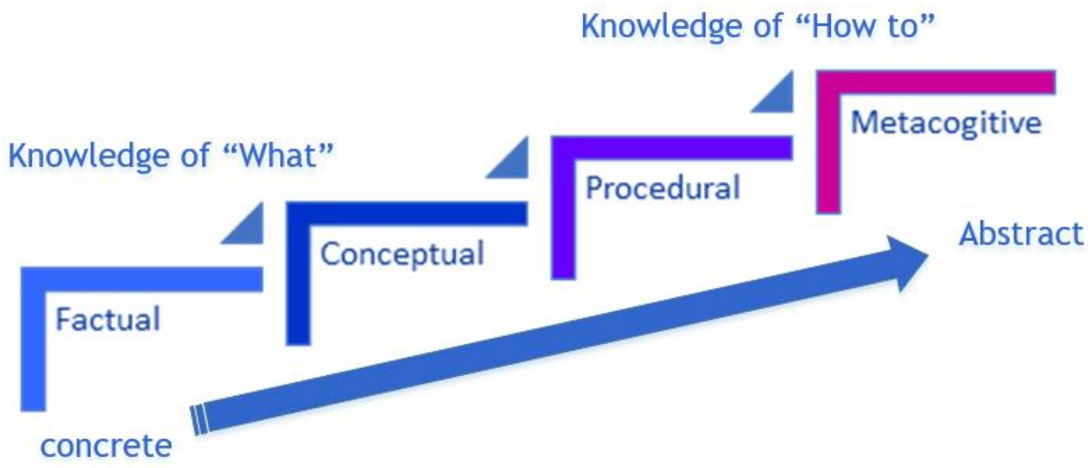


Table 2: The Knowledge Dimension

KNOWLEDGE DIMENSION		Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	Terminology, Elements & Components	Label map, List names	Interpret paragraph, Summarize book	Use math algorithm	Categorize words	Critique article	Create short storey

Conceptual Knowledge	Categories, Principles, Theories	Define levels of cognitive taxonomy	Describe taxonomy in own words	Write objectives using taxonomy	Differentiate levels of cognitive taxonomy	Critique written objectives	Create new classification system
Procedural Knowledge	Specific skills & techniques, Criteria for use	List steps in problem solving	Paraphrase problem-solving process in own words	Use problem-solving process for assigned task	Compare convergent & divergent techniques	Critique appropriateness of techniques used in case analysis	Develop orginal approach to problem solving
Meta-Cognitive Knowledge	General knowledge, Self-knowledge	List elements of personal learning style	Describe implications of learning style	Develop study skills appropriate to learning style	Compare elements of dimensions in learning style	Critique appropriateness of particular learning style theory to own learning	Create orginal learning style theory

Table 3: Action Verbs for Course Outcomes

Lower Order of Thinking(LOT)				**Higher Order of Thinking(HOT)**		
Definitions	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Bloom's Definition	Exhibit memory of previously learned material by recalling facts, terms, basic concepts, and answers.	Demonstrate understanding of facts and ideas by organizing, comparing, translating, interpret in, giving descriptions, and Stating main ideas.	Solve problems on new situations by applying acquired knowledge, facts, techniques and rules in a different way.	Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalizations.	Present and defend opinions by making judgments about information, validity of ideas, or quality of work based on a set of criteria.	Compile information together in a different way by combining elements in a new pattern or proposing alternative solution.
Verbs	• Choose • Define • Find • How • Label • List • Match • Extend	• Classify • Compare • Contrast • Demonstrate • Explain • Illustrate • Infer • Interpret	• Apply • Build • Choose • Construct • Develop • Interview • Make use of • Model	• Analyze • Assume • Categorize • Classify • Compare • Discover • Dissect • Distinguish	• Agree • Appraise • Assess • Award • Choose • Criticize • Decide • Deduct • Importance	• Adapt • Build • Solve • Choose • Combine • Invent • Compile • Compose • Construct
Verbs	• Name • Omit	• Outline • Relate	• Organize • Plan	• Divide • Examine	• Defend • Determine	• Create • Design

	• Recall • Relate • Select • Show • Spell • Tell • What • When • Where • Which • Who • Why	• Rephrase • Show • Summarize • Translate • Experiment with • Illustrate • Infer • Interpret • Outline • Relate • Rephrase • Show • Summarize • Translate • Experiment with	• Select • Solve • Utilize • Identify • Interview • Make use of • Model • Organize • Plan • Select • Solve • Utilize • Identify	• Function • Inference • Inspect • List Motive • Simplify • Survey • Take part in • Test for Theme • Conclusion • Contrast	• Disprove • Estimate • Evaluate • Influence • Interpret • Judge • Justify Mark • Measure • Opinion • Perceive • Prioritize • Prove • Criteria • Criticize • Compare • Conclude	• Develop • Estimate • Formulate • Happen • Imagine • Improve • Makeup • Maximize • Minimize • Modify • Original • Originate • Plan • Predict • Propose • Solution

Knowledge and Attitude Profile

- Well-Defined Knowledge Profiles (WKs) specify the expected volume of learning and graduate attributes required for effective professional performance.
- WKs help extend and clarify Program Outcomes (POs) by defining measurable knowledge, skills, and attitudes.
- The curriculum is designed to develop mathematical, computational, design, and creative thinking abilities.
- Learning is addressed across the cognitive, affective, and psychomotor domains.
- A total of nine knowledge and attitude profiles are incorporated to ensure holistic graduate development.
- These profiles reflect both the depth of learning and the work attitude expected from graduates.

WK	Explanation
WK1	A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social science
WK2	Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at therefore front of the discipline.
WK5	Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline
WK7	Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.
WK8	Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
WK9	Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitude

KNOWLEDGE AND ATTITUDE PROFILE KEY INDICATORS

Table 3: Key Indicator of Knowledge and Attitude Profile

WK No.	Knowledge & Attitude Profile	Key Indicators	No of Key Indicators
WK1	**Engineering Knowledge & Natural Sciences**	❖ Utilizes principles of physics to solve complex engineering problems. ❖ Employs concepts of chemistry in the analysis of engineering materials and processes. ❖ Uses mathematical principles for the formulation and solution of engineering problems. ❖ Integrates concepts from social sciences to address societal, environmental, and human factors in engineering practice. ❖ Employs discipline-specific engineering fundamentals for analysis, design, and problem-solving in specialized domains.	**5**
WK2	**Mathematical, Statistical & Data Analysis**	❖ Applies algorithms and numerical methods for engineering analysis. ❖ Uses statistical principles to summarize data and draw valid conclusions. ❖ Performs data cleaning, exploration, visualization, and ethical data handling. ❖ Interprets, evaluates, and compares analytical results using appropriate tools.	**4**

WK3	**Modelling & System Analysis**	❖ Develops analytical models of engineering systems. ❖ Develops numerical and empirical models to predict system behavior. ❖ Uses physical models to test and validate engineering assumptions. ❖ Evaluates model accuracy and validity of assumptions.	4
WK4	**Computational Tools & Digital Systems**	❖ Uses computer systems to store and manage large datasets ❖ Applies computational tools for simulation and modelling. Uses data visualization techniques for effective analysis and interpretation. ❖ Evaluates limitations of computational tools and results.	3
WK5	**Problem Identification & Engineering Analysis**	❖ Identifies constraints, requirements, and secondary impacts of engineering problems. ❖ Formulates accurate and realistic problem statements ❖ Applies analytical methods for problem investigation. ❖ Validates assumptions and analytical outcomes.	4
WK6	**Engineering Design, Sustainability & Safety**	❖ Develops innovative and sustainable design solutions. ❖ Evaluates feasibility considering technical, economic, environmental, and societal factors. ❖ Conducts life-cycle analysis for sustainability assessment. ❖ Identifies hazards and applies risk mitigation strategies. ❖ Ensures compliance with environmental and safety regulations.	5
WK7	**Engineering Management & Professional Practice**	❖ Applies engineering management principles in decision-making. ❖ Performs economic analysis for project implementation. ❖ Manages resources, time, and budget effectively. ❖ Demonstrates professional responsibility in practice.	4
WK8	**Research, Investigation & Critical Thinking**	❖ Reviews current research literature to identify research gaps. ❖ Designs and executes experiments and investigations. ❖ Applies qualitative and quantitative research methods. ❖ Analyzes data and considers sources of error. ❖ Draws and justifies valid conclusions. ❖ Evaluates emerging technologies, including Generative AI.	6
WK9	**Ethics, Law, Diversity & Inclusivity**	❖ Demonstrates ethical responsibility and professional integrity. ❖ Applies laws, regulations, and professional codes in practice. ❖ Identifies and justifies ethical courses of action. ❖ Respects diversity and promotes inclusivity in professional environments. ❖ Evaluates ethical implications of new and emerging technologies.	5

PO-WK MAPPING

Table 4 presents the mapping between the Program Outcomes (POs) and the corresponding elements of the Knowledge and Attitude profile (WK) framework for the M.Tech Structural Engineering programme.

