OBE MANUAL

M.Tech Embedded Systems

MLRS R 20 Regulation

MARRI LAXMAN REDDY INSTITUTE OF TECHNOLOGY AND MANAGEMENT

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.

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.

The National Board of Accreditation (NBA) is the authorized body responsible for accrediting technical programmes in India. NBA accreditation is programme-specific and not institution-specific. As a full signatory of the Washington Accord, the NBA ensures that accredited engineering programmes meet international quality standards based on outcomes and graduate attributes.

NBA classifies Higher Education Institutions into:

- **Tier–1:** IITs, NITs, Central Universities, State Universities, and Autonomous Institutions. Tier-1 institutions benefit fully from Washington Accord recognition.
- **Tier–2:** Affiliated colleges offering professional programmes.

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.

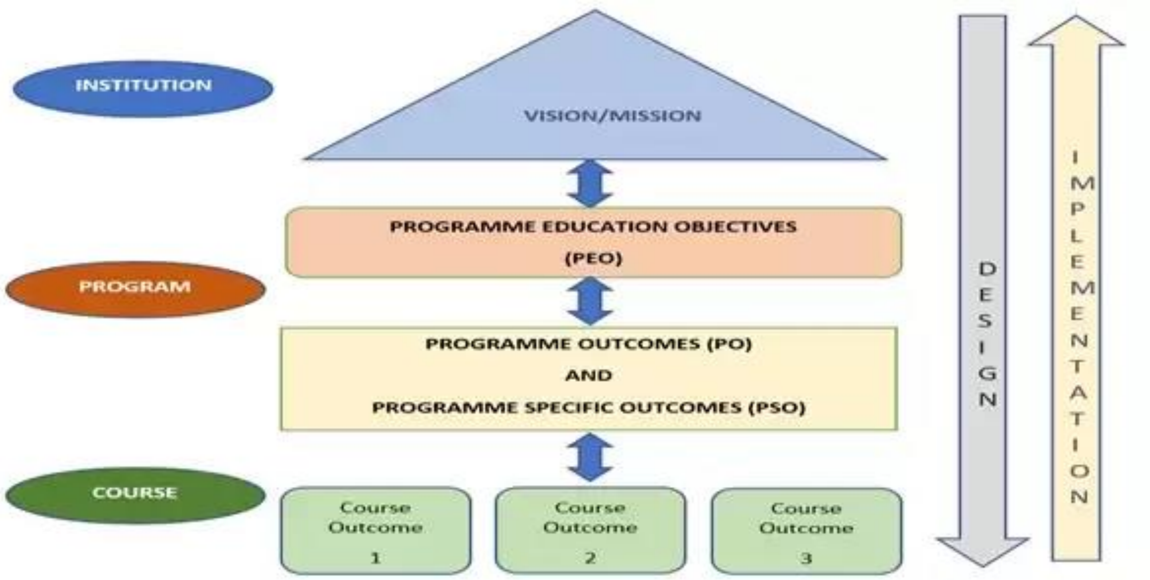

Figure 1: OBE process

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 and enhances global employment opportunities.
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.

Benefits of Outcome-Based Education

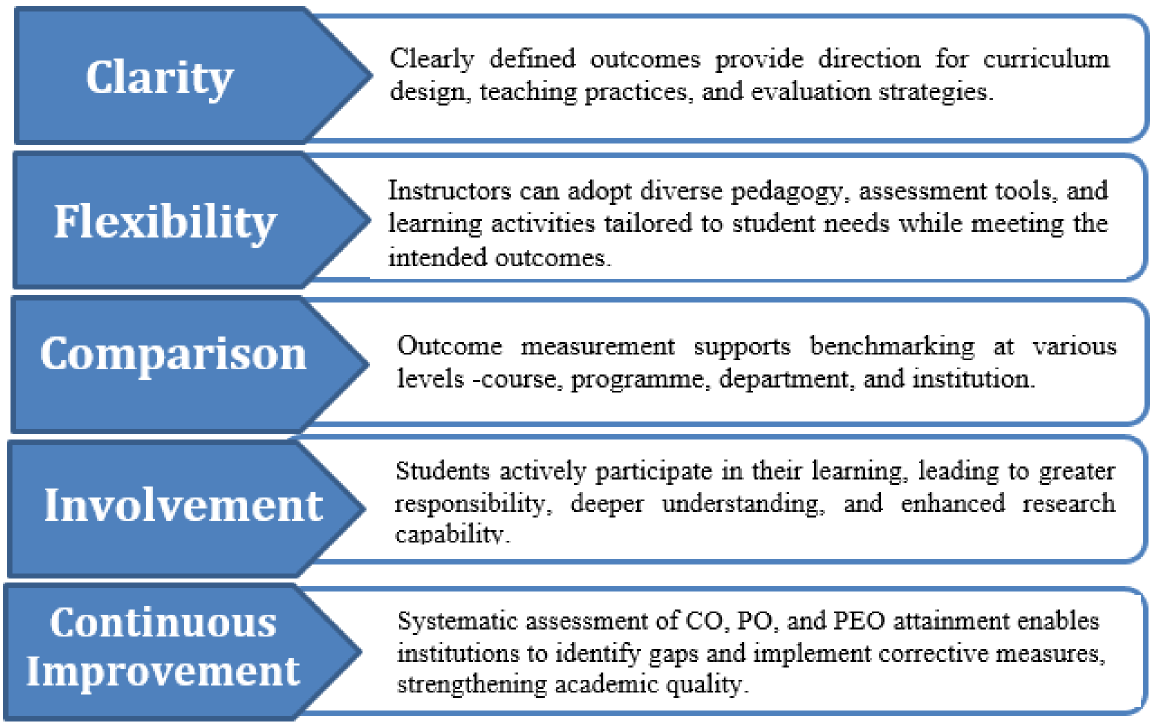

Figure 2: Benefits of Outcome Based Education

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

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.

