OBE MANUAL

M.Tech Structural Engineering

MLRS R 22 Regulation

MARRI LAXMAN REDDY INSTITUTE OF TECHNOLOGY AND MANAGEMENT

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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.

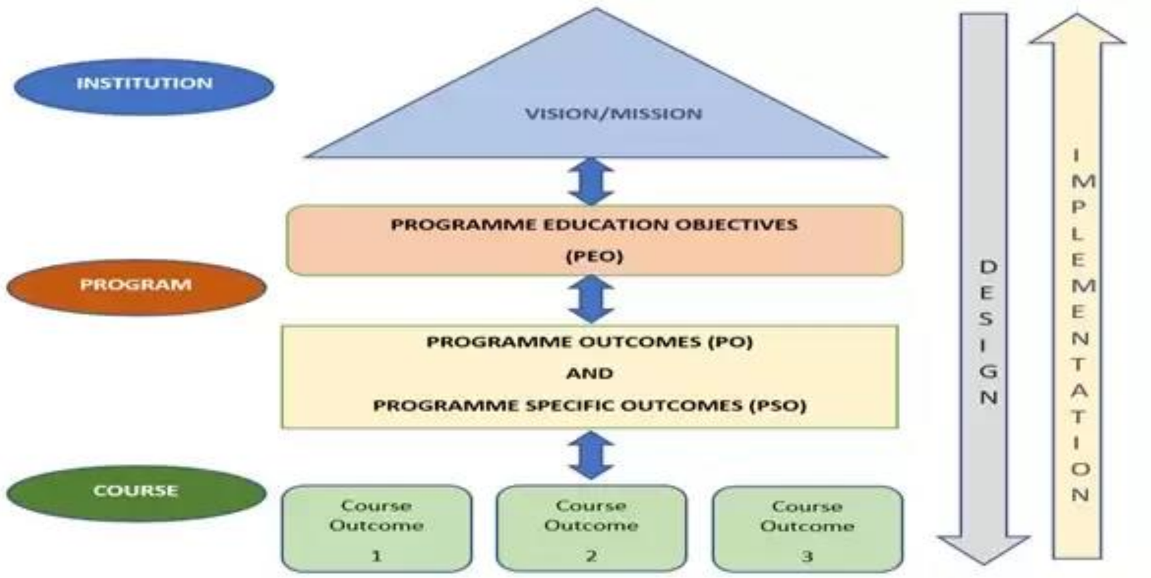


Figure1: OBE process

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

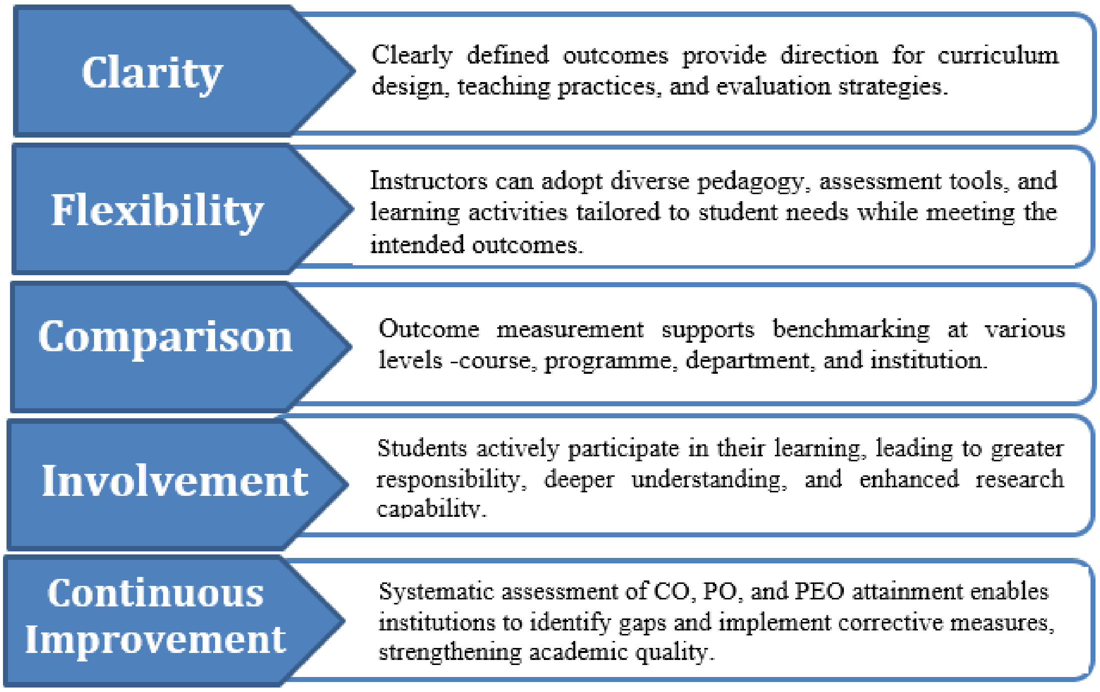


Figure 2: Benefits of Outcome Based Education

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

1.1Vision 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
Student performance is tracked continuously, and results are analyzed to identify strengths and areas for improvement.

Curriculum Gap Analysis
Gaps between curriculum outcomes and industry requirements are identified and bridged through additional learning modules, workshops, and expert lectures.

Program Outcome Attainment Review
PO 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 empower students to be skilled, competitive and dedicated Civil Engineers by imparting advanced technical knowledge and ethical values, equipping them to play a key role in the planning and execution of the nation's infrastructure and development activities.

2.2 Mission of the Department

M1: Provide quality education in civil engineering through a combination of excellent teaching, advanced facilities, and continuous mentorship.
M2: Produce civil engineering graduates who demonstrate strong skills and expertise.
M3: Encourage professional development to address complex technical challenges and engage in innovation with creativity, leadership, ethics, and social awareness.

2.3 Program Educational Objectives (PEOs)

PEO1

Equip for success in the engineering domain through a strong foundation in structural engineering and advanced design skills.

PEO2

Foster industrial awareness and a research-oriented mindset by engaging with emerging trends and technologies in structural engineering.

PEO3

Prepare for successful employment by developing professional ethics and critical thinking to address evolving societal needs.

PEO4

Develop leadership qualities to excel in professional and societal environments, contributing responsibly and ethically.

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.

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 Structural Engineering

PO4
Application of Engineering Principles

Impart core and interdisciplinary knowledge for analyzing and solving complex problems in structural engineering and related domains.