Table 4: PO-WK Mapping

POs		WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
PO1	Research/ investigation	3	4	4	3	4	5	4	6	4
PO2	Report Preparation	1	1	1	1	1	1	2	1	2
PO3	Domain Mastery	3	3	4	2	4	5	3	6	3
PO4	Application of Engineering Principles	5	3	4	3	4	5	4	6	5
PO5	Design and Sustainability	3	3	4	2	4	5	3	6	3
PO6	Lifelong Learning and Professional Development	3	3	4	2	4	5	4	6	5

COMPLEX ENGINEERING PROBLEMS

Complex Engineering Problems are engineering challenges that are broad, open-ended, and ambiguous, requiring the application of advanced engineering knowledge, professional judgment, and integration of multiple disciplines. These problems do not have a single optimal or readily testable solution and are characterized by uncertainty, multiple constraints, and the need for innovative and iterative approaches.

Key features of Complex Engineering Problems

- Broad scope involving multiple interconnected systems and disciplines
- Unstable and unpredictable parameters that evolve over time
- Require advanced and specialized engineering knowledge beyond routine practice
- Multiple experiments or direct testing may not be feasible
- Solutions are iterative, involving analysis, optimization, and innovation
- No bounded set of alternative solutions; trade-offs must be evaluated
- High levels of uncertainty, including unknown variables and risks
- Solutions cannot be based solely on standard codes or practices
- Demand consideration of safety, economy, sustainability, constructability, and societal impact
- Typically require collaboration among multidisciplinary teams and stakeholders

Characteristics Of Complex Engineering Problems

Table 5: Characteristics of complex engineering problems

S No.	Keyword / Aspect	Description
1	**Depth of knowledge required**	Cannot be resolved without in-depth engineering knowledge at the level of one or more of **WK3, WK4, WK5, WK6, or WK8**, enabling a fundamentals-based and first-principles analytical approach.
2	**Range of conflicting requirements**	Involve wide-ranging and often conflicting technical, engineering, economic, environmental, and societal issues.
3	**Depth of analysis required**	Have no obvious solution and require abstract thinking, originality, and advanced analytical skills to formulate appropriate models and solution strategies.
4	**Familiarity of issues**	Involve issues that are infrequently encountered and not routine in professional engineering practice.
5	**Extent of applicable codes**	Lie outside the scope of problems fully addressed by existing standards and codes of professional engineering practice.
6	**Extent of stakeholder involvement & conflicting requirements**	Involve diverse stakeholder groups with widely varying and often conflicting needs, expectations, and constraints.
7	**Interdependence**	Represent high-level problems comprising many interdependent components or sub-problems that must be addressed holistically.

Adopting United Nations Sustainable Development Goals

In the era of rapid industrialization and digital transformation, engineering education plays a decisive role in addressing global challenges such as climate change, energy crises, resource depletion, social inequality, and sustainable urbanization. Recognizing this responsibility, the Engineering Program formally adopts the United Nations' Sustainable Development Goals (SDGs) as a guiding framework to align technical education with sustainable, ethical, and socially responsible development.

The program integrates SDGs within the Outcome-Based Education (OBE) framework to ensure that graduates are equipped not only with advanced technical competence but also with sustainability awareness and global citizenship.

INTEGRATION OF SDGs WITHIN THE M.TECH PROGRAM

S. No.	Keyword / Aspect of Complex Engineering Problems	Relevant Program Outcomes (POs)	Linked UN SDGs	Justification of Linkage (Structural Engineering Context)
1	Depth of knowledge required	PO3 – Domain Mastery, PO4 – Application of Engineering Principles	SDG 4, SDG 9, SDG 7, SDG 6	Advanced education in structural analysis and mechanics enables innovation in infrastructure, renewable energy structures, and water-related systems, supporting sustainable development.
2	Range of conflicting requirements	PO5 – Design and Sustainability, PO6 – Lifelong Learning & Professional Development	SDG 4, SDG 8, SDG 10, SDG 11	Sustainable structural design balances safety, economy, inclusivity, and environmental impact, promoting equitable urban development and economic growth.
3	Depth of analysis required	PO1 – Research / Investigation, PO4 – Application of Engineering Principles	SDG 4, SDG 9, SDG 12	Research-driven analysis supports material efficiency, life-cycle design, and innovative construction practices for responsible production and infrastructure resilience.
4	Familiarity of issues	PO1 – Research / Investigation, PO6 – Lifelong Learning &	SDG 4, SDG 13, SDG 15, SDG 14	Continuous learning enables engineers to respond to climate change, environmental protection, coastal structures,

		Professional Development		and land-use-sensitive development.
5	Extent of applicable codes	PO4 – Application of Engineering Principles, PO5 – Design and Sustainability	SDG 4, SDG 9, SDG 16	Ethical application of advanced principles beyond codes ensures public safety, institutional accountability, and innovation in complex structural projects.
6	Stakeholder involvement & conflicting needs	PO2 – Report Preparation, PO5 – Design and Sustainability	SDG 4, SDG 5, SDG 11, SDG 16	Inclusive reporting, ethical documentation, and stakeholder engagement promote gender equity, transparent governance, and socially responsible infrastructure.
7	Interdependence of components	PO1 – Research / Investigation, PO3 – Domain Mastery, PO5 – Design and Sustainability	SDG 4, SDG 1, SDG 2, SDG 3, SDG 12	Integrated structural systems support safe housing, healthcare, food storage, and livelihood infrastructure, contributing to social well-being and poverty reduction.
8	Collaboration, outreach & global responsibility	PO2 – Report Preparation, PO6 – Lifelong Learning & Professional Development	SDG 4, SDG 17	Industry–academia collaboration, professional practice, and research partnerships strengthen global cooperation for sustainable development goals.

Course Outcomes (COs)

5. Course Outcomes (COs)

A Course Outcome is a formal statement of what students are expected to learn in a course. When creating Course Outcomes, remember that the outcomes should clearly state what students will do or produce to determine and/or demonstrate their learning. Course learning outcome statements refer to specific knowledge, practical skills, areas of professional development, attitudes, higher-order thinking skills, etc., that faculty members expect students to develop, learn, or master during a course.

A well-formulated set of Course Outcomes will describe what a faculty member hopes to successfully accomplish in offering their particular course(s) to prospective students, or what specific skills, competencies, and knowledge the faculty member believes that students will have attained once the course is completed. The learning outcomes need to be concise descriptions of what learning is expected to take place by course completion.

5.1 Guide lines for writing Course Outcome Statements:

Well-written course out comes involve the following parts:

1. **Action Verb** – Specifies observable student performance
2. **Subject Content** – Indicates the knowledge or skill area
3. **Level of Achievement** – Reflects cognitive depth (Bloom's Taxonomy)
4. **Conditions of Performance** (if applicable) – Defines context or tools used

5.2 Developing Course Outcomes

When creating course outcomes consider the following guidelines as you develop them either individually or as part of a multi-section group:

- Limit the course outcomes to 5-6 statements for the entire course [more detailed outcomes can be developed for individual units, assignments, chapters, etc. if the instructor(s) wish (es)].
- Focus on overarching knowledge and/or skills rather than small or trivial details.
- Emphasize knowledge and skills that are central to the course topic and/or discipline.
- Create statements that have a student focus rather than an instructor-centric approach. (Example: Demonstrate the stability behavior of columns under axial, flexural, and torsional buckling with and without lateral bracing.).
- Limit outcomes to 5–6 statements per course
- Focus on core knowledge and essential skills
- Avoid trivial or overly detailed content
- Use student-centered language
- Emphasize learning results, not teaching activities

- Align outcomes with departmental and institutional mission
- Include multiple ways students can demonstrate learning (analyze, model, design, evaluate, present, etc.)
- Ensure outcomes are observable, measurable, and assessable

Student-focused outcome: "Upon completion of this course, students will be able to demonstrate the stability behavior of columns under axial, flexural, and torsional buckling with and without lateral bracing by outlining theoretical principles, analyzing critical load conditions, modeling structural responses, and depicting solutions through sketches, simulations, or design examples."
Instructor-centric objective (to avoid): "One objective of this course is to teach students the concepts of axial, flexural, and torsional buckling of columns with and without lateral bracing."

Focus on the learning that results from the course rather than describing activities or lessons that are in the course.

Incorporate and/or reflect the institutional and departmental mission.
Include various ways for students to show success (e.g., outlining, describing, modelling, depicting, etc.) rather than using a single statement such as "At the end of the course, students will know" as the stem for each expected outcome statement.

When developing learning outcomes, here are the core questions to ask yourself:

- What do we want students in the course to learn?
- What do we want the students to be able to do?
- Are the outcomes observable, measurable, and able to be performed by the students?

Course outcome statements at the course level describe:

- What faculty members want students to know at the end of the course AND
- What faculty members want students to be able to do at the end of the course.

Course outcomes have three major characteristics:

- They specify an action by the students/learners that is observable.
- They specify an action by the students/learners that is measurable.
- They specify an action that is done by the students/learners rather than the faculty members.

Effectively developed expected learning outcome statements should possess all three of these characteristics.

When this is done, the expected learning outcomes for a course are designed so that they can be assessed. When stating expected learning outcomes, it is important to use verbs that describe exactly what the student(s)/learner(s) will be able to do upon completion of the course.

5.3 Relationship of Course Outcome to Program Outcome

Learning outcomes formula:

STUDENTS SHOULD BE ABLE TO + BEHAVIOR + RESULTING EVIDENCE

The Course Outcomes need to link to the Program Outcomes.