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) and Program Specific Outcomes (PSOs)
POs represent the graduate attributes as defined by the NBA, while PSOs 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. Activities like tutorials, practical sessions, seminars, projects, and assignments are designed to enhance self-learning and practical understanding.
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 and PSO 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 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: To cultivate strong industry partnerships, and engaging actively with the community for societal and technological progress.

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

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**.**

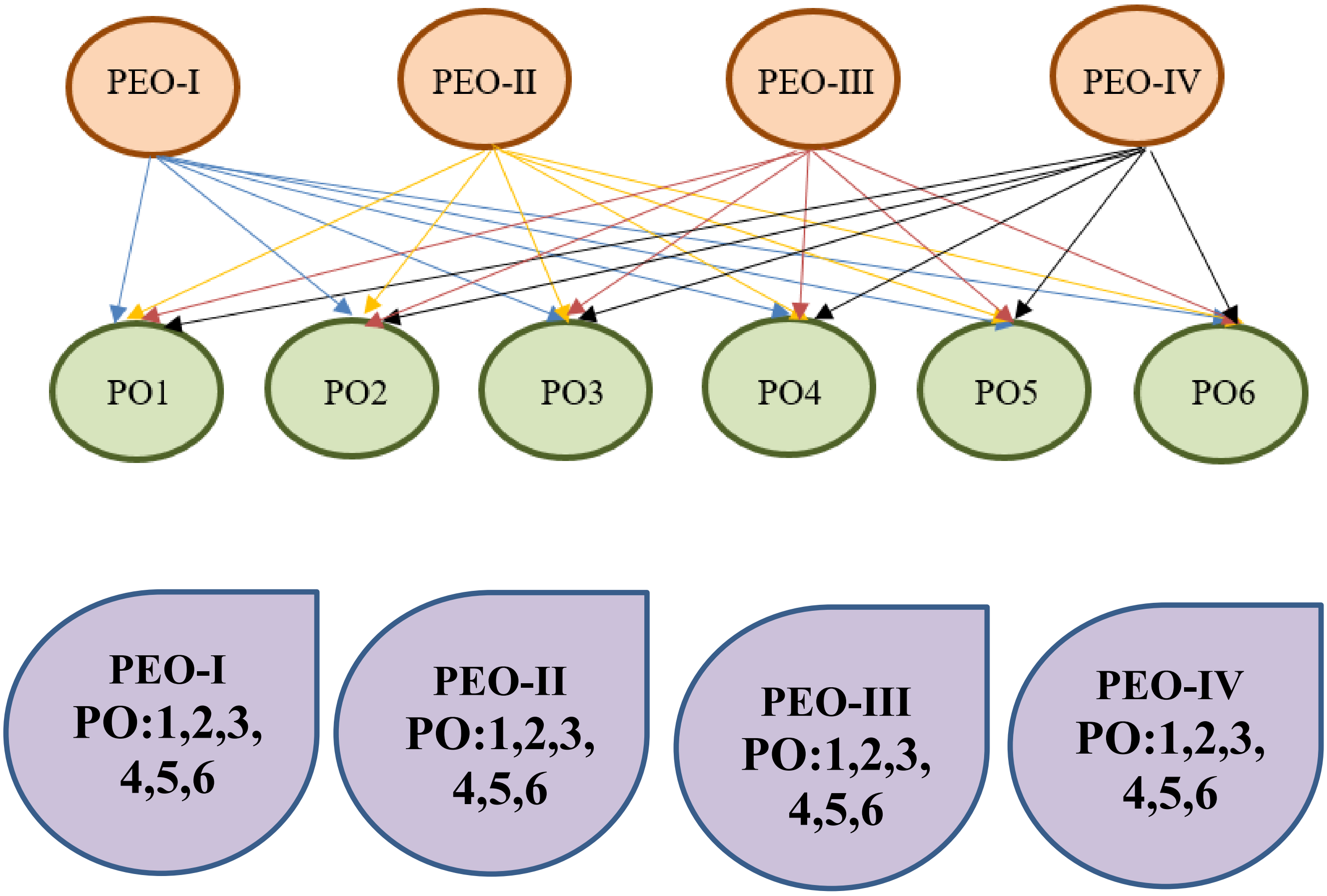

Figure 4: Correlation between the PEOs and the POs

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.

Blooms Taxonomy

4.1 What is Bloom's Taxonomy?

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.