PO5
Design and Sustainability

Conceptualize and design safe, efficient, and sustainable civil engineering structures in social, economic, and environmental factors.

PO6
Lifelong Learning and Professional Development

Engage in lifelong learning through continuous education, research, and professional development.

NBA-Defined Common POs

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

Department Defined Program Outcomes

4. Application of Engineering Principles
5. Design and Sustainability
6. Lifelong Learning and Professional Development

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**.**

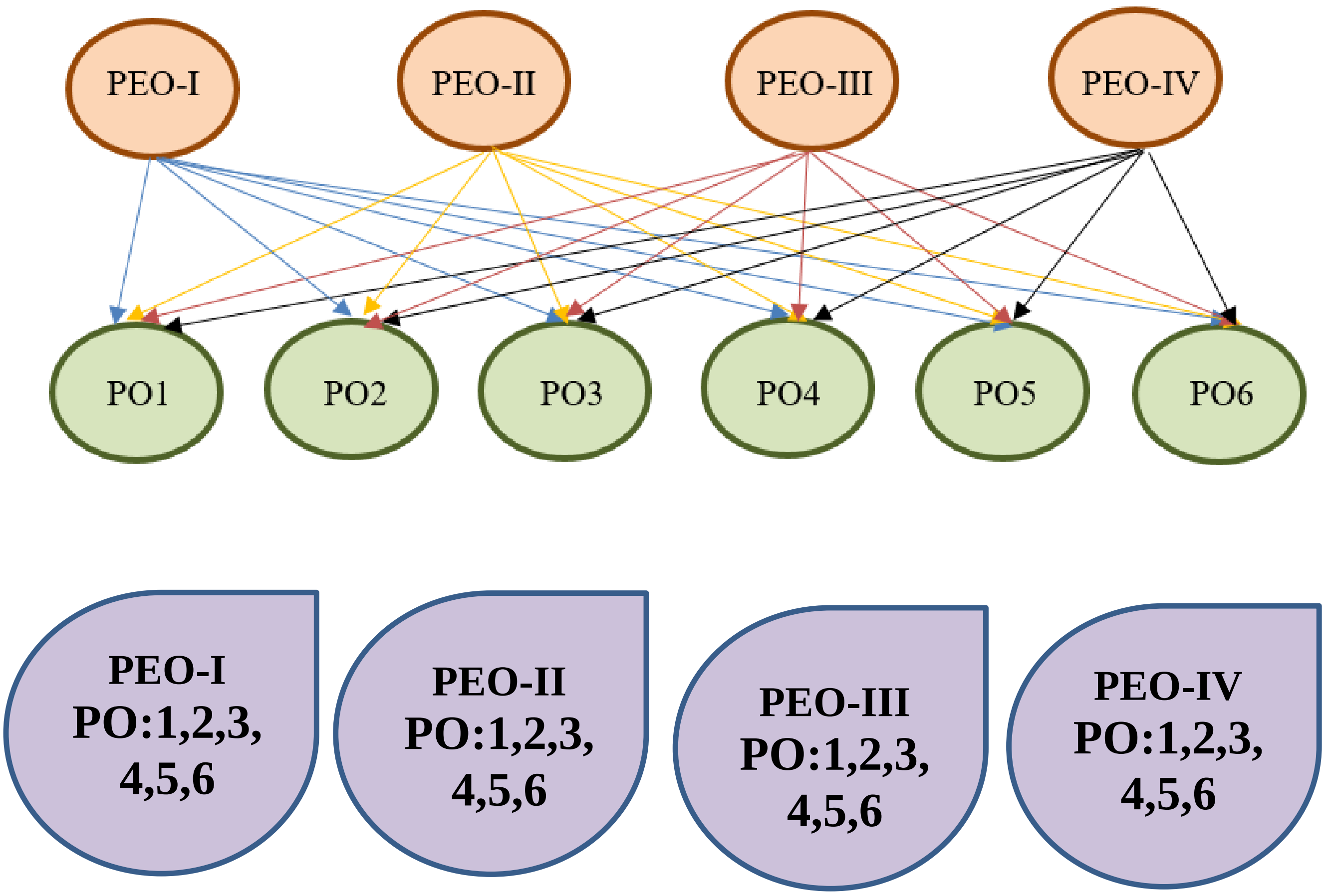


Figure 4: Correlation between the PEOs and the POs

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) Continued Self-Learning**	**(4) Effective Contribution to Society**
PO1	Independently carry out research /investigation and development work to solve practical problems.	3	3	2	1
PO2	Write and present a substantial technical report/document.	3	2	1	2
PO3	Demonstrate a degree of mastery over the area in Structural Engineering.	3	3	2	1
PO4	Impart core and interdisciplinary knowledge for analyzing and solving complex problems in structural engineering and related domains.	3	3	3	2
PO5	Conceptualize and design safe, efficient, and sustainable civil engineering structures in social, economic, and environmental factors.	3	2	2	3
PO6	Engage in lifelong learning through continuous education, research, and professional development.	3	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 Evaluation (CIE),
- Mid-term examinations, and
- 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.

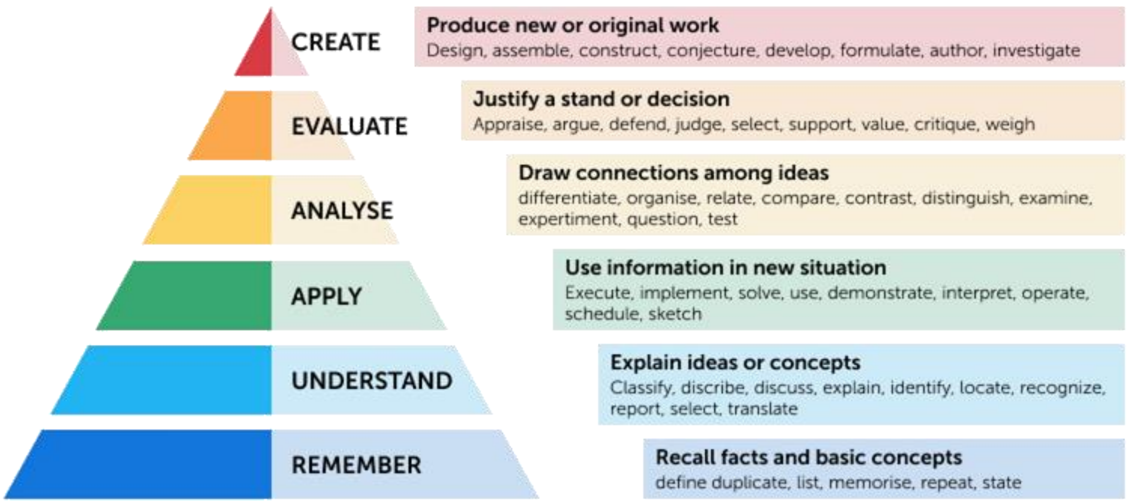


Figure 5: Blooms Taxonomy

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.