For example, you can use the following template to help you write an appropriate course level learning outcome.
"Upon completion of this course students will be able to (knowledge, concept, rule or skill you expect them to acquire) by (how will they apply the knowledge or skill/how will you assess the learning)."

5.4 Characteristics of Effective Course Outcomes

Well written course outcomes:

- Describe what you want your students to learning your course.
- Are aligned with program goals and objectives.
- Tell how you will know an instructional goal has been achieved.
- Use action words that specify definite, observable behaviors.
- Arrases able through one or more indicators (papers, quizzes, projects, presentations, journals, portfolios, etc.)
- Are realistic and achievable.
- Use simple language.

5.5 Examples of Effective Course Outcomes

After successful completion of the course, Students will be able to:

- Apply combinational logic design techniques using Hardware Description Languages to implement optimized arithmetic and logic circuits on FPGAs.
- Evaluate fault detection approaches and state identification techniques for sequential circuits.
- Explain the organization, operation, and leakage mechanisms of semiconductor memory technologies.
- Summarize pattern recognition techniques and dimensionality reduction methods for classification.
- Design automotive embedded systems using architecture description languages and model-based development approaches.
- Explain the fundamentals of real-time operating systems, their components, and scheduling mechanisms.
- Investigate USB transfer types, enumeration steps, descriptor structures, and device driver function for reliable USB communication.
- Evaluate design specification, co-design verification, and interface verification methods.
- Apply hardware security primitives and perform security and trust assessment of hardware systems.
- Explain fundamental concepts of digital image processing and image transform techniques.

- Evaluate Serial Front Panel Data Port concepts and signal traits on fiber and copper achieving high-speed, low-latency links.
- Describe the meaning, sources, and key characteristics of a good research problem and common errors in its selection.
- Conduct a comprehensive literature review and demonstrate ethical standards in research for the avoidance of plagiarism.

A more detailed model for stating learning objectives requires at objectives have three parts: a condition, an observable behavior, and a standard.
The table below provides three examples.

Table 4: Examples of Course Outcomes Using the Condition-Behavior-Standard Model

S. No	Condition	Observable Behavior	Standard
1	Provided with sequential circuit models and fault scenarios	The student will be able to evaluate and identify suitable fault detection approaches and state identification techniques	Correctly identifying faults and states with at least 80% accuracy
2	After a lecture on semiconductor memory technologies and their architectures	The student will be able to explain the organization, operation, and leakage mechanisms of semiconductor memory devices	Accurately describing at least three memory types and two leakage mechanisms
3	Provided with automotive system requirements and model-based development tools	The student will be able to design automotive embedded systems using architecture description languages	Producing a functional system model satisfying specified design constraints
4	Immediately after instruction on real-time operating systems concepts	The student will be able to explain RTOS fundamentals, components, and scheduling mechanisms	Identifying and explaining at least three RTOS components and two scheduling algorithms
5	Using system design documentation and verification tools	The student will be able to evaluate design specifications, co-design verification, and interface verification methods	Demonstrating verification steps that validate system functionality with documented results

The following examples describe a course outcome that is not measurable as written, an explanation for why the course outcome is not considered measurable, and a suggested edit that improves the course outcome

Table 5: Refinement of Course Outcomes – From Original to Improved Measurable Statements

Original course out-come	Evaluation of language used in this course outcome	Improved course outcome
Evaluate design specification, co-design verification, and interface verification methods.	The outcome uses measurable terminology but should specify comparison or validation of verification techniques.	Upon completion of this course, the students will be able to analyze and compare design specification methods, co-design verification techniques, and interface verification approaches.
Conduct a comprehensive literature review and demonstrate ethical standards in research for the avoidance of plagiarism.	The outcome is measurable but may specify the expected deliverable such as a documented review.	Upon completion of this course, the students will be able to prepare a structured literature review with proper citations while adhering to ethical research standards and avoiding plagiarism.

Examples that are TOO general and VERY HARD to measure...

- ...will appreciate the benefits of learning a foreign language.
- ...will be able to access resources at the Institute library.
- ...will develop problem-solving skills.
- ...will have more confidence in their knowledge of the subject matter.

Examples that are still general and HARD to measure...

- ...will value knowing a second language as a communication tool.
- ...will develop and apply effective problem-solving skills that will enable one to adequately navigate through the proper resources within the institute library.
- ...will demonstrate the ability to resolve problems that occur in the field.
- ...will demonstrate critical thinking skills, such as problem-solving as it relates to social issues.

Examples that are SPECIFIC and relatively EASY to measure...

- ...will be able to read and demonstrate good comprehension of text in areas of the student's interest or professional field.
- ...will demonstrate the ability to apply basic research methods in psychology, including research design, data analysis, and interpretation.
- ...will be able to identify environmental problems, evaluate problem-solving strategies, and develop science-based solutions.
- ...will demonstrate the ability to evaluate, integrate, and apply appropriate information from various sources to create cohesive, persuasive arguments, and to propose design concepts.

An Introspection - Examine Your Own Course Outcomes

- If you have written statements of broad course goals, take a look at them. If you do not have a written list of course goals, reflect on your course and list the four to six most important student outcomes you want your course to produce.

- Look over your list and check the one most important student outcome. If you could only achieve one outcome, which one would it be?
- Look for your outcome on the list of key competencies or outcomes society is asking us to produce. Is it there? If not, is the reason a compelling one?
- Check each of your other "most important" outcomes against the list of outcomes. How many are on the list of key competencies?
- Take stock. What can you learn from this exercise about what you are trying to accomplish as a teacher? How clear and how important are your statements of outcomes for your use and for your students? Are they very specifically worded to avoid misunderstanding? Are they supporting important needs on the part of the students?

5.6 Write Your Course Outcomes!

One of the first steps you take in identifying the expected learning outcomes for your course is identifying the purpose of teaching the course. By clarifying and specifying the purpose of the course, you will be able to discover the main topics or themes related to students' learning. Once discovered, these themes will help you to outline the expected learning outcomes for the course. Ask yourself:

- What role does this course play within the program?
- How is the course unique or different from other courses?
- Why should/do students take this course? What essential knowledge or skills should they gain from this experience?
- What knowledge or skills from this course will students need to have mastered to perform well in future classes or jobs?
- Why is this course important for students to take?

CO-PO Course Articulation Matrix

6. CO-PO Course Articulation Matrix

A Course Articulation Matrix (CAM) shows the relationship between the Course Outcomes (COs) and the Program Outcomes (POs). It reflects the level to which each CO contributes to the attainment of specific POs. This matrix helps determine whether students are achieving the intended learning outcomes of a course. It is applicable to any course and is a valuable tool for evaluating and improving a course syllabus.

Table 3 provides information about the action verbs used in the Program Outcomes (POs) and the Bloom's Taxonomy levels associated with them. Understanding the intention of each PO and the Bloom's levels linked to its verbs allows faculty to appropriately design Course Outcomes (COs). Once the COs are defined, the faculty can determine the extent of correlation between each CO and each PO.

The mapping of COs to POs is evaluated using descriptors such as High**,** Medium**,** Low, or No Correlation**.** These assigned values are later used to compute PO attainment for the course.

Observations:

1. For theory courses**,** COs should generally be designed within Bloom's Levels 1 to 4.
2. For programming-oriented courses, COs should usually be limited to Bloom's Levels 1 to 3**,** while other theory courses may extend up to Level 4.
3. For laboratory courses**,** COs may be framed within Bloom's Levels 1 to 5.
4. Only in mini-projects and major projects may COs be designed up to Bloom's Level 6.
5. For a given course, the course in-charge should involve all faculty members teaching the course in preparing the CO-PO mapping. The course in-charge may take the average of all submitted mappings or follow the majority. Faculty members should perform the mapping independently, without discussing values among themselves.
6. When correlating COs with POs, ensure that the action verbs in the COs align with the intent and scope defined in the POs.

6.1 Tips for Assigning the values while mapping COs to POs

1 Choose action verbs from appropriate Bloom's levels based on the importance of each CO.
2 Use **one primary action verb** per CO; additional verbs may be used only when necessary.
3 Each assigned CO-PO value must be **justified** with a short statement (1-2 lines) that references words or phrases from the CO, PO, and course syllabus.
4 Values for the CO-PO mapping may be assigned as follows:

3 (High): Strong alignment between the CO and the PO.
2 (Medium): Moderate alignment.
1 (Low): Minimal alignment.
"-" (No alignment): No meaningful correlation.

5 If an action verb appears across multiple Bloom's levels, determine which level best matches how the verb is used in the CO.