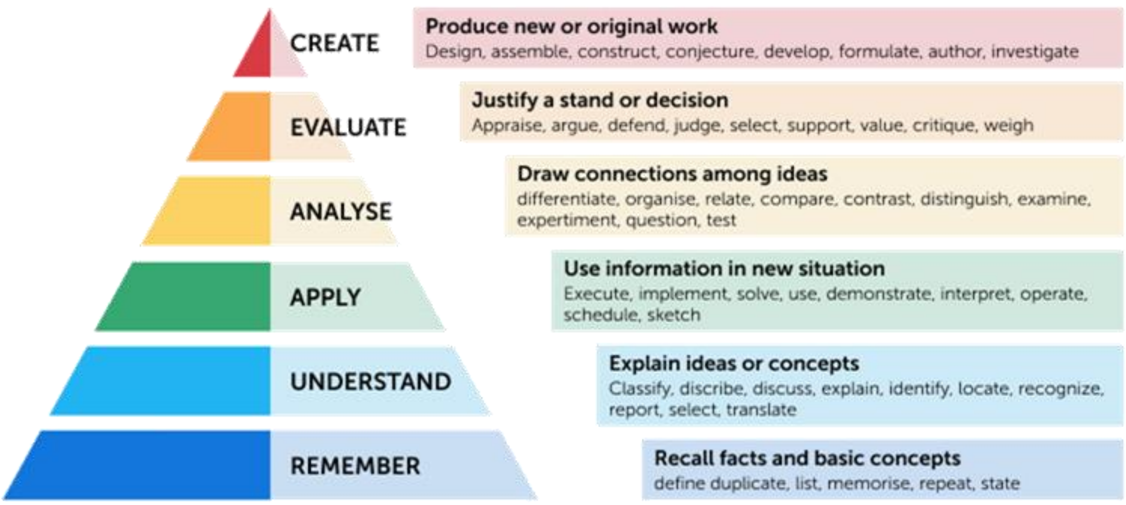

Figure 5: Blooms Taxonomy

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.

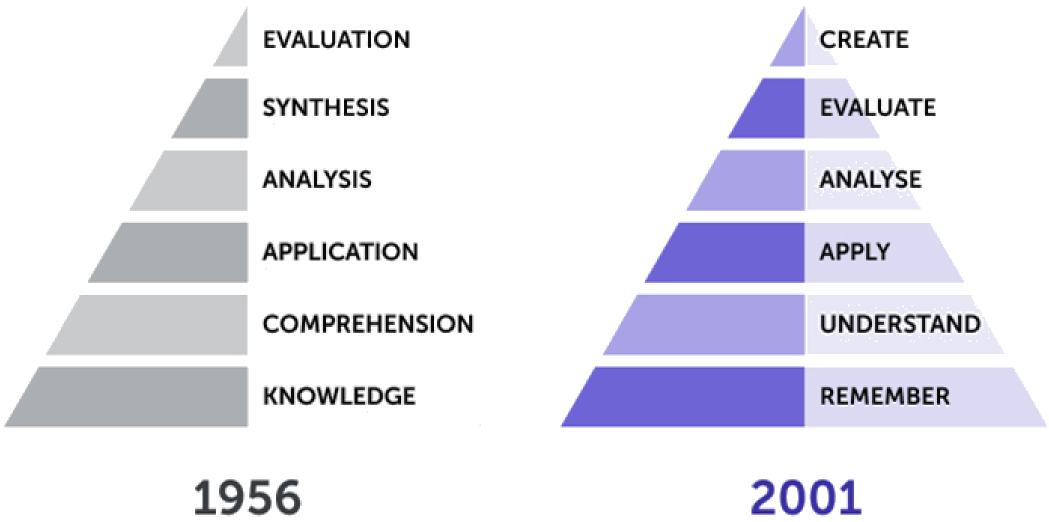

Figure 6: Blooms Taxonomy (Original and Revised)

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.