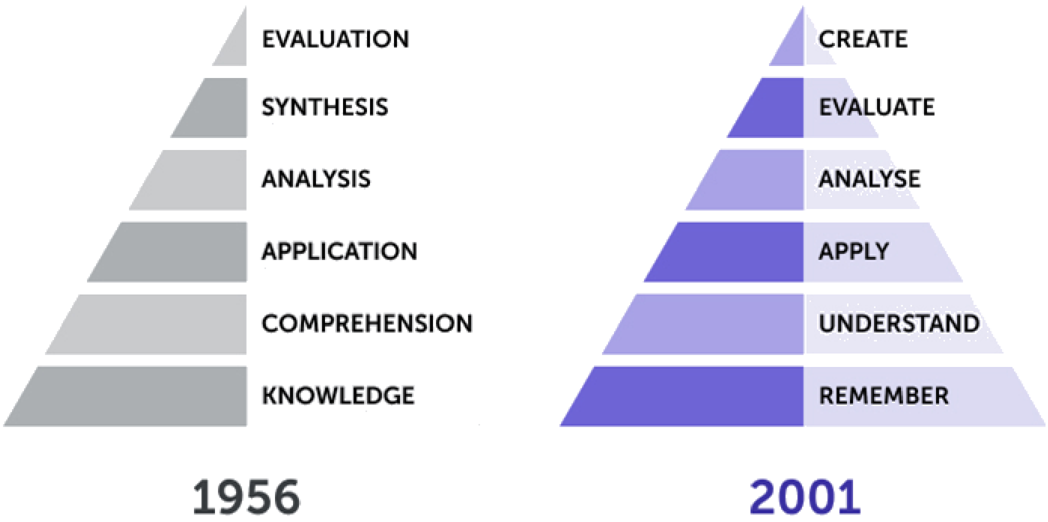


Figure 6: Blooms Taxonomy (Original and Revised)

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.

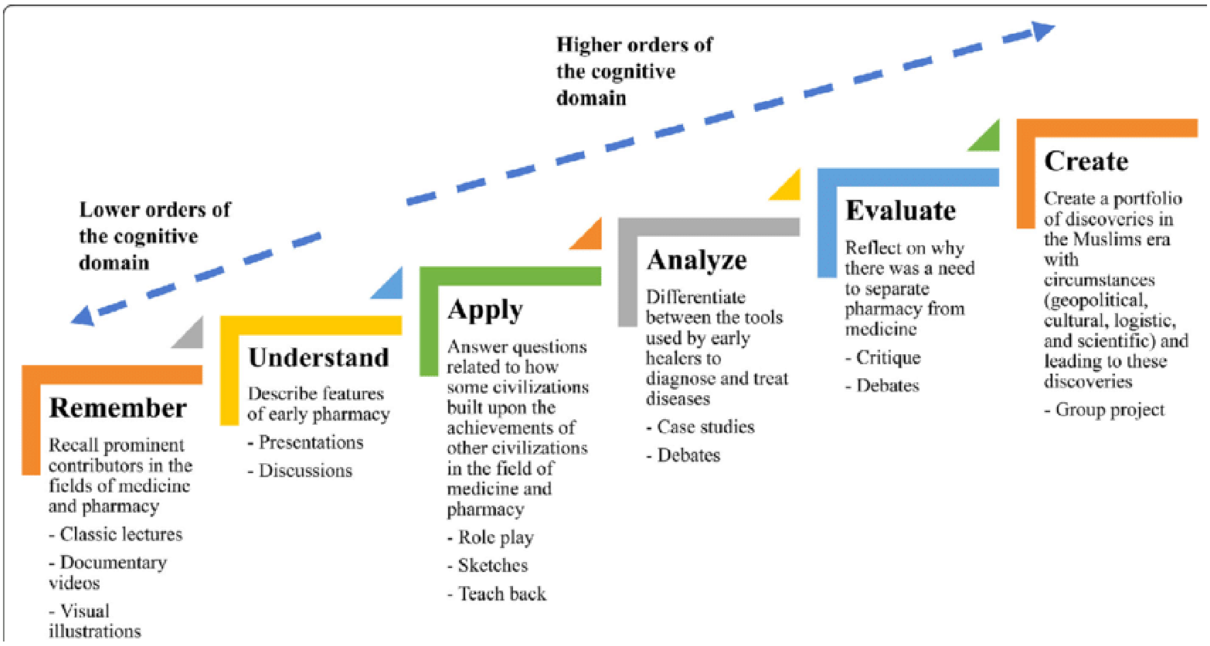


Figure 7: The cognitive process dimensions – categories

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)

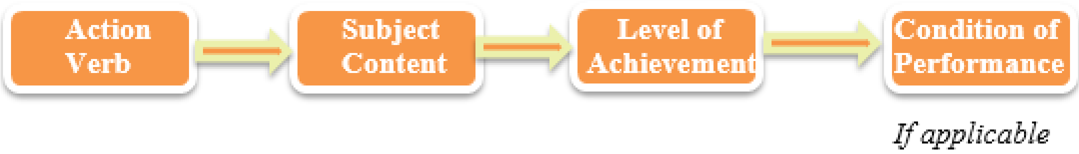
A Course Outcome is a formal statement of what students are expected to learn in a course. When creating Course Outcomes, remember that the outcomes should clearly state what students will do or produce to determine and/or demonstrate their learning. Course learning outcome statements refer to specific 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:

- Critically analyze the stability behavior of columns subjected to axial, flexural, and torsional buckling with and without lateral bracing.
- Design reinforced concrete and steel structural components in accordance with relevant IS codes.
- Evaluate the seismic performance of multi-storey buildings and propose appropriate retrofitting strategies.
- Apply finite element methods to model and interpret the response of complex structural systems.
- Assess the durability and sustainability aspects of construction materials for long-term performance.
- Develop structural health monitoring approaches using sensor data and diagnostic techniques.
- Produce and present a comprehensive technical report on a design or research problem.
- Demonstrate professional ethics, teamwork, and leadership skills in solving multidisciplinary engineering problems.