6.2 Method for Articulation

1. Identify the key competencies of POs for each CO and create a corresponding mapping table by assigning marks in the corresponding cell. One important observation is that the first five POs are purely technical in nature, while the other POs are non-technical.
2. Justify each CO-PO mapping with a justification statement and recognize the number of vital features mentioned in the justification statement that match the given Key Attributes for Assessing Program Outcomes. Use a combination of words found in the COs, POs, and your course syllabus for writing the justification.
3. Create a table listing the number of key competencies for CO-PO mapping with reference to the maximum given Key Attributes for Assessing Program Outcomes.
4. Create a table displaying the percentage of key competencies for CO-PO mapping with reference to the maximum given Key Attributes for Assessing Program Outcomes.
5. Finally, prepare a Course Articulation Matrix (CO-PO Mapping) with COs and POs on a scale of 0 to 3, where:
   - 0 = No correlation (marked as "-")
   - 1 = Low/slight correlation
   - 2 = Medium/moderate correlation
   - 3 = Substantial/high correlation

The correlation is based on the following strategy:

Range	Correlation	Level
$0 \leq C \leq 5\%$	No correlation	0
$5\% < C \leq 40\%$	Low/Slight correlation	1
$40\% < C < 60\%$	Moderate correlation	2
$60\% \leq C < 100\%$	Substantial/High correlation	3

6.3 Key Competencies for Assessing Program Outcomes:

To ensure that Program Outcomes (POs) are effectively achieved, each PO must be broken down into measurable Key Competencies. These competencies explain the specific abilities, skills, and knowledge that students must demonstrate. The table 6 below outlines the detailed key components for each PO, along with the total number of components associated with it. This structured approach enables transparency, accuracy in CO–PO mapping, and consistency during assessment and evaluation.

Table 6: Key Competencies for Assessing Program Outcomes

PO No.	NBA Statement / Vital Features	Key Components	No. of Key Components
PO1	Independently carry out research /investigation and development work to solve practical problems	1. Research problems in structural engineering are clearly identified and defined. 2. Literature review highlights research gaps and suitable methods. 3. Experiments or simulations are conducted using appropriate tools. 4. Data is collection, analyses, and interpretation systematically. 5. Innovative approaches are applied to engineering problem-solving. 6. Results are validated against established theories and standards	**6**
PO 2.	Write and present a substantial technical report/document	1. Technical reports, dissertations, and papers are well-structured. 2. Referencing and academic integrity practices are properly maintained. 3. Content is presented with clarity, precision, and logical flow. 4. Oral communication and presentation skills are effectively demonstrated. 5. Digital tools are used for documentation and visualization. 6. Research findings are communicated to both technical and non-technical audiences.	**6**
PO 3.	Demonstrate a degree of mastery over the area in Electronics and Communication Engineering	1. Knowledge in structural mechanics, design, and analysis is demonstrated. 2. Advanced structural methods are effectively applied. 3. Proficiency in designing RCC, steel, and composite structures is shown. 4. Software tools are used for modeling and structural design. 5. IS codes, international standards, and recent research are followed. 6. Theoretical knowledge is applied to real-world structural challenges.	**6**

PO 4.	Impart core and interdisciplinary knowledge for analyzing and solving complex problems in structural engineering and related domains.	1. Core knowledge in structural engineering is effectively applied. 2. Interdisciplinary concepts are integrated into problem-solving. 3. Modern computational tools are utilized for analysis. 4. Complex engineering systems are critically evaluated.	**4**
PO 5.	Conceptualize and design safe, efficient, and sustainable civil engineering structures in social, economic, and environmental factors.	1. Structural designs are safe, durable, and code-compliant. 2. Sustainability principles are integrated into material selection and construction. 3. Economic feasibility and cost-benefit aspects are considered. 4. Structural designs address disaster resilience and risk reduction. 5. Social, ethical, and environmental implications are incorporated in solutions. 6. Innovative structural systems are developed for future challenges.	**6**
PO 6.	Engage in lifelong learning through continuous education, research, and professional development.	1. Professional certifications, MOOCs, and higher studies are actively pursued. 2. Emerging technologies and global trends are regularly updated. 3. Seminars, workshops, and professional societies are actively participated in. 4. Contributions to technical literature are made through publications and patents. 5. Knowledge exchange with peers and professionals is continuously maintained. 6. Adaptability to technological and industrial changes is demonstrated. 7. Self-learning, critical thinking, and reflective practices are adopted. 8. Commitment to lifelong personal and professional growth is shown.	**8**

6.4 Program Outcomes Attained through course modules:

Courses offered in Embedded Systems Curriculum (MLRS-R24) and POs attained through course modules for I, II, III and IV semesters.

Table 7: CO-PO articulation Matrix for M.Tech Embedded Systems

(MLRS R 24) regulation

S. No	SUBJECT	Course Code	Program Outcomes					
			1	2	3	4	5	6
1	Digital System Design with FPGAs	2415503	√	√	√	√	√	√
2	System Design with Embedded Linux	2415504	√	√	√	√	√	√
3	CMOS VLSI Design	2415507	√	√	√	√	√	√
4	Pattern Recognition and Machine Learning	2415508	√	√	√	√	√	√
5	Wireless Sensor Networks	2415509	√	√	√	√	√	√
6	Communication Buses and Interfaces	2415510	√	√	√	√	√	√
7	Advanced Computer Architecture	2415511	√	√	√	√	√	√
8	CMOS Analog IC Design	2415512	√	√	√	√	√	√
9	Digital System Design with FPGAs Lab	2415521	√	√	√	√	√	√
10	System Design with Embedded Linux Lab	2415522	√	√	√	√	√	√
11	Research Methodology & IPR	2415502	√	√	√	√	√	√
12	English for Research Paper Writing	2410001	√	√				√
13	ARM Microcontrollers	2425505	√	√	√	√	√	√
14	Digital Control Systems	2425506	√	√	√	√	√	√
15	IoT Architectures and System Design	2425513	√	√	√	√	√	√
16	Design For Testability	2425514	√	√	√	√	√	√
17	SOC Design	2425515	√	√	√	√	√	√
18	Hardware and Software Co-Design	2425516	√	√	√	√	√	√
19	Secure Networks	2425517	√	√	√	√	√	√
20	Physical Design Automation	2425518	√	√	√	√	√	√
21	ARM Microcontrollers Lab	2425523	√	√	√	√	√	√
22	Digital Control Systems Lab	2425524	√	√	√	√	√	√
23	Mini Project with Seminar	2425525	√	√	√	√	√	√
24	Pedagogy Studies	2420006		√			√	√
25	Embedded Networks	2435519	√	√	√	√	√	√
26	CMOS Mixed Signal Design	2435520	√	√	√	√	√	√
27	Human Machine Interface	2435521	√	√	√	√	√	√
28	Fault Tolerance Systems	2435846	√	√	√	√	√	√
29	Dissertation Work Review -I	2435526	√	√	√	√	√	√
30	Dissertation Work Review-II	2445527	√	√	√	√	√	√
31	Dissertation Viva - Voce	2445528	√	√	√	√	√	√

Methods for measuring Learning Outcomes and Value Addition

7. Methods for measuring Learning Outcomes and Value Addition

There are many different ways to assess student learning. In this section, we present the different type of assessment approaches available and the different frameworks to interpret the results.

I. Continuous Internal Assessment (CIA).
II. Semester end examination(SEE)
III. Laboratory and project work
IV. Course End survey
V. Program exit survey
VI. Alumni survey
VII. Employer survey
VIII. Program Assessment and Quality Improvement Committee (PAQIC)
IX. Department Advisory Board (DAB)
X. Faculty meetings
XI. Professional Societies
XII. CO-Assessment processes and tools
XIII. Direct Assessment

The some of above assessment indicators are detailed below.

7.1 Continuous Internal Assessment (CIA)

Two Continuous Internal Assessment (CIAs) are conducted for all courses by the department. All students must participate in this evaluation process. These evaluations are critically reviewed by HOD and senior faculty and the essence is communicated to the faculty concerned to analyze, improve and practice so as to improve the performance of the student.

7.2 Semester End Examination (SEE)

The semester end examination is conducted for all the courses in the department. Before the Semester end examinations course reviews are conducted, feedback taken from students and remedial measures will be taken up such that the student gets benefited before going for end exams. The positive and negative comments made by the students about the course are recorded and submitted to the departmental academic council and to the principal for taking necessary actions to better the course for subsequent semesters.

7.3 Comprehensive Assessment Tool (CAT)

The Comprehensive Assessment Tool (CAT) is a flexible, outcome-driven evaluation mechanism that enhances faculty autonomy by enabling the design of innovative and diverse pedagogical practices beyond conventional examinations. It encompasses a broad range of activities including certifications from open coding platforms, Tech Talks, term papers, MOOCs, open-ended experiments, concept videos, hackathons, and language proficiency tests. Through the CAT, the classroom is transformed into an effective learning centre where assessment is continuous, comprehensive, and aligned with defined Course Outcomes (COs) and Program Outcomes (POs). This tool fosters holistic student development by integrating technical proficiency, critical thinking, and professional communication into a unified and measurable assessment framework.

7.4 Laboratory and Project Works

The laboratory work is continuously monitored and assessed to suit the present demands of the industry. Students are advised and guided to do project works giving solutions to research/industrial problems to the extent possible by the capabilities and limitations of the student. The results of the assessment of the individual projects and laboratory work can easily be conflated in order to provide the students with periodic reviews of the overall progress and to produce terminal marks and grading.

7.5 Course End Surveys

Students are encouraged to fill-out a brief survey on the fulfillment of course objectives. The data is reviewed by the concerned course faculty and the results are kept open forth entire faculty. Based on this, alterations or changes to the course objectives are undertaken by thorough discussions in faculty and meetings.