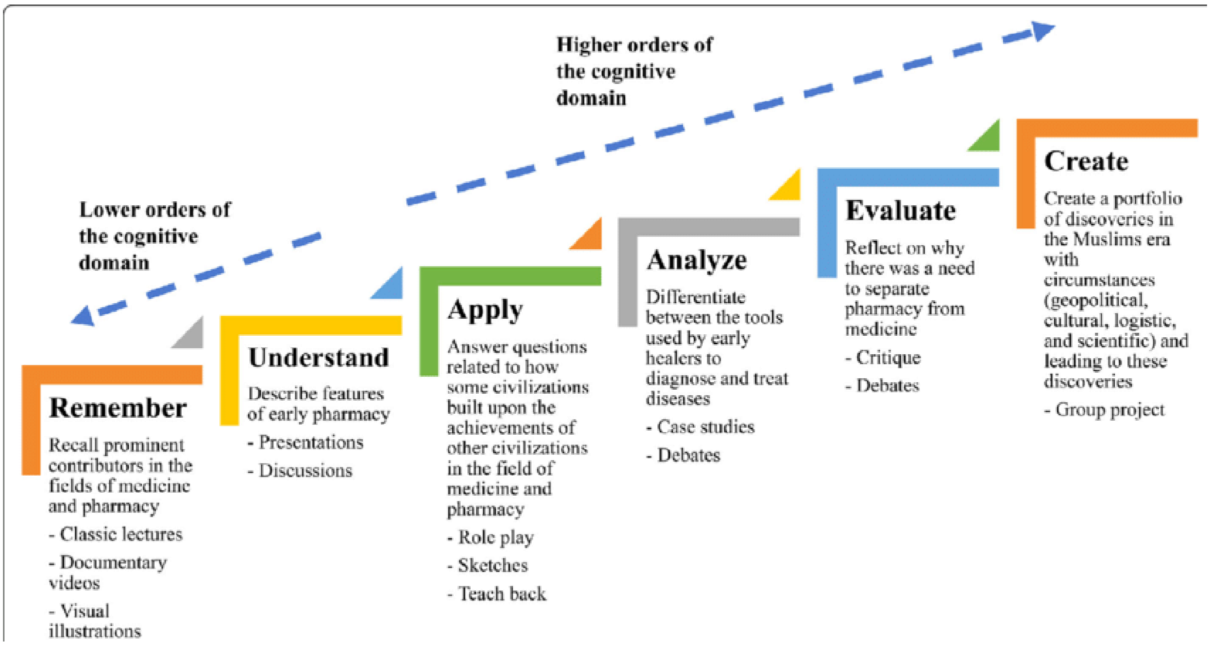

Figure 7: The cognitive process dimensions – categories

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

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
2. Subject content
3. Level of achievement
4. Conditions of performing task (if applicable)

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.)

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 Structural 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	**6**

		real-world structural challenges.	
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-R20) 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 20) regulation

Code	Subject	PO					
		1	2	3	4	5	6
I M. Tech –I Semester							
2015503	Microcontrollers & Programmable Digital Signal Processors	√	√	√	√	√	√
2015504	System Design with Embedded Linux	√	√	√	√	√	√
2015507	Programming Languages for Embedded Software	√	√	√	√	√	√
2015510	Communications Buses & Interfaces	√	√	√	√		√
2015521	Microcontrollers & Programmable Digital Signal Processors Lab	√	√	√	√	√	√
2015522	System Design with Embedded Linux Lab	√	√	√	√	√	√
2015502	Research Methodology & IPR	√	√	√	√	√	√
2015528	English for Research Paper Writing and its significance	√	√	√	√	√	√
I M. Tech –II Semester							
2025505	RTL Simulation and Synthesis with PLDs	√	√	√	√	√	√
2025506	Advanced Digital Signal Processing	√	√	√	√	√	√
2025513	IoT & Applications	√	√	√	√	√	√
2025516	Hardware and Software Co-Design	√		√	√	√	√
2025523	RTL Simulation and Synthesis with PLDs Lab	√	√	√	√	√	√
2025524	Advanced Digital Signal Processing Lab	√	√	√	√	√	√
2025525	Mini Project with Seminar	√	√	√	√	√	√
2025533	Pedagogy Studies	√	√	√	√	√	√
IIM. Tech –I Semester							
2035521	Wireless Sensor Networks	√	√	√	√	√	√
2034032	Energy from Waste	√	√	√	√	√	√
2035526	Dissertation Phase -I	√	√	√	√	√	√
II M. Tech –II Semester							
2045527	Dissertation Phase-II	√	√	√	√	√	√
2045528	Dissertation Viva - Voce	√	√	√	√	√	√

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

The above assessment indicators are detailed below.

7.1 Continuous Internal Evaluation (CIA)

Two Continuous Internal Assessments (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 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.

7.4 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.

7.5 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.

7.6 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.

7.7 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.

7.8 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.

7.9 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

7.10 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.

7.11 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.

7.12 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%

7.13 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.

- Mid Term examination, semester end examinations, Assignment and Viva-voce/Tutorial/Case study/Application/Poster presentation are used for CO calculation.
- The 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	25	Answer script
		Assignment	Twice in a semester	05	Assignment script
		Semester End Examination	Once in a semester	70	Answer script
2	Laboratory	Day to day evaluation	Once in a week	15	Observation and record
		Viva-voce/Tutorial/Case study/Application/Poster presentation	Twice in a semester	5	Work sheets
		Internal practical examination	Twice in a semester	10	Answer script
		Semester End Examination	Once in a semester	70	Answer script
3	Dissertation Work	Presentation	Twice in a semester	30	Presentation
		Semester End Examination	Once in a semester	70	Thesis report
4	Mini Project with Seminar	Semester End Examination	Twice in a semester	100	Seminar report

7.14 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.

Table10: 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.

7.15 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.

7.16 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.