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	Given a column subjected to axial load with specified end conditions	The student will be able to determine the critical buckling load using Euler's theory	Within ±5% error compared to theoretical values
2	Immediately after a lecture on earthquake-resistant design principles	The student will be able to outline and explain the key provisions of IS 1893 for seismic analysis of buildings	Mentioning at least four out of five key provisions
3	Using finite element analysis software and a provided beam model	The student will be able to analyze bending stress distribution and validate results with theoretical calculations	Achieving correlation within 10% of hand calculations

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
Explore in depth the literature on an aspect of teaching strategies.	Exploration is not a measurable activity, but the quality of the product of exploration would be measurable with a suitable rubric.	Upon completion of this course, the students will be able to: write a paper based on an in-depth exploration of the literature on an aspect of teaching strategies.

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

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:

5 **(High):** Strong alignment between the CO and the PO.

2 **(Medium):** Moderate alignment.

3 **1 (Low):** Minimal alignment.
4 **"-" (No alignment):** No meaningful correlation.

6 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 real-world structural challenges.	**6**

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

6.3 Program Outcomes Attained through course modules:

Courses offered in Civil Engineering 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 Structural Engineering (MLRS R 22) regulation

Code	Subject	PO					
		1	2	3	4	5	6
I M. Tech –I Semester							
2212011	Advanced Structural Mechanics	1.4	1	3	3	1.4	2.4
2212012	Theory Of Elasticity And Plasticity	1.2	1	3	3	1.6	1
2212041	Theory Of Plates And Shells	1	1	3	3	2	1
2212042	Computer Oriented Numerical Methods	1.4	1.4	1	3		1
2212043	Structural Stability	2.2	1	3	3	1	2
2212044	Advanced Reinforced Concrete Design	2.2	1	3	3	2	2.2
2212045	Structural Health Monitoring	2	1	3	3	1.8	2.4
2212046	Structural Optimization	1.8	1	3	3	1.8	2
2212071	Computer Aided Design Laboratory	1.8	1	3	3	1.8	3
2212072	Structural Engineering Laboratory	1.4	1.6	3	3	1.2	3
2212021	Research Methodology & IPR	3	3	3	3		1
2210001	English For Research Paper Writing	1	1	3	3	1	1
2210002	Disaster Management	1.4		1	1		1
2210003	Sanskrit For Technical Knowledge		1.2				1
2210004	Value Education					1	1
I M. Tech –II Semester							
2222013	Finite Element Analysis	1.4	1	1.4	1.6	1.8	1
2222014	Structural Dynamics	1.2	1	3	3	1.8	1
2222047	Advanced Structural Steel Design	1.4	1	3	3	1.8	1
2222048	Structural Reliability	1.2	1	3	3	1.8	1
2222049	Design Of High-Rise Buildings	1.2	1	3	3	1.6	1
2222050	Advanced Prestressed Concrete Design	1.6	1	3	3	1.8	1
2222051	Industrial Structures	1.6	1	3	3	1.8	1
2222052	Design Of Bridges	1.6	1	3	3	1.8	1
2222073	Numerical Analysis Laboratory	2	3	3	3	2	3
2222074	Advanced Structural Analysis And Design Laboratory	2	3	3	3	2	3

2222075	Mini Project With Seminar	3	3	3	3	3	3
2220005	Constitution Of India					1	1
2220006	Pedagogy Studies	1.2	1	1.2	1.4	1.4	1
2220007	Stress Management By Yoga					1	1
2220008	Personality Development Through Life Enlightenment Skills					1	1
IIM. Tech –I Semester							
2232053	Earthquake Resistance Design Of Structures	1.4	1	3	3	1.8	1
2232054	Pre-Engineered Buildings	1.6	1	3	3	2.4	1
2232055	Rehabilitation And Retrofitting Of Structures	1.6	1	3	3	2.8	1
2232001	Green Building	1.4	1	3	3	1.6	1
2232002	Construction Project Management	1.6	1	1.2	1.4	1.6	1
2232003	Safety And Construction Practice Regulations	1.6	1	1.2	1.6	1.6	1
2232076	Dissertation Work Review – I	3	3	3	3	3	3
II M. Tech –II Semester							
2242077	Dissertation Work Review – III	3	3	3	3	3	3
2242078	Dissertation Viva -Voce	3	3	3	3	3	3

Methods for measuring Learning

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 Evaluation (CIE).
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 (CIE)

Two Continuous Internal Evaluation (CIEs) 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 like Association of Consulting Civil Engineers (ACCE), American Society of Civil Engineers (ASCE) Institute of Civil Engineers (ICE), etc., are explained to the students and they are encouraged to become members of the above to carry out their continuous search for knowledge. Student and faculty chapters of the above societies are constituted for a better technical and entrepreneurial environment. These professional societies promote excellence in instruction, research, public service and practice.

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 Evaluation (CIE) 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 Evaluation (CIE)	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	Midterm Examination	Twice in a semester	30	Answer script
		Viva-voce/PPT/Poster Presentation/Case study	Once in a semester	05	PPT
		Assignment	Twice in a semester	05	Assignment script
		Semester End Examination	Once in a semester	60	Answer script
2	Laboratory	Day to day evaluation	Once in a week	10	Observation and record
		Viva-voce/Tutorial/Case study/Application/Poster presentation	Twice in a semester	10	Work sheets
		Design/software/hardware Model presentation/App development/Prototype presentation	Once in a semester	10	Presentation
		Internal practical examination	Twice in a semester	10	Answer script
		Semester End Examination	Once in a semester	60	Answer script
3	Dissertation Work	Presentation	Twice in a semester	40	Presentation
		Semester End Examination	Once in a semester	60	Thesis report
4	Mini Project	Semester End Examination	Twice in a	100	Seminar

S No	Courses	Components	Frequency	Max. Marks	Evidence
	With Seminar		semester		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

<table>
<tr><td rowspan="4">POs Attainment</td><th>Assessment</th><th>Tools</th><th>Weight</th></tr>
<tr><td>Direct Assessment</td><td>CO attainment of courses</td><td>80%</td></tr>
<tr><td rowspan="2">Indirect Assessment</td><td>Program exit survey</td><td rowspan="2"></td></tr>
<tr><td>Alumni survey</td></tr>
</table>

		Employer survey	20%

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.