7.6 Programme Exit Survey

The Program Exit Questionnaire is to be completed by all students leaving the institution. The questionnaire is designed to gather information from students regarding program educational objectives, overall program experiences, career choices, and any suggestions or comments for program improvement. The opinions expressed in the exit interview forms are reviewed by the Department Advisory Committee (DAC) for potential implementation.

7.7 Alumni Survey

The survey gathers insights from former students of the department regarding their employment status, further education, perceptions of institutional emphasis, estimated gains in knowledge and skills, undergraduate involvement, and continued engagement with Marri Laxman Reddy Institute of Technology and Management. This survey is conducted every three years, and the collected data is analyzed for continuous improvement.

7.8 Employer Survey

The main purpose of this employer questionnaire is to know employers' views about the skills they require of employees compared to the skills actually possessed by them. The purpose is also to identify gaps in technical and vocational skills, determine the need for required training practices to fill these gaps, and establish criteria for hiring new employees. These employer surveys are reviewed by the College Academic Council (CAC) to modify the present curriculum to suit the requirements of the employer.

7.9 Program Assessment and Quality Improvement Committee (PAQIC)

The course expert team is responsible in exercising the central domain of expertise in developing and renewing the curriculum and assessing its quality and effectiveness to the highest of professional standards. Inform the Academic Committee the 'day-to-day' matters as are relevant to the offered courses. This committee will consider the student and staff feedback on the efficient and effective development of the relevant courses. The committee also review the course full stack content developed by the respective course coordinator.

7.10 Department Advisory Board

The Departmental Advisory Board (DAB) plays an important role in the development of the department. The department-level Advisory Board is established to provide guidance and direction for the qualitative growth of the department. The board interacts and maintains liaison with key stakeholders.

The DAB will monitor the progress of the program and develop or recommend new or revised goals and objectives for the program. Additionally, the DAB will review and analyse the gaps between the curriculum and industry requirements, providing necessary feedback or advice to improve the curriculum

7.11 Faculty Meetings

The DAC meets bi-annually for every academic year to review the strategic planning and modification of PEOs. Faculty meetings are conducted atleast once in fortnight for ensuring the implementation of DAC's suggestions and guidelines. All these proceedings are recorded and kept for the availability of all faculties.

7.12 Professional Societies

The importance of professional societies such as the Institute of Electrical and Electronics Engineers (IEEE) and the Institution of Electronics and Telecommunication Engineers (IETE) is explained to students, and they are encouraged to participate in the IEEE Student Branch and IETE Student Forum for continuous professional development. Institutional technical groups such as the Team VLSI Club and the Robotics and Automation Club provide platforms for students to work on projects, workshops, and technical competitions. These societies help create a strong technical environment and promote innovation, research, and professional growth among students.

7.13 CO-Assessment processes and tools

Course outcomes are evaluated based on two approaches namely direct and indirect assessment methods. The direct assessment methods are based on the Continuous Internal

Assessment (CIA) and Semester End Examination (SEE) whereas the indirect assessment methods are based on the course end survey and program exit survey provided by the students, Alumni and Employer.

The weightage in CO attainment of Direct and Indirect assessments are illustrated in Table.

Table 8: CO-PO Mapping

Assessment Method	Assessment Tool	Weightage in CO attainment
Direct Assessment	Continuous Internal Assessment (CIA)	80%
	Semester End Examination	
Indirect Assessment	Course End Survey	20%

7.14 Direct Assessment

Direct assessment methods are based on the student's knowledge and performance in various assessments and examinations. These assessment methods provide evidence that a student has command over a specific course, content, or skill. Additionally, they demonstrate that the student's work exhibits specific qualities such as creativity, analysis, or synthesis.

The various direct assessment tools used to assess the impact of the delivery of course content is listed in the table.

- Continues internal examination, semester end examinations, Assignment and Viva-voce/Tutorial/Case study/Application/Poster presentation (are used for CO calculationThe attainment values are calculated for individual courses and are formulated and summed for assessing the POs.
- Performance in Assignment is indicative of the student's communication skills.
- Viva-voce/PPT/Poster Presentation/Case study reflects the student's **knowledge, skills, application, and understanding** of the course.

Table 9: Tools used in direct assessment methods

S No	Courses	Components	Frequency	Max. Marks	Evidence
1	Core / Elective	Continuous Internal Evaluation (CIE)	Twice in a semester	20	Answer script
		Assignment	Twice in a semester	10	Assignment script
		Viva-voce/PPT/Poster Presentation/Case study	Once in a semester	10	PPT
		Semester End Examination	Once in a semester	60	Answer script
2	Laboratory	Day to day evaluation	Once in a week	10	Observation and record
		Viva-voce/Tutorial/Case study/Application/Poster	Twice in a semester	10	Work sheets

S No	Courses	Components	Frequency	Max. Marks	Evidence
		presentation			
		Laboratory Project Which consists of Design/ software/ hardware Model presentation/ App development/ Prototype presentation	Once in a semester	10	Presentation
		Internal practical examination	Twice in a semester	10	Answer script
		Semester End Examination	Once in a semester	60	Answer script
3	Mini Project with Seminar	Presentation Semester End Examination	Twice in a semester Once in a semester	100	Seminar report
4	Dissertation Review -I	Internal evaluation	Twice in a semester	100	Presentation
5	Dissertation Review-II	Internal evaluation	Twice in a semester	100	Dissertation report
6	Dissertation Viva Voce	Dissertation Evaluation (Viva-Voce) Examination	Once in a Semester	100	Dissertation report

7.15 Indirect Assessment

Course End Survey- In this survey, questionnaires are prepared based on the level of understanding of the course and the questions are mapped to Course Outcomes. The tools and processes used in indirect assessment are shown in Table 10.

Table 10: Tools used in indirect assessment

Tools	Process	Frequency
Course end survey	• Taken for every course at the end of the semester • Gives an overall view that helps to assess the extent of coverage/compliance of COs • Helps the faculty to improve upon the various teaching methodologies	Once in a semester

Direct Tools: (Measurable in terms of marks and w.r.t.CO) Assessment done by faculty at department level.

Indirect Tools: (Non measurable (surveys) in terms of marks and w.r.t. CO) Assessment done at institute level.

7.16 PO Assessment tools and Processes

The institute has the following methods for assessing the attainment of POs.

1. Direct method
2. Indirect method

The attainment levels of course outcomes help in computing the PO based upon the mapping done.

Table11: Attainment of PO

	Assessment	Tools	Weight
POs Attainment	Direct Assessment	CO attainment of courses	80%
	Indirect Assessment	Program exit survey	20%
		Alumni survey	
		Employer survey	

The CO values of both theory and laboratory courses, with appropriate weightage as per CO-PO mapping, as per the Program Articulation Matrix, are considered for the calculation of direct attainment of PO.

7.17 PO Direct Attainment is calculated using the rubric

PO Direct Attainment = (Strength of CO-PO) * CO attainment / Sum of CO-PO strength.

The below figure represents the evaluation process of POs/PSOs attainment through course outcome attainment.

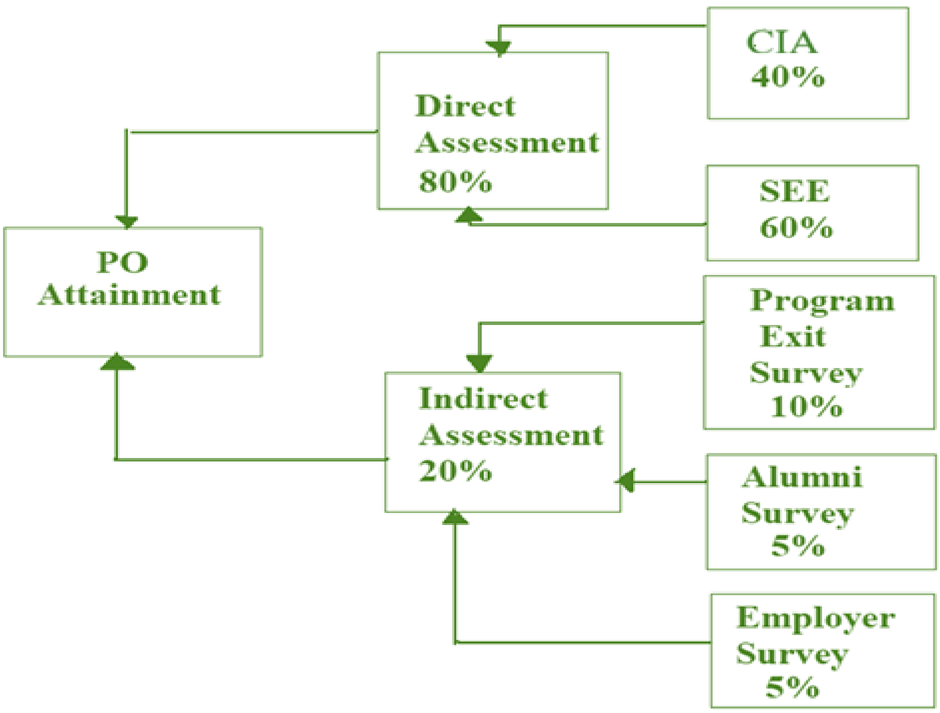


Figure 3: Evaluation process of POs attainment

Course Description

8 Course Description:

The “Course Description” provides general information regarding the topics and content addressed in the course. A sample course description is given in Annexure – A for reference.