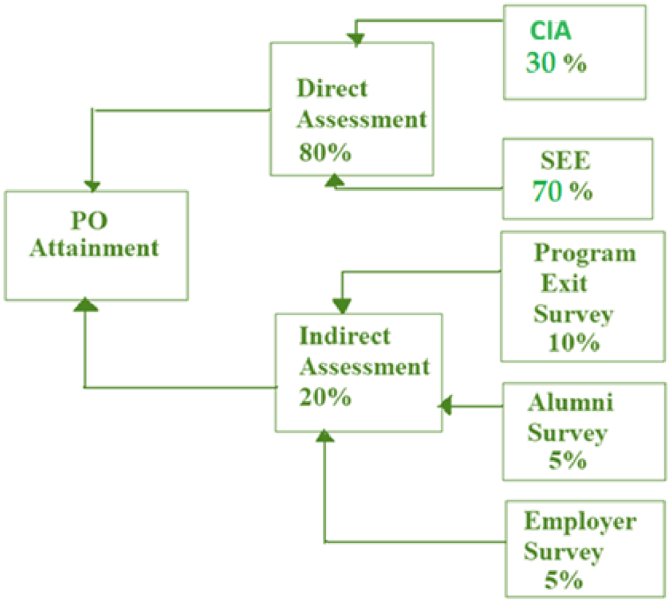

Figure3: Evaluation process of POs attainment

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 & APPLICATIONS

1	**Department**	ELECTRONICS AND COMMUNICATIONS ENGINEERING							
2	**Course Name**	IOT & APPLICATIONS							
3	**Course Code**	2025513							
4	**Year/Semester**	I/II							
5	**Regulation**	MLRS-R20							
6	**Structure of the course**	Theory				Practical			
		Lecture	Tutorials	Practical	Credit	L	T	P	C
		3	0	0	3	0	0	0	0
7	**Type of course**	PC ×	PE ✓	MC ×	AC ×	PS ×	OE ×		
8	**Course Offered**	Odd Semester		×	Even Semester			✓	
9	Total lecture, tutorial and practical hours for this course Offered (16 weeks of teaching per semester)								
	Lectures: 48 Hours		**Tutorials:** 0 hours		**Practical:** 0 hours				
10	**Course Coordinator**	Dr. Rupa Kumar Dhanavath							
11	**Date Approved by BOS**	13.12.2019							
12	**Course Webpage**	www.mlritm.ac.in/							
13	**Prerequisites/Co-requisites**	Level	Course Code		Semester	Prerequisites			
		-	-		-	-			

14. 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. A detailed study of IoT architectures and reference models provides insights into functional, informational, and deployment perspectives. 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.

15. COURSE OBJECTIVES

The students will try to learn:

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

16. COURSE OUTCOMES

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

CO No	Course Outcomes
CO 1	Explain the concepts of IoT, web technologies, and the Internet of Things vision, with their applications and future potential.
CO 2	Differentiate between IoT and M2M concepts for value chains in the global industrial context.
CO 3	Implement IoT system components according to reference architectures for specific applications.
CO 4	Analyze IoT application scenarios identifying potential benefits, challenges, and value creation opportunities in industry and home management.
CO 5	Design secure and trustworthy IoT platforms integrating privacy, governance, and data aggregation strategies for smart city applications.

17. COURSE LEARNING OUTCOME (CLOs)

S No	Topic Name	CLO No	Course Learning Outcome (CLO)	Course Outcome	Bloom's Level
1	IoT introduction	CLO 1	Define IoT and explain its evolution, growth, and application areas	CO1	Understand
2	IoT stack, Enabling technologies	CLO 2	Illustrate the IoT stack, levels, and enabling technologies	CO1	Understand
3	IoT sensing, actuation and types	CLO 3	Differentiate between sensing types and actuator types in IoT systems	CO1	Analyze
4	IoT and M2M	CLO 4	Compare M2M and IoT in terms of concepts, similarities, and differences	CO2	Analyze
5	SDN and NFV for IoT	CLO 5	Explain the role of SDN and NFV in enabling IoT systems	CO2	Understand
6	M2M Value Chains and industrial structure for IoT	CLO 6	Analyze IoT and M2M value chains and their impact on global industries	CO2	Evaluate
7	IoT Hands-on	CLO 7	Write simple programs in Arduino and Python to control IoT devices	CO3	Apply
8	Introduction to Raspberry Pi and its interfacing	CLO 8	Integrate sensors and actuators with Arduino and Raspberry Pi	CO3	Apply
9	Implementation of IoT with Raspberry Pi	CLO 9	Implement a basic IoT application using Raspberry Pi and peripherals	CO3	Create
10	IoT Architecture	CLO 10	Describe the components of IoT architecture and its simplified models	CO4	Understand
11	Comparing IoT architectures	CLO 11	Compare various IoT architectures and their functional stacks	CO4	Analyze
12	IoT data management and compute stack	CLO 12	Evaluate IoT data management and compute stack for real-world applications	CO4	Evaluate
13	Challenges associated with IoT, Emerging pillors of IoT	CLO 13	Identify challenges and emerging pillars in IoT system design	CO5	Analyze
14	Agricultural IoT, Vehicular IoT	CLO 14	Design IoT-based solutions for agriculture, vehicular systems, healthcare, and smart cities	CO5	Create
15	IoT in Transportation and logistics.	CLO 15	Assess IoT applications in transportation and logistics for efficiency improvement	CO5	Evaluate

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.

19. CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES

✓	Power Point Presentation	✓	Chalk & Talk	✓	Assignments	×	MOOC
✓	Case Studies	✓	Seminars	×	Group Project	✓	Concept Videos

20. EVALUATION METHODOLOGY

The performance of a student in a course will be evaluated for 100 marks each, with 30 marks allotted for CIA (Continuous Internal Assessment) and 70 marks for SEE (Semester End-Examination). In CIA, for theory subjects, during a semester, there shall be two mid-term examinations. Each Mid-Term examination consists of two parts i) **Part – A** for 10 marks, ii) **Part – B** for 15 marks with a total duration of 90 minutes as follows:

Mid Term Examination for 25 marks:

a. Part-A: Objective/quiz/short answer type paper for 10 marks.
b. Part-B: Descriptive paper for 15 marks.