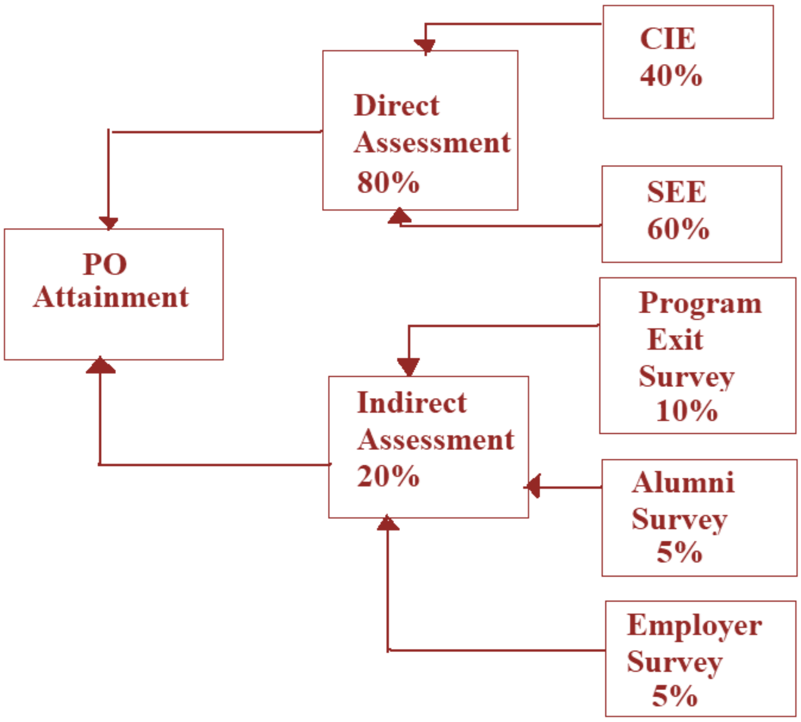


Figure3: Evaluation process of POs attainment

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

THEORY OF ELASTICITY AND PLASTICITY

COURSE DESCRIPTOR

1	**Department**	CIVIL ENGINEERING
2	**Course Name**	THEORY OF ELASTICITY AND PLASTICITY
3	**Course Code**	2212012
4	**Year/Semester**	I/I
5	**Regulation**	MLRS-R22
6	**Course Offered**	I Semster
7	**Course Coordinator**	Mr.T.Jaya Krishna
8	**Date Approved by BOS**	14-11-2022
9	**Course Webpage**	www.mlritm.ac.in/

10.Structure of the Course

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

11. Credits of the Course

Theory		Practical	Project	
Lecture	Tutorials	Practical	Mini project	Major Project
3	-	-	-	-
Total Credits:3				

12. Type of the Course

PC	PE	AC	MPS	PS
√	-	-	-	-
Total Credits:				

13. Total Hours Offered

Lectures	Tutorials	Practicals
46	-	-

14. Prerequisites/ Co-requisites

Level	Course Code	Semester	Prerequisites
UG	-	-	

15. Course Overview

The course Theory of Elasticity and Plasticity is designed to provide postgraduate students with a comprehensive understanding of plastic deformation behavior of materials under various loading conditions. It emphasizes the fundamental concepts of stress–strain relations beyond the elastic limit, yielding criteria, plastic stress–strain relations, and hardening rules. The course also covers slip-line field theory, plastic potential, and applications to metal forming processes. Through this course, students will develop the ability to model, analyze, and solve advanced engineering problems related to material plasticity, which are crucial in structural, geotechnical, and manufacturing engineering. By integrating theoretical knowledge with practical problem-solving, the course strengthens analytical skills and prepares students for research, industrial applications, and advanced computational studies in the field of material behavior and plasticity.

16. Course Objectives

The students will try to learn:

1	To impart fundamental knowledge of stress–strain relations in plastic range and various yield criteria governing material deformation.
2	To develop an understanding of plastic stress–strain relations, flow rules, and hardening mechanisms in metals.
3	To introduce slip-line field theory and its applications to plane strain plasticity problems.
4	To enable students to analyze and model metal forming processes using plasticity principles.
5	To strengthen analytical and research skills for solving advanced problems in structural, geotechnical, and manufacturing engineering involving plastic deformation

17. Course Outcomes

After successful completion ofthe course, students should be able to:

- **CO1** • Analyze the state of stress in two- and three-dimensional systems using stress tensors, transformations, and invariants.
- **CO2** • Interpret different components of strain and their transformations to determine principal and octahedral strains.
- **CO3** • Derive stress–strain relationships and material constants for various material symmetries under plane and axi-symmetric conditions.
- **CO4** • Solve two and three dimensional elasticity problems using stress function approaches and membrane analogy concepts.
- **CO5** • Evaluate yielding behaviour of materials using different yield criteria and hardening rules in plasticity.

18. Employability Skills

Skill Category	Description	Relevance to Course
Problem-Solving Skills	Develops ability to identify complex stress and strain problems and propose analytical or numerical solutions.	Solving problems on stress-strain relationships, compatibility conditions, and boundary value problems in elastic and plastic regions.
Analytical Thinking	Encourages logical analysis of material behavior under different loading and boundary conditions.	Deriving stress functions, applying equilibrium equations, and analyzing two- and three-dimensional stress systems.
Software & Hardware Integration	Enhances proficiency in using computational tools for solving elasticity and plasticity problems.	Utilizing software like MATLAB and ANSYS for solving and visualizing stress distribution and deformation patterns.
Collaboration & Teamwork	Fosters teamwork in modeling and analyzing structural components under complex loading.	Working in groups for mini-projects involving stress analysis or validation of theoretical results using simulations.
Adaptability & Continuous Learning	Prepares students to adopt new analytical, experimental, and computational techniques in solid mechanics.	Learning modern theories of plastic flow, yield criteria, and advanced elasticity applications in structural engineering.
System Design Thinking	Develops capability to design and evaluate materials and structures considering elastic and plastic behavior.	Designing components that ensure safety, sustainability, and performance under elastic and plastic deformation conditions.