The “Course Description” contains the following contents:

- Course Overview
- Prerequisite(s)
- Marks Distribution
- Content Delivery / Instructional Methodologies
- Evaluation Methodology
- Course Objectives
- Course Outcomes
- Program Outcomes
- Program Specific Outcomes
- How Program Outcomes are Assessed
- Mapping of each CO with PO(s)
- Justification for CO–PO Mapping - Direct
- Total Count of Key Competencies for CO–PO Mapping
- Percentage of Key Competencies for CO–PO
- Course Articulation Matrix (PO Mapping)
- Assessment Methodology - Direct
- Assessment Methodology - Indirect
- Syllabus
- List of Textbooks / References / Websites

IOT ARCHITECTURES AND SYSTEM DESIGN

1	**Department**	ELECTRONICS AND COMMUNICATIONS ENGINEERING
2	**Course Name**	IOT ARCHITECTURES AND SYSTEM DESIGN
3	**Course Code**	2425513
4	**Year/Semester**	I/I
5	**Regulation**	MLRS-R24
6	**Course Offered**	Even Semester
7	**Course Coordinator**	Dr. Rupa Kumar Dhanavath
8	**Date Approved by BOS**	3-10-2023
9	**Course Webpage**	www.mlritm.ac.in/

10.Structure of the Course

Theory		**Practical**	**Project**	
Lecture	Tutorials	Practical	Mini project	Major Project
3	-	-	-	-

11. Credits of the Course

Theory		**Practical**	**Project**	
Lecture	Tutorials	Practical	Mini project	Major Project
3	-	-	-	-

Total Credits: 3

12. Type of the Course

PC	PE	AC	MPS	PS
-	√	-	-	-

13. Total Hours Offered

Lectures	Tutorials	Practicals
48	-	-

14. Prerequisites/ Co-requisites

Level	Course Code	Semester	Prerequisites
-	-	-	-

15. Course Overview

This course introduces the fundamentals of the Internet of Things (IoT), its evolution, and integration with web technologies. Students explore the current IoT landscape, its vision, and strategic research directions, including networks, data management, and device-level energy issues. The course highlights the transition from Machine-to-Machine (M2M) communication to IoT, examining value chains, architectures, and international standards shaping this field. Learners analyze how IoT enables value creation across industries through applications in manufacturing, retail, oil and gas, home automation, and eHealth. Special emphasis is placed on big data, smart objects, and business value generation. Students also investigate the privacy, security, and governance challenges of IoT ecosystems and smart cities. The course draws on global initiatives and research recommendations to highlight emerging trends and innovations. By combining theoretical knowledge with real-world examples, it equips learners to design and evaluate IoT systems. Overall, it builds a strong foundation for understanding, implementing, and managing IoT technologies and applications.

16. Course Objectives

The students will try to learn:

1	The fundamentals, evolution, growth, and characteristics of IoT along with its enabling technologies and sensing/actuation mechanisms.
2	The transition from M2M to IoT, and compare their value chains, industrial structures, and global information systems.
3	Programming skills in Arduino and Raspberry Pi to integrate sensors, actuators, and peripherals for IoT applications.
4	Different IoT architectures and data management stacks to identify their suitability for varied IoT applications.
5	The IoT-based system designs addressing real-world challenges in agriculture, healthcare, smart cities, and logistics.

17. Course Outcomes and Cognitive Levels

After successful completion of the course, students should be able to:

CO1
- Explain the fundamentals, evolution, characteristics, and enabling technologies of IoT.

CO2
- Differentiate between IoT and M2M concepts for value chains in the global industrial context.

CO3
- Develop simple IoT applications using Arduino and Raspberry Pi by integrating sensors and actuators.

CO4
- Examine different IoT architectures and evaluate the core functional and data management stacks.

CO5
- Design IoT-based solutions for agriculture, healthcare, smart cities, and transportation

Cognitive Levels of Blooms Taxonomy Level

Blooms Taxonomy Level	Cognitive Level in Percentage (%)
Remember	0
Understand	40
Apply	20
Analyse	20
Evaluate	20
Create	0

18. Employability Skills

Skill Category	Description	Relevance to Course
Problem-Solving Skills	Develops ability to identify IoT challenges and propose efficient solutions.	Designing IoT solutions for domains like healthcare, agriculture, and smart cities.
Analytical Thinking	Encourages logical decomposition of IoT systems and evaluation of architectures.	Comparing IoT vs. M2M, analyzing IoT architectures, and assessing global IoT value chains.
Software & Hardware Integration	Enhances proficiency in programming, sensor interfacing, and embedded system design.	Implementing IoT applications using Arduino, Raspberry Pi, Python, sensors, and actuators.
Collaboration & Teamwork	Fosters teamwork in developing, debugging, and deploying IoT solutions.	Participation in group projects and labs on IoT system design and prototype development.
Adaptability & Continuous Learning	Prepares students to adopt new IoT frameworks, platforms, and technologies.	Staying updated with IoT standards, protocols, and emerging pillars (e.g., SDN, NFV, smart cities).
System Design Thinking	Develops end-to-end solution design skills by considering scalability, interoperability, and sustainability.	Creating IoT solutions for transportation, logistics, and industrial applications.

20. Complex Engineering Problems

Design a smart IoT-based water distribution system for a large urban area facing significant water loss due to leakages, illegal connections, and inefficient monitoring. The system must integrate multiple sensor nodes equipped with flow, pressure, and water quality sensors deployed across pipelines. Each node should operate on low power using battery and solar energy, requiring efficient energy management strategies. Data collected must be transmitted using a reliable communication protocol such as LoRaWAN or NB-IoT under conditions of intermittent connectivity. A gateway layer should preprocess data to reduce latency and bandwidth before sending it to the cloud. The cloud platform must store large-scale time-series data and support real-time analytics. Machine learning algorithms should be implemented to detect anomalies indicating leaks or bursts in pipelines. The system should also forecast water demand based on historical usage patterns. Remote control of valves must be enabled for quick response to detected issues. Security mechanisms are required to prevent unauthorized access and data tampering. The architecture must be scalable to support thousands of devices across the city. Finally, the system should provide a user-friendly dashboard for monitoring, alerts, and decision-making by municipal authorities.

19. Content Delivery / Instructional Methodologies

PowerPoint Presentation	√	**Chalk& Talk**	√	**Assignments**	√	**MOOC**	x
Case study	x	**Seminars**	√	**Mini Project**	x	**DSS/Videos**	√

20. Evaluation Methodology

Total marks for each course shall be based on Continuous Internal Assessment (CIA) and Semester End Examinations (SEE). There shall have a uniform pattern of 40:60 for CIA and SEE of both theory and practical courses. The institute shall conduct multiple continuous internal assessments (CIA) for theory courses. All the performances of a student shall be considered for Continuous Internal Assessment (CIA) marks.

Outline for Continuous Internal Assessments (CIA-1and CIA-2) and SEE:

Table 1: **Outline for Continues Internal Assessment (CIA-1 and CIA-2) and SEE**

Activities	CIA-1	CIA-2	SEE	Total Marks
Continuous Internal Examination (CIE)	10	10		20
Assignment	5	5		10
Comprehensive Assessment Tool (CAT)	5	5		10
Semester End Examination (SEE)			60	60
Total				**100**

Continuous Internal Examination (CIE)

For theory courses, two Continuous Internal Examinations (CIE-I and CIE-II) shall be conducted in each semester as per the academic calendar. Each Continuous Internal Examination shall be evaluated for 30 marks. To finalize CIE marks these 30 marks will be scale down to 10 marks.

- The time duration of each CIE shallbe1hour and 30 minutes.
- Question paper pattern for CIE (30Marks) shall be as follows:

PART-A: 5X2M=10M

a. All questions are compulsory.

b. 02 questions from full units and one question from half unit.

PART-B: 4*5=20M

a. There shall be a total of 06 questions.

b. There shall be two questions from each UNIT with internal choice i.e., ‘either’ ‘or’ choice.

c. Student shall answer one question from each UNIT.

Assignment:

Five (5) marks are allocated for assignments. The firstassignment should be submitted before the conduct of the first mid-term examination, and the secondassignment should be submitted before the conduct of the second mid-term examination. The average of the two assignments shall betaken as the final marks for assignment (for 5 marks).

Comprehensive Assessment Tool (CAT):

The CAT may include Certificate of completion from Open Coding platforms such as Hacker rank, codechef etc., Tech talk, quiz, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), Concept video, MOOCs, Inter-institute participation in hackathons etc, Language Proficiency test .

Semester End Examination (SEE)

Part A consists of five compulsory questions, each carrying 2 marks, totaling 10 marks. There shall be one question from each unit, and all questions are mandatory. This section is intended to assess students’ basic conceptual knowledge across the entire syllabus.

Part B carries a total of 50 marks and comprises five questions, each worth 10 marks. Students are required to answer one question from each unit. There will be no choice for questions from the first and second units. From the third unit onwards, an "either–or" choice will be provided, and the student must attempt only one of the two questions. Each question in Part B shall have a maximum of two subdivisions, namely Part (a) and Part (b). Part (a) shall be a descriptive-type question carrying 5 marks, while Part (b) shall be **a critical thinking or problem-solving question,** also carrying 5 marks.