The average of two CIA shall be taken as the final marks for mid -term examinations.

The semester end examinations (SEE), will be conducted for 70 marks consisting of two parts viz. i) **Part-A** for 20 marks, ii) **Part-B** for 50 marks.

a. Part-A is a compulsory question which consists of ten sub-questions from all units carrying equal marks.
b. Part-B consists of five questions (numbered from 2 to 11) carrying 10 marks each. Each of these questions is from each unit and may contain sub-questions. For each question there will be an "either" "or" choice, which means that there will be two questions from each unit and the student should answer either of the two questions.
c. The duration of Semester End Examination is 3 hours.

Table 1: Outline for Continues Internal Assessment (CIA-I and CIA-II) and SEE

Activities	CIA-I	CIA-II	Average of CIA	SEE	Total Marks
Continues Internal Evaluation (CIE)	25 Marks	25 Marks			Average of CIA + SEE
Assignment	5 Marks	5 Marks			
Total Marks	**30 Marks**	**30 Marks**	**30 Marks**	**70 Marks**	**100 Marks**

21. COURSE CONTENT - NUMBER OF MODULES

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.	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	10

	structure for IoT, The international driven global value chain and global information monopolies.	
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.	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	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.	9

TEXT BOOKS:

1. S. Misra, A. Mukherjee, and A. Roy, Introduction to IoT. Cambridge, U.K.: Cambridge University Press.
2. D. Hanes, G. Salgueiro, P. Grossetete, R. Barton, and J. Henry, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for IoT. Indianapolis, IN, USA: Cisco Press.

REFERENCE BOOKS:

1. C. Pfister, Getting Started with the Internet of Things. Sebastopol, CA, USA: O'Reilly Media, 2011.
2. F. daCosta, Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, 1st ed. Berkeley, CA, USA: Apress, 2013.
3. Internet of Things: Concepts and Applications. Hoboken, NJ, USA: Wiley.
4. A. Bahga and V. Madisetti, Internet of Things: A Hands-on Approach. Hyderabad, India: Universities Press, 2014.
5. S. K. Vasudevan, R. M. D. Sundaram, and A. S. Nagarajan, Internet of Things. Hoboken, NJ, USA: John Wiley & Sons.
6. M. Banzi and M. Shiloh, Make: Getting Started with Arduino, 3rd ed. Mumbai, India: Shroff Publishers/Maker Media, 2014.

22. 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
	YouTube (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

23. COURSE PLAN

Unit	Class	Subject Topics	Cos	Text/Ref Book
Module -1	LH 1	Introduction and definition of IoT	CO 1	R4:1.1
	LH 2	Evolution of IoT	CO 1	R4:1.1
	LH 3	IoT growth	CO 1	R4:1.1
	LH 4	Application areas of IoT	CO 1	R4:1.1
	LH 5	Characteristics of IoT	CO 1	R4:1.1
	LH 6	IoT stack	CO 1	R4:1.2
	LH 7	Enabling technologies	CO 1	R4:1.4
	LH 8	IoT levels	CO 1	R4:1.5
	LH 9	IoT sensing and actuation	CO 1	R6:2.1
	LH 10	Sensing types and Actuator types (**Active Learning - 1 Flipped Class Room)**	CO1	-
Module -2	LH11	M2M to IoT – A Basic Perspective– Introduction	CO 2	R4:3.1
	LH 12	Differences and similarities between M2M and IoT	CO 2	R4:3.3
	LH 13	SDN and NFV for IoT	CO 2	R4:3.4
	LH 14	M2M Value Chains	CO 2	R4:3.4.1
	LH 15	IoT Value Chains	CO 2	R4:4.3.2
	LH 16	An emerging industrial structure for IoT	CO 2	R4:7.1
	LH 17	The international driven global value chain	CO 2	R4:7.2

	LH 18	Global information monopolies	CO 2	R4:7.3
	LH 19	Case discussions on IoT vs. M2M (**Active Learning - 2 Collaborative Learning)**	CO 2	-
	LH 20	Summary and review of IoT-M2M	CO 2	R4:7
Module -3	LH 21	Introduction to Arduino Programming	CO 3	R2:4.1
	LH 22	Integration of Sensors with Arduino	CO 3	R2:4.1
	LH 23	Integration of Actuators with Arduino	CO 3	R2:4.2
	LH 24	Introduction to Python programming for IoT	CO 3	R2:4.3
	LH 25	Introduction to Raspberry Pi	CO 3	R2:4.4
	LH 26	Interfacing Raspberry Pi with Sensors	CO 3	R2:4.4
	LH 27	Interfacing Raspberry Pi with Actuators	CO 3	R2:4.4
	LH 28	Interfacing Raspberry Pi with other peripherals	CO 3	R2:4.5
	LH 29	Implementation of IoT with Raspberry Pi – Part I	CO 3	R2:4.6
	LH 30	Implementation of IoT with Raspberry Pi – Part II	CO 3	R2:4.6
	LH 31	Hands-on project discussion (**Active Learning -3: Muddiest Point)**	CO 3	-s
Module -4	LH 32	IoT Architecture components	CO 4	R3:5.1
	LH 33	Comparing IoT architectures	CO 4	R3:5.2
	LH 34	A simplified IoT architecture	CO 4	R3:5.2
	LH 35	The core IoT functional stack	CO 4	R3:5.3
	LH 36	IoT data management stack	CO 4	R3:5.4
	LH 37	IoT compute stack	CO 4	R3:5.4
	LH 38	Case study on IoT architecture	CO 4	R3:5.5
	LH 39	Summary of IoT architectures ((**Active Learning - 4 Think Pair Share))**	CO 4	R3:5.6
Module -5	LH 40	Challenges associated with IoT	CO 5	R3:5.7
	LH 41	Emerging pillars of IoT	CO 5	R3:5.8
	LH 42	Agricultural IoT	CO 5	R3:5.9
	LH 43	Vehicular IoT	CO 5	R3:5.9
	LH 44	Healthcare IoT	CO 5	R3:5.9
	LH 45	Smart cities	CO 5	R3:5.10
	LH 46	Transportation IoT	CO 5	R3:5.11