19. Content Delivery / Instructional Methodologies

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

20. Evaluation Methodology

The performance of a student in a course will be evaluated for 100 marks each, with 40 marks allotted for CIE (Continuous Internal Evaluation) and 60 marks for SEE (Semester End-Examination). In CIE, for theory subjects, during a semester, there shall be two mid-term examinations.

Each Mid-Term examination (30 Marks) consists of two parts

i) **Part – A** for 10 marks (Short Answer Types),

ii) **Part – B** for 20 marks (Descriptive answer Type) with a total duration of 1.5 hours as follows:

Total 30 marks will be scale down 10 marks.

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

The semester end examinations (SEE), will be conducted for 60 marks consisting of two parts viz.i) **Part-A** for 10 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 three questions (numbered from 2 to 6) 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 Evaluation (CIE-I and CIE-II) and SEE**

Activities	CIE-I	CIE-II	Average of CIE	SEE	Total Marks
Continues Internal Evaluation (CIE)	10 Marks	10 Marks	40 Marks	60 Marks	100 Marks
Assignment	5 Marks	5 Marks			
CAT (Concept video/Tech-talk/certificate)	5 Marks	5 Marks			
Total Marks	**20 Marks**	**20 Marks**	**40 Marks**	**60 Marks**	**100 Marks**

21. Course content - Number of modules: Five:

Module	Module Description	No. of Lectures
MODULE 1	**Stress:** Introduction to Elasticity – Definition of Kinetics and Kinematics - Notation for forces and stress- Components of stresses – Stress tensor - Differential equations of equilibrium in 2D & 3D in Cartesian coordinates and in polar coordinates - boundary conditions – Cauchy's postulate – Stress transformation – Direction Cosines -Principal stresses – Stress invariants – Decomposition of stresses-Hydrostatic and Deviatoric stresses – Octahedral stresses – stress concentration factors	No. of theory classes : 14
MODULE 2	**Strain:** Notation for strain - Components of strain – Strain tensor – Strain Components -Strain -displacement relations - Strain Compatibility Conditions - Strain transformation – Direction Cosines -Principal strains – Strain invariants - Octahedral strains – Strain Rosette	No. of theory classes : 12
MODULE 3	**Stress -Strain Relationship:** Navier's equation for stress-strain relationships – Relationship between Material constants – Stress - strain relations in 2D and 3D – Complementary conditions for shear - Material symmetry -Reduction of Material constants from anisotropic to orthotropic, monoclinic, isotropic and transversely isotropic – Plane stress, Plane strain and axi-symmetric idealizations - Mohr circle in 2D and 3D – Airy's stress function – Potential function	No. of theory classes : 15
MODULE 4	**Solution of 2D and 3D elasticity problems:** Problem solving using stress function approach: Beam bending problems – Symmetric stress distribution problems, Plane problems. Torsion problems in Elasticity – Membrane analogy approach – Application to non- circular thin walled sections	No. of theory classes : 12
MODULE 5	**Plasticity:** Introduction to plasticity – Yield criteria for pressure dependent and independent materials – Tresca's criterion – Von mises criterion – Mohr-Coulomb criterion -Rankine criterion -Flow rule – Associative and Non-Associative-Hardening rules and consistency conditions -Introduction to iterative and return mapping.	No. of theory classes : 5

REFERENCE BOOKS

1. Theory of Elasticity by Timeshenko, McGraw-Hill Publications
2. Theory of Elasticity by Y.C.Fung
3. Advanced Mechanics of solids by LS Srinath,
4. Elasticity and Plasticity for structural Engineers by Wang & Chen

ELECTRONIC RESOURCES

Resource Type	Title/Description	Link
Online Courses	Swayam: Theory of Elasticity By Prof. Amit Shaw, Prof. Biswanath Banerjee, IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc20_ce42/preview
	Mechanical Behaviour Of Materials By Prof. Shashank Shekhar, Prof. Sudhanshu Shekhar Singh, IIT Kanpur	https://onlinecourses.nptel.ac.in/noc23_mm44/preview#:~:text=He%20joined%20IITK%20in%202010%20and%20has,as%20well%20as%

		204th%20year%20 UG%20students.
You Tube DSS Lectures-MLRITM	Theory of Elasticity and Plasticity by Mrs.T.Neha	https://www.youtube.com/watch?v=oI_Srw3FD6g&t=52s

22. COURSE PLAN

S. No.	Topics to be covered	COs	Reference
1	Introduction to OBE		
2	Introduction to Stress: Definitions, Kinetics and Kinematics	CO1	R1: Ch.1, R2: Ch.1
3	Notation for forces and stress	CO1	R1: Ch.1, R2: Ch.1
4	Components of stresses, Stress tensor	CO1	R1: Ch.2, R2: Ch.2
5	Differential equations of equilibrium in 2D Cartesian coordinates	CO1	R1: Ch.3, R3: Ch.1
6	Differential equations of equilibrium in 3D Cartesian coordinates	CO1	R1: Ch.3, R3: Ch.2
7	Differential equations in polar coordinates, Boundary conditions	CO1	R1: Ch.3, R2: Ch.3
8	Cauchy's postulate, Stress transformation	CO1	R1: Ch.4, R2: Ch.4
9	Direction Cosines, Principal stresses	CO1	R1: Ch.4, R2: Ch.4
10	Stress invariants, Decomposition of stresses	CO1	R1: Ch.5, R4: Ch.2
11	Hydrostatic and Deviatoric stresses	CO1	R1: Ch.5, R4: Ch.2
12	Octahedral stresses, Stress concentration factors	CO1	R1: Ch.6, R4: Ch.3
13	Active Learning (Collaborative Learning)	CO1	R1: Ch.6, R4: Ch.3
14	Strain: Notation, Components	CO2	R1: Ch.7, R2: Ch.5
15	Strain tensor, Strain components	CO2	R1: Ch.7, R2: Ch.5
16	Strain-displacement relations	CO2	R1: Ch.8, R2: Ch.5
17	Strain compatibility conditions	CO2	R1: Ch.8, R2: Ch.5
18	Strain transformation, Direction Cosines	CO2	R1: Ch.8, R4: Ch.4
19	Principal strains, Strain invariants	CO2	R1: Ch.9, R4: Ch.4
20	Octahedral strains, Strain Rosette	CO2	R1: Ch.9, R4: Ch.4
21	Active Learning (Think Pair Share)		
22	Stress-Strain Relationships: Navier's equation	CO3	R1: Ch.10, R3: Ch.3