21. Course content - Number of modules: Five:

Module	Module Description	No. of Lectures
MODULE 1	IoT introduction: Introduction and definition of IoT, Evolution of IoT, IoT growth, Application areas of IoT, Characteristics of IoT, IoT stack, enabling technologies, IoT levels, IoT sensing and actuation, Sensing types, Actuator types.	No. of theory classes: 10
MODULE 2	IoT and M2M: M2M to IoT – A Basic Perspective– Introduction, Differences and similarities between M2M and IoT, SDN and NFV for IoT.M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT, The international driven global value chain and global information monopolies.	No. of theory classes: 10
MODULE 3	IoT Hands-on: Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino. Introduction to Python programming, Introduction to Raspberry Pi, Interfacing Raspberry Pi with basic peripherals, Implementation of IoT with Raspberry Pi.	No. of theory classes: 11
MODULE 4	IoT Architecture: IoT Architecture components, Comparing IoT architectures, A simplified IoT architecture, The core IoT functional stack, IoT data management and compute stack	No. of theory classes: 8
MODULE 5	IoT System design: Challenges associated with IoT, Emerging pillors of IoT, Agricultural IoT, Vehicular IoT, Healthcare IoT, Smart cities, Transportation and logistics.	No. of theory classes: 9

REFERENCE BOOKS

1. Sudip Misra, Anandarup Mukherjee, Arijit Roy "Introduction to IOT", Cambridge University Press.
2. David Hanes, Gonzalo salgueiro, Patrick Grossetete, Rob barton, Jerome henry "IoT Fundamentals Networking technologies, protocols, and use cases for IoT", Cisco Press
3. Cuno pfister, "Getting started with the internet of things", O Reilly Media, 2011
4. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1 st Edition, Apress Publications.
5. "Internet of Things concepts and applications", Wiley
6. Arshdeep Bahga,Vijay Madisetti "Internet of Things A Hands on approach", Universities Press
7. 5.Shriram K Vasudevan, RMD Sundaram, Abhishek S Nagarajan, "Internet of things" John Wiley and Sons. Massimo Banzi, Michael Shiloh Make: Getting Started with the Arduino, Shroff Publisher/Maker Media Publishers.

ELECTRONIC RESOURCES

Resource Type	Title/ Description	Link
Online Courses	Swayam: Introduction to Internet of Things by Prof. Sudip Misra | IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc25_cs147/preview
	Swayam: Introduction to Industry 4.0 and Industrial Internet of Things by Prof. Sudip Misra | IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc25_cs146/preview
You Tube DSS Lectures-MLRITM	Internet of Things by Mr. Rupa Kumar Dhanavath	https://www.youtube.com/watch?v=W7-QVUqMJHQ&t=848s https://www.youtube.com/watch?v=TS3c2YpcdAk https://www.youtube.com/watch?v=LuAZMacZetc

22. COURSE PLAN

S. No.	Topics to be covered	COs	Reference
1	Introduction and definition of IoT	CO 1	R4:1.1
2	Evolution of IoT	CO 1	R4:1.1
3	IoT growth	CO 1	R4:1.1
4	Application areas of IoT	CO 1	R4:1.1
5	Characteristics of IoT	CO 1	R4:1.1
6	IoT stack	CO 1	R4:1.2
7	Enabling technologies	CO 1	R4:1.4
8	IoT levels	CO 1	R4:1.5
9	IoT sensing and actuation	CO 1	R6:2.1
10	Sensing types and Actuator types (**Active Learning - 1 Flipped Class Room)**	CO1	-
11	M2M to IoT – A Basic Perspective– Introduction	CO 2	R4:3.1
12	Differences and similarities between M2M and IoT	CO 2	R4:3.3
13	SDN and NFV for IoT	CO 2	R4:3.4
14	M2M Value Chains	CO 2	R4:3.4.1
15	IoT Value Chains	CO 2	R4:4.3.2
16	An emerging industrial structure for IoT	CO 2	R4:7.1
17	The international driven global value chain	CO 2	R4:7.2
18	Global information monopolies	CO 2	R4:7.3
19	Case discussions on IoT vs. M2M (**Active Learning - 2 Collaborative Learning)**	CO 2	-
20	Summary and review of IoT-M2M	CO 2	R4:7
21	Introduction to Arduino Programming	CO 3	R2:4.1

22	Integration of Sensors with Arduino	CO 3	R2:4.1
23	Integration of Actuators with Arduino	CO 3	R2:4.2
24	Introduction to Python programming for IoT	CO 3	R2:4.3
25	Introduction to Raspberry Pi	CO 3	R2:4.4
26	Interfacing Raspberry Pi with Sensors	CO 3	R2:4.4
27	Interfacing Raspberry Pi with Actuators	CO 3	R2:4.4
28	Interfacing Raspberry Pi with other peripherals	CO 3	R2:4.5
29	Implementation of IoT with Raspberry Pi – Part I	CO 3	R2:4.6
30	Implementation of IoT with Raspberry Pi – Part II	CO 3	R2:4.6
31	Hands-on project discussion (**Active Learning -3: Muddiest Point)**	CO 3	-s
32	IoT Architecture components	CO 4	R3:5.1
33	Comparing IoT architectures	CO 4	R3:5.2
34	A simplified IoT architecture	CO 4	R3:5.2
35	The core IoT functional stack	CO 4	R3:5.3
36	IoT data management stack	CO 4	R3:5.4
37	IoT compute stack	CO 4	R3:5.4
38	Case study on IoT architecture	CO 4	R3:5.5
39	Summary of IoT architectures ((**Active Learning - 4 Think Pair Share))**	CO 4	R3:5.6
40	Challenges associated with IoT	CO 5	R3:5.7
41	Emerging pillars of IoT	CO 5	R3:5.8
42	Agricultural IoT	CO 5	R3:5.9
43	Vehicular IoT	CO 5	R3:5.9
44	Healthcare IoT	CO 5	R3:5.9
45	Smart cities	CO 5	R3:5.10
46	Transportation IoT	CO 5	R3:5.11
47	Logistics IoT	CO 5	R3:5.11
48	Summary and case studies of IoT applications (**Active Learning - 5 Stump Your Partner)**	CO 5	R3:5.11

23. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

PO NO	NBA Statement / Vital Features		
	Graduate Attributes	**Program Outcomes**	**No. of key competencies**
PO1	Research / Investigation	An ability to independently carry out research /investigation and development work to solve practical problems	6
PO2	Report Preparation	An ability to write and present a substantial technical report/document	6
PO3	Domain Mastery (Embedded Systems)	Students should be able to demonstrate a degree of mastery in Embedded Systems	7

PO4	Application of Engineering Principles	Acquire and apply engineering principles to design embedded systems and processes that address complex real-world problems.	7
PO5	Modern Tools & Societal Impact	Use modern tools to conduct experiments, apply technical skills, and develop solutions for societal challenges and sustainable development.	6
PO6	Lifelong Learning & Adaptability	Recognize the value of lifelong learning and proactively engage in ongoing professional development by embracing and integrating emerging technologies.	7

24. HOW PROGRAM OUTCOMES ARE ASSESSED

PO No.	NBA Statement / Vital Features			
	Graduate Attributes	**Program Outcomes**	**Strength**	**Proficiency Assessed by**
PO1	Research / Investigation	An ability to independently carry out research /investigation and development work to solve practical problems	1	CIE/PPT/ SEE/ Objective /quiz/ Assignments
PO2	Report Preparation	An ability to write and present a substantial technical report/document	1	CIE/ Quiz/ SEE/ Assignments/ Tech-Talk/ Viva-Voce/ Internship Report
PO3	Domain Mastery (Embedded Systems)	Students should be able to demonstrate a degree of mastery in Embedded Systems	3	CIE/ Quiz/ SEE/ Assignments/ Tech-Talk/ Viva-Voce/ Internship Report
PO4	Application of Engineering Principles	Acquire and apply engineering principles to design embedded systems and processes that address complex real-world problems.	2	CIE/ Quiz/ SEE/ Assignments/ Tech-Talk/ Viva-Voce/ Internship Report
PO5	Modern Tools & Societal Impact	Use modern tools to conduct experiments, apply technical skills, and develop solutions for societal challenges and sustainable development.	2	CIE/ Quiz/ SEE/ Assignments/ Tech-Talk/ Viva-Voce/ Internship Report
PO6	Lifelong Learning & Adaptability	Recognize the value of lifelong learning and proactively engage in ongoing professional development by embracing and integrating emerging technologies.	3	CIE/ Quiz/ SEE/ Assignments/ Tech-Talk/ Viva-Voce/ Internship Report

3 = High; 2 = Medium; 1 = Low

25. MAPPING OF EACH CO WITH PO(s)

COs	Program Outcomes (POs)					
	1	2	3	4	5	6
CO1		√	√			√
CO2	√	√	√			√
CO3	√	√	√	√	√	√
CO4	√	√	√	√	√	√
CO5	√	√	√	√	√	√