	LH 47	Logistics IoT	CO 5	R3:5.11
	LH 48	Summary and case studies of IoT applications (**Active Learning - 5 Stump Your Partner)**	CO 5	R3:5.11

24. PROGRAM 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

25. 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

26. MAPPING OF EACH CO WITH PO(s)

Course Outcomes (COs)	**Program Outcomes (POs)**					
	1	**2**	**3**	**4**	**5**	**6**
CO 1		Y	Y			Y
CO 2	Y	Y	Y			Y
CO 3	Y	Y	Y	Y	Y	
CO 4	Y		Y	Y	Y	Y
CO 5	Y	Y	Y	Y	Y	Y

27. JUSTIFICATIONS FOR CO – PO MAPPING - DIRECT:

Course Outcomes (COs)	**POs**	**Justification for mapping (Students will be able to)**	**No. of key competencies**
CO 1	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. Advanced programming skills for microcontrollers, processors, and real-time systems 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 2. Innovation, curiosity, and proactive upskilling for long-term professional growth	**2**
CO 2	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. Digital tools are used for documentation and visualization.	**3**
	PO3	1. Embedded communication protocols, concepts and design methodologies	**1**

	PO6	1. Awareness of emerging technologies in embedded systems and related domains 2. Professional networking and collaborative knowledge exchange 3. Engagement in courses, certifications, and workshops on contemporary technologies 4. Knowledge and evaluation of frameworks, programming languages, and platforms for sustainable, future-ready embedded practices	**4**
CO 3	PO 1	1. Experiments or simulations are conducted using appropriate tools. 2. Innovative approaches are applied to engineering problem-solving. 3. Data collection, analysis and interpretation systematically. 4. Results are validated against established theories and standards	**4**
	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	**3**
	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	**4**

		3. Real-time constraints, scheduling, and performance optimization in embedded processes 4. Use of modern tools, frameworks, and programming environments for embedded applications	
	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**
CO 4	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**
	PO3	1. System performance evaluation for efficiency, reliability, and scalability 2. Secure, low-power and high-performance design strategies in embedded systems 3. Embedded communication protocols, concepts and design methodologies 4. Real-time constraints and scheduling in embedded system design	**4**
	PO4	1. Complex embedded system problems in operations, management, and technology. 2. Real-time constraints, scheduling, and performance optimization in embedded processes	**2**

	PO5	1. Computational and simulation-based experimental data handling	**1**
	PO6	1. Awareness of emerging technologies in embedded systems and related domains 2. Knowledge and evaluation of frameworks, programming languages, and platforms for sustainable, future-ready embedded practices 3. Professional networking and collaborative knowledge exchange	**3**
CO 5	PO1	1. Research problem identification and problem statement. 2. Literature review highlighting research gaps and suitable methods. 3. Experiments or simulations are conducted using appropriate tools. 4. Data collection, analysis and interpretation systematically. 5. Innovative approaches are applied to engineering problem-solving.	**5**
	PO2	1. Technical reports, dissertations, and papers are well-structured. 2. Research findings are communicated to both technical and non-technical audiences.	**2**
	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**

		5. Advanced programming skills for microcontrollers, processors, and real-time systems	
	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	**3**
	PO5	1. Energy and resource efficient sustainable design practices 2. Documentation and reporting of experimental results for societal applications 3. Computational and simulation-based experimental data handling	**3**
	PO6	1. Awareness of emerging technologies in embedded systems and related domains 2. Knowledge and evaluation of frameworks, programming languages, and platforms for sustainable, future-ready embedded practices 3. Professional networking and collaborative knowledge exchange	**3**

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

Course Outcomes (COs)	Program Outcomes (POs)					
	1	2	3	4	5	6
	6	6	7	7	6	7
CO 1		2	5			2
CO 2	4	3	1			4
CO 3	4	1	3	4	3	
CO 4	3		4	2	1	3
CO 5	5	2	5	3	3	3

29. PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

Course Outcomes (COs)	Program Outcomes (POs)					
	1	2	3	4	5	6
	6	6	7	7	6	7
CO 1		33	71			29
CO 2	67	50	14			57
CO 3	67	17	43	57	50	
CO 4	50		57	71	17	43
CO 5	83	33	71	43	50	43