23	Relationship between Material constants	CO3	R1: Ch.10, R3: Ch.3
24	Stress-strain relations in 2D and 3D	CO3	R1: Ch.11, R4: Ch.5
25	Complementary conditions for shear	CO3	R1: Ch.11, R4: Ch.5
26	Material symmetry and Reduction of material constants	CO3	R1: Ch.12, R4: Ch.6
27	Plane stress, Plane strain, Axi-symmetric idealizations	CO3	R1: Ch.12, R4: Ch.6
28	Mohr circle in 2D and 3D	CO3	R1: Ch.13, R4: Ch.7
29	Airy's stress function, Potential function	CO3	R1: Ch.14, R4: Ch.7
30	Active Learning (Stump Your Partner)	CO3	R1: Ch.14, R4: Ch.7
31	Solution of 2D elasticity problems using stress function	CO4	R1: Ch.15, R4: Ch.8
32	Beam bending problems	CO4	R1: Ch.15, R3: Ch.4
33	Symmetric stress distribution problems	CO4	R1: Ch.15, R3: Ch.4
34	Plane problems, Torsion problems in elasticity	CO4	R1: Ch.16, R4: Ch.8
35	Membrane analogy approach, Application to non-circular thin-walled sections	CO4	R1: Ch.16, R4: Ch.9
36	Active Learning (Stump Your Partner)	CO4	R1: Ch.16, R4: Ch.9
37	Introduction to Plasticity	CO5	R1: Ch.17, R4: Ch.10
38	Yield criteria for pressure dependent and independent materials	CO5	R1: Ch.18, R4: Ch.10
39	Tresca criterion, Von Mises criterion	CO5	R1: Ch.18, R4: Ch.11
40	Mohr-Coulomb criterion, Rankine criterion	CO5	R1: Ch.19, R4: Ch.11
41	Flow rules – Associative and Non-Associative	CO5	R1: Ch.20, R4: Ch.12
42	Hardening rules and consistency conditions	CO5	R1: Ch.20, R4: Ch.12
43	Introduction to iterative methods and return mapping	CO5	R1: Ch.21, R4: Ch.13
44	Applications of plasticity in structural engineering	CO5	R1: Ch.21, R4: Ch.13
45	Unit Test / Review of all topics	CO5	R1: Ch.22, R4: Ch.14
46	Active Learning (Muddiest Point)	CO5	R1: Ch.22, R4: Ch.14

23. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

	NBA Statement / Vital Features

PO NO	Graduate Attributes	Program Outcomes	No. of key competencies
PO1	Research / Investigation	Independently carry out research / investigation and development work to solve practical problems	6
PO2	Report Preparation	Write and present a substantial technical report/document	6
PO3	Domain Mastery (Embedded Systems)	Demonstrate a degree of mastery over the area in Structural Engineering	6
PO4	Application of Engineering Principles	Impart core and interdisciplinary knowledge for analyzing and solving complex problems in structural engineering and related domains	4
PO5	Modern Tools & Societal Impact	Conceptualize and design safe, efficient, and sustainable civil engineering structures in social, economic, and environmental factors	6
PO6	Lifelong Learning & Adaptability	Engage in lifelong learning through continuous education, research, and professional development	8

24. HOW PROGRAM OUTCOMES ARE ASSESSED

PO No.	NBA Statement / Vital Features			
	Graduate Attributes	**Program Outcomes**	**Strength**	**Proficiency Assessed by**
PO1	Research / Investigation	Independently carry out research / investigation and development work to solve practical problems	1.2	CIE/PPT/ SEE/ Objective /quiz/ Assignments
PO2	Report Preparation	Write and present a substantial technical report/document	1	CIE/ Quiz/ SEE/ Assignments/ Tech-Talk/ Viva-Voce/ Internship Report
PO3	Domain Mastery (Embedded Systems)	Demonstrate a degree of mastery over the area in Structural Engineering	3	CIE/ Quiz/ SEE/ Assignments/ Tech-Talk/ Viva-Voce/ Internship Report
PO4	Application of Engineering Principles	Impart core and interdisciplinary knowledge for analyzing and solving complex problems in structural engineering and related domains	3	CIE/ Quiz/ SEE/ Assignments/ Tech-Talk/ Viva-Voce/ Internship Report

PO5	Modern Tools & Societal Impact	Conceptualize and design safe, efficient, and sustainable civil engineering structures in social, economic, and environmental factors	1.6	CIE/ Quiz/ SEE/ Assignments/ Tech-Talk/ Viva-Voce/ Internship Report
PO6	Lifelong Learning & Adaptability	Engage in lifelong learning through continuous education, research, and professional development	1	CIE/ Quiz/ SEE/ Assignments/ Tech-Talk/ Viva-Voce/ Internship Report

3 = High; 2 = Medium; 1 = Low

25. MAPPING OF EACH CO WITH PO(s)

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

26. JUSTIFICATIONS FOR CO – PO MAPPING - DIRECT

Course Outcomes (COs)	POs	Justification for Mapping (Students will be able to...)	No. of Key Components
CO1: Analyze the state of stress in two- and three-dimensional systems using stress tensors, transformations, and invariants.	**PO1**	1: Identify and define research problems in stress analysis. 2: Apply innovative analytical approaches to evaluate stress states.	2
	PO3	1: Demonstrate theoretical mastery in stress transformation and invariants. 2: Apply analytical and computational tools for principal stress determination. 3: Integrate stress components for advanced problem-solving. 5: Validate analytical results through real-world structural interpretations.	4
	PO4	1: Employ advanced computational tools to solve elasticity and compatibility problems .2: Apply simulation results to assess structural performance. 3: Analyze interdisciplinary data for improved understanding. 4: Develop innovative approaches to validate elasticity theories.	4