26. JUSTIFICATIONS FOR CO – PO MAPPING - DIRECT

Course Outcomes (COs)	POs	Justification for Mapping (Students will be able to...)	No. of Key Components
CO1: Explain the fundamentals, evolution, characteristics, and enabling technologies of IoT.	PO 2	1. Content is presented with clarity, precision, and logical flow. 2. Research findings are communicated to both technical and non-technical audiences.	**2**
	PO3	1. Embedded communication protocols, concepts and design methodologies 2. System performance evaluation for efficiency, reliability, and scalability 3. Problem-solving abilities for embedded system challenges	**3**
	PO6	1. Awareness of emerging technologies in embedded systems and related domains 2. Innovation, curiosity, and proactive upskilling for long-term professional growth 3. Continuous learning and interdisciplinary integration across hardware, software, and communication technologies	**3**

CO2: Differentiate between IoT and M2M concepts for value chains in the global industrial context.	PO1	1. Experiments or simulations are conducted using appropriate tools. 2. Data collection, analysis and interpretation systematically. 3. Innovative approaches are applied to engineering problem-solving. 4. Results are validated against established theories and standards	**4**
	PO2	1. Content is presented with clarity, precision, and logical flow. 2. Research findings are communicated to both technical and non-technical audiences. 3. Referencing and academic integrity practices are properly maintained.	**3**
	PO3	1. Embedded communication protocols, concepts and design methodologies 2. System performance evaluation for efficiency, reliability, and scalability 3. Hardware–software integration expertise in embedded applications 4. Real-time constraints and scheduling in embedded system design 5. Secure, low-power and high-performance design strategies in embedded systems	**5**
	PO6	1. Awareness of emerging technologies in embedded systems and related domains	**1**
CO3: Develop simple IoT applications using Arduino and Raspberry Pi by integrating sensors and actuators	PO 1	1. Experiments or simulations are conducted using appropriate tools. 2. Innovative approaches are applied to engineering problem-solving.	**2**
	PO2	1. Digital tools are used for documentation and visualization.	**1**

	PO3	1. Hardware–software integration expertise in embedded applications 2. Advanced programming skills for microcontrollers, processors, and real-time systems 3. Problem-solving abilities for embedded system challenges 4. Embedded communication protocols, concepts and design methodologies 5. Real-time constraints and scheduling in embedded system design	**5**
	PO4	1. Hardware–software integration, fault-tolerance, and multidisciplinary approaches in embedded applications 2. Prototypes and validations of designs through simulation, testing, and real-world deployment 3. Innovative design approaches for societal and industrial needs 4. Complex embedded system problems in operations, management, and technology. 5. User needs and specifications for functional embedded solutions	**5**
	PO5	1. Contemporary tools and frameworks for design of embedded applications 2. Prototype development and testing using microcontrollers and processors 3. Limitations of tools and adaptation for realistic implementations	**3**
	PO6	1. Innovation, curiosity, and proactive upskilling for long-term professional growth	**3**

		2. Continuous learning and interdisciplinary integration across hardware, software, and communication technologies 3. Awareness of emerging technologies in embedded systems and related domains	
CO4: Examine different IoT architectures and evaluate the core functional and data management stacks.	PO1	1. Literature review highlighting research gaps and suitable methods. 2. Data collection, analysis and interpretation systematically. 3. Results are validated against established theories and standards	**3**
	PO2	1. Technical reports, dissertations, and papers are well-structured. 2. Content is presented with clarity, precision, and logical flow.	**2**
	PO3	1. System performance evaluation for efficiency, reliability, and scalability 2. Secure, low-power and high-performance design strategies in embedded systems 3. Hardware–software integration expertise in embedded applications	**3**
	PO4	1. Complex embedded system problems in operations, management, and technology. 2. Real-time constraints, scheduling, and performance optimization in embedded processes 3. User needs and specifications for functional embedded solutions 4. Prototypes and validations of designs through simulation, testing, and real-world deployment	**4**

	PO5	1. Innovative design approaches for societal and industrial needs 2. Complex embedded system problems in operations, management, and technology. 3. User needs and specifications for functional embedded solutions 4. Real-time constraints, scheduling, and performance optimization in embedded processes	**4**
	PO6	1. Awareness of emerging technologies in embedded systems and related domains 2. Innovation, curiosity, and proactive upskilling for long-term professional growth 3. Knowledge and evaluation of frameworks, programming languages, and platforms for sustainable, future-ready embedded practices 4. Continuous learning and interdisciplinary integration across hardware, software, and communication technologies	**4**
CO5: Design IoT-based solutions for agriculture, healthcare, smart cities, and transportation.	PO1	1. Awareness of emerging technologies in embedded systems and related domains 2. Research problem identification and problem statement. 3. Data collection, analysis and interpretation systematically. 4. Innovative approaches are applied to engineering problem-solving.	**4**
	PO2	1. Technical reports, dissertations, and papers are well-structured. 2. Oral communication and presentation skills are effectively demonstrated.	**3**

		3. Research findings are communicated to both technical and non-technical audiences.	
	PO3	1. Problem-solving abilities for embedded system challenges 2. Real-time constraints and scheduling in embedded system design 3. System performance evaluation for efficiency, reliability, and scalability 4. Hardware–software integration expertise in embedded applications 5. Secure, low-power and high-performance design strategies in embedded systems	**5**
	PO4	1. Innovative design approaches for societal and industrial needs 2. User needs and specifications for functional embedded solutions 3. Prototypes and validations of designs through simulation, testing, and real-world deployment 4. Complex embedded system problems in operations, management, and technology. 5. Real-time constraints, scheduling, and performance optimization in embedded processes	**5**
	PO5	1. Energy and resource efficient sustainable design practices 2. Prototype development and testing using microcontrollers and processors 3. Documentation and reporting of experimental results for societal applications	**3**
	PO6	1. Awareness of emerging technologies in embedded systems and related domains	**4**

		2. Effective communication and documentation of knowledge and technical insights 3. Innovation, curiosity, and proactive upskilling for long-term professional growth 4. Continuous learning and interdisciplinary integration across hardware, software, and communication technologies	

27. TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING

Course Outcomes (COs)	Program Outcomes					
	1	2	3	4	5	6
CO1		2	3			3
CO2	4	3	5			1
CO3	2	1	5	5	3	3
CO4	3	2	3	4	4	4
CO5	4	3	5	5	3	4

28. PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

Course Outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6
No. of Key Components	6	6	7	7	6	7
CO1		33	43			43
CO2	67	50	71			14
CO3	33	17	71	71	50	43
CO4	50	33	43	57	67	57
CO5	67	50	71	71	50	57

29. COURSE ARTICULATION MATRIX (PO MAPPING)

CO’S and PO’S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0- 0≤ C≤ 5% – No correlation, 2 - 40 % <C < 60% –Moderate
1- 5 <C≤ 40% – Low/ Slight 3 - 60% ≤ C < 100% – Substantial /High

Course Outcomes (COs)	Program Outcomes					
	1	2	3	4	5	6
CO1		1	2			2

CO2	3	2	3			1
CO3	1	1	3	3	2	2
CO4	2	1	2	2	3	2
CO5	3	2	3	3	2	2
Average	2.3	1.4	2.6	2.67	2.3	1.8

30. ASSESSMENT METHODOLOGY DIRECT

CIE Exams	✓	**SEE**	✓	**Seminars**	-
Objective / quiz	-	**Viva-Voce/PPT**	✓	**MOOCS**	-
Assignments	✓	**Project**	-		

31. ASSESSMENT METHODOLOGY INDIRECT

✓	**Course End Survey (CES)**

32. Percentage of POs-WKs Mapping

POs		WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
	No of Indicators	5	4	4	3	4	5	4	6	4
PO1	Research/ investigation	60	100	100	100	100	100	60	100	100
PO2	Report Preparation	20	25	25	33	25	20	20	25	25
PO3	Domain Mastery	60	75	100	67	100	100	60	75	100
PO4	Application of Engineering Principles	100	75	100	100	100	100	100	75	100
PO5	Design and Sustainability	60	75	100	67	100	100	60	75	100
PO6	Lifelong Learning and Professional Development	60	75	100	67	100	100	60	75	100

33. RELEVANCE TO SUSTAINABILITY GOALS

Theory of elasticity and plasticity play a significant role in advancing various SDGs.

S.NO.	SDGS	DESCRIPTION
1	NO POVERTY	
2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	Ensures safety and reliability of structures such as hospitals and community buildings by accurate stress and strain analysis, preventing structural failures that can endanger lives.
4	QUALITY EDUCATION	Strengthens quality education by developing analytical, design, and problem-solving skills essential for sustainable engineering practices.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	

9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	Develops the ability to design, analyze, and optimize safe, sustainable, and innovative infrastructure using elasticity and plasticity principles.
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	Enables the design of earthquake-resistant, resilient, and sustainable structural systems for urban and rural development.
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	
13	CLIMATE ACTION	
14	LIFE BELOW WATER	
15	LIFE ON LAND	Promotes sustainable land infrastructure by reducing the environmental footprint through optimized structural design and material selection.
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	
17	PARTNERSHIPS FOR THE GOALS	Encourages interdisciplinary research collaborations and industry partnerships for solving real-world structural and material challenges.

Signature of Course Coordinator **HOD**