30. COURSE ARTICULATION MATRIX (PO – MAPPING)

CO'S and PO'S, CO'S and PSO'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≤ 10% – No correlation,

1- 10 <C≤ 40% – Low/ Slight

2 - 40 % <C ≤ 60% –Moderate

3 - 60% < C ≤ 100% – Substantial /High

Course Outcomes (COs)	Program Outcomes (POs)					
	1	2	3	4	5	6
	6	6	7	7	6	7
CO 1		1	3			1
CO 2	3	2	1			2
CO 3	3	1	2	2	3	
CO 4	2		2	3	1	2
CO 5	3	1	3	2	2	2
Total	11	6	11	7	6	7
Mean	2.75	1.50	2.20	2.33	2.00	1.75

31. ASSESSMENT METHODOLOGY DIRECT

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

32. ASSESSMENT METHODOLOGY INDIRECT

✓	Course End Survey (CES)

33. RELEVANCE TO SUSTAINABILITY GOALS

x	1	NO POVERTY	
✓	2	ZERO HUNGER	IoT enables smart agriculture by facilitating real-time monitoring of soil moisture, weather conditions, and crop health using sensors and data analytics. Precision agriculture reduces resource wastage and improves crop yield. Drones, GPS, and IoT devices help optimize

			planting, irrigation, and harvesting. Implementing IoT in rural areas can empower farmers with better decision-making tools, reducing hunger and increasing food security.
✓	3	GOOD HEALTH AND WELL-BEING	IoT in healthcare (Healthcare IoT) allows remote patient monitoring, smart wearables, and real-time health data tracking. This enables faster diagnosis, continuous care, and early detection of diseases. IoT-based systems reduce the burden on hospitals and extend healthcare to rural and underserved areas. Innovations like telemedicine and smart ambulances are powered by IoT solutions.
✓	4	QUALITY EDUCATION	Hands-on experience with Arduino, Raspberry Pi, and Python in the IoT curriculum equips students with essential technical and programming skills. Project-based learning using IoT fosters creativity, critical thinking, and problem-solving abilities. Exposure to real-world IoT applications prepares students for jobs in Industry 4.0. It supports inclusive and equitable education through practical and digital literacy.
X	5	GENDER EQUALITY	
x	6	CLEAN WATER AND SANITATION	
x	7	AFFORDABLE AND CLEAN ENERGY	
✓	8	DECENT WORK AND ECONOMIC GROWTH	The IoT industry is a major driver of new jobs and startups in technology, agriculture, transport, and healthcare sectors. Understanding IoT value chains opens opportunities for entrepreneurship and digital economy roles. The curriculum fosters innovation-driven employment, especially in emerging markets. Digital skill development through IoT tools prepares a future-ready workforce.
✓	9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	IoT enables intelligent manufacturing, predictive maintenance, and automation, forming the backbone of Industry 4.0. Learning about IoT architecture, stacks, and enabling technologies prepares students to design smart, scalable systems. SDN and NFV in IoT support

			efficient infrastructure. The curriculum promotes sustainable industrial growth through technology innovation.
✓	10	REDUCED INEQUALITIES	IoT can bridge the digital divide by bringing smart solutions to remote and underserved communities, especially in healthcare and agriculture. Open-source IoT platforms like Arduino and Raspberry Pi are low-cost tools that democratize access to innovation. When integrated with global value chains, IoT can help small businesses and farmers compete more fairly.
✓	11	SUSTAINABLE CITIES AND COMMUNITIES	Smart city solutions powered by IoT—like traffic management, smart lighting, waste management, and air quality monitoring—lead to more sustainable urban development. The curriculum emphasizes IoT's role in making cities more livable, efficient, and resilient. Learners gain the skills to contribute to urban innovation and sustainability.
✓	12	RESPONSIBLE CONSUMPTION AND PRODUCTION	IoT supports real-time monitoring of resource usage in manufacturing, agriculture, and households. This enables better decision-making, reducing overproduction and energy waste. Students learn how IoT systems can optimize operations and lower environmental footprints. Data-driven processes promote efficiency and circular economy practices.
✓	13	CLIMATE ACTION	IoT systems are key in monitoring environmental parameters like CO_2 levels, temperature, and energy usage. They provide critical data for climate modeling, disaster prediction, and sustainable planning. IoT-based smart grids and transportation reduce emissions. By understanding and deploying such systems, students contribute to tackling climate change.
X	14	LIFE BELOW WATER	
X	15	LIFE ON LAND	
✓	16	PEACE, JUSTICE AND STRONG INSTITUTIONS	IoT enables better governance through smart public infrastructure, enhanced security systems, and transparent data collection. Efficient IoT architectures improve digital services and public accountability. Secure data management and network protocols learned in the curriculum can support ethical tech deployment and robust institutions.

✓	17	PARTNERSHIPS FOR THE GOALS	The global nature of IoT value chains emphasizes the importance of international collaboration in technology standards, data sharing, and innovation. Through SDN, NFV, and global IoT structures, students learn the value of cross-border cooperation. Open innovation and shared research in IoT accelerate progress toward multiple SDGs.

Course Coordinator **HoD**