	PO5	1: Apply safe and sustainable design considerations in stress evaluation.	1
	PO6	7: Engage in lifelong learning through advanced analysis of stress systems.	1
CO2: Interpret different components of strain and their transformations to determine principal and octahedral strains.	**PO1**	2: Review literature and analytical formulations for strain computation. 4: Conduct experimental or simulation-based analysis to validate strain transformation results.	2
	PO3	1: Demonstrate theoretical mastery of strain transformation concepts. 2: Apply analytical and computational methods for principal and octahedral strain evaluation. 3: Integrate stress–strain relationships for structural performance assessment. 5: Interpret analytical outcomes to improve practical design accuracy.	4
	PO4	1: Apply core and interdisciplinary knowledge to analyze strain tensors. 2: Utilize computational mechanics for complex strain field solutions. 3: Combine theoretical and numerical approaches for strain prediction. 4: Critically evaluate model assumptions and limitations.	4
	PO5	1: Ensure safety and material efficiency in strain-based design approaches. 2: Integrate sustainability concepts while optimizing material deformation responses.	2
	PO6	7: Engage in self-learning to advance understanding of modern strain analysis techniques. 8: Demonstrate commitment to professional growth through continuous upskilling in structural mechanics.	2
CO3: Derive stress–strain relationships and material constants for various material symmetries under plane and axi-symmetric conditions.	**PO1**	2: Conduct investigations on elastic constants and strain compatibility. 3: Perform analytical derivations of constitutive equations using theoretical frameworks.	2
	PO3	1: Demonstrate mastery of constitutive modeling and isotropic/anisotropic behavior. 2: Apply advanced elasticity theories to practical structural applications. 3: Validate models using material test data. 5: Relate theory to real-world stress–strain responses in engineering materials.	4
	PO4	1: Integrate material science and structural analysis principles. 2: Utilize computational modeling for material behavior simulation. 3: Employ theoretical-numerical coupling to derive constants. 4: Evaluate results through comparative interpretation.	4
	PO5	1: Incorporate sustainable material use and safety considerations in elastic design.	3

		3: Apply material selection principles in line with environmental goals. 5: Assess economic feasibility of materials through mechanical efficiency.	
	PO6	7: Exhibit self-directed learning in advanced material mechanics.	1
CO4: Solve two- and three-dimensional elasticity problems using stress function approaches and membrane analogy concepts.	**PO1**	3: Conduct experiments or simulations using appropriate tools. 4: Analyze elasticity solutions using numerical models .6: Validate theoretical solutions with computational outcomes.	3
	PO2	1: Prepare structured technical documentation for problem-solving procedures. 4: Communicate elasticity results with clarity and accuracy.	2
	PO3	1: Demonstrate mastery in analytical stress function methods. 2: Apply computational models for two- and three-dimensional elasticity problems. 3: Evaluate principal stresses using simulation-based tools. 5: Validate theoretical findings using applied problem-solving.	4
	PO4	1: Integrate core elasticity principles with interdisciplinary modeling. 2: Apply finite element methods for elasticity solutions. 3: Correlate theoretical and computational stress analysis. 4: Evaluate complex structures under multi-axial stresses.	4
	PO5	1: Design elasticity-based solutions ensuring structural safety. 4: Integrate sustainable and innovative materials in elasticity analysis.	2
	PO6	6: Apply self-learning through computational tools. 7: Engage in reflective learning on stress distribution and deformation. 8: Exhibit commitment to professional development in structural mechanics.	3
CO5: Evaluate yielding behavior of materials using different yield criteria and hardening rules in plasticity.	**PO1**	5: Apply innovative approaches to material yielding behavior. 6: Validate experimental and analytical models of plastic deformation.	2
	PO2	2: Develop structured reports explaining yield theories. 3: Communicate analytical and experimental findings effectively.	2
	PO3	1: Demonstrate mastery of yield criteria (von Mises, Tresca, etc.). 2: Analyze plastic deformation and stress-strain behavior using theoretical models.	4

		3: Validate plasticity models through computational simulation. 5: Apply findings to engineering design processes.	
	PO4	1: Apply interdisciplinary plasticity concepts with computational mechanics. 2: Evaluate multi-axial yielding problems. 3: Use simulation tools for plastic strain and stress distribution. 4: Assess practical implications in structural components.	4
	PO5	1: Incorporate safety and sustainability in plastic design. 2: Design components for resilience against failure. 5: Address social and environmental aspects in material selection. 6: Apply innovative structural systems for durable plastic design.	4
	PO6	6: Enhance self-learning on modern plasticity theories. 7: Pursue continuous learning on material hardening behaviors. 8: Apply advanced simulation tools for plastic deformation analysis.	3

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

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

28. PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

Course Outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6
No. of Key Components	**6**	**6**	**6**	**4**	**6**	**8**
CO1	33.33		66.67	100.00	16.67	12.50
CO2	33.33		66.67	100.00	33.33	25.00
CO3	33.33		66.67	100.00	50.00	12.50
CO4	50.00	33.33	66.67	100.00	33.33	37.50
CO5	33.33	33.33	66.67	100.00	66.67	37.50

29. COURSE ARTICULATION MATRIX (PO MAPPING)

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

0- 0≤ C≤ 5% – No correlation, 2 - 40 % <C < 60% –Moderate

1- 5 <C≤ 40% – Low/ Slight 3 - 60% ≤ C < 100% – Substantial /High

Course Outcomes (COs)	Program Outcomes					
	1	2	3	4	5	6
CO1	1		3	3	1	1
CO2	1		3	3	1	1
CO3	1		3	3	2	1
CO4	2	1	3	3	1	1
CO5	1	1	3	3	3	1
Average	1.2	1.0	3.0	3.0	1.6	1.0

30. ASSESSMENT METHODOLOGY DIRECT

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

31. ASSESSMENT METHODOLOGY INDIRECT

✓	Course End Survey (CES)

32. RELEVANCE TO SUSTAINABILITY GOALS

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

S.NO.	SDGS	DESCRIPTION
1		
2		
3		Ensures safety and reliability of structures such as hospitals and community buildings by accurate stress and strain analysis, preventing structural failures that can endanger lives.

4	QUALITY EDUCATION	Strengthens quality education by developing analytical, design, and problem-solving skills essential for sustainable engineering practices.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	Develops the ability to design, analyze, and optimize safe, sustainable, and innovative infrastructure using elasticity and plasticity principles.
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	Enables the design of earthquake-resistant, resilient, and sustainable structural systems for urban and rural development.
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	

13	CLIMATE ACTION	
14	LIFE BELOW WATER	
15	LIFE ON LAND	Promotes sustainable land infrastructure by reducing the environmental footprint through optimized structural design and material selection.
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	
17	PARTNERSHIPS FOR THE GOALS	Encourages interdisciplinary research collaborations and industry partnerships for solving real-world structural and material challenges.

Signature of Course Coordinator **HOD**