OBE MANUAL

M. Tech CAD/CAM

MLRS R 22 Regulation

MARRI LAXMAN REDDY INSTITUTE OF TECHNOLOGY AND MANAGEMENT

OVERVIEW

Outcome Based Education (OBE) forms the foundation of quality assurance in higher technical education, particularly in postgraduate program 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 program. 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 programs in India. NBA accreditation is program-specific and not institution-specific. As a full signatory of the Washington Accord, the NBA ensures that accredited engineering programs 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 programs.

Institutions offering MTech programs 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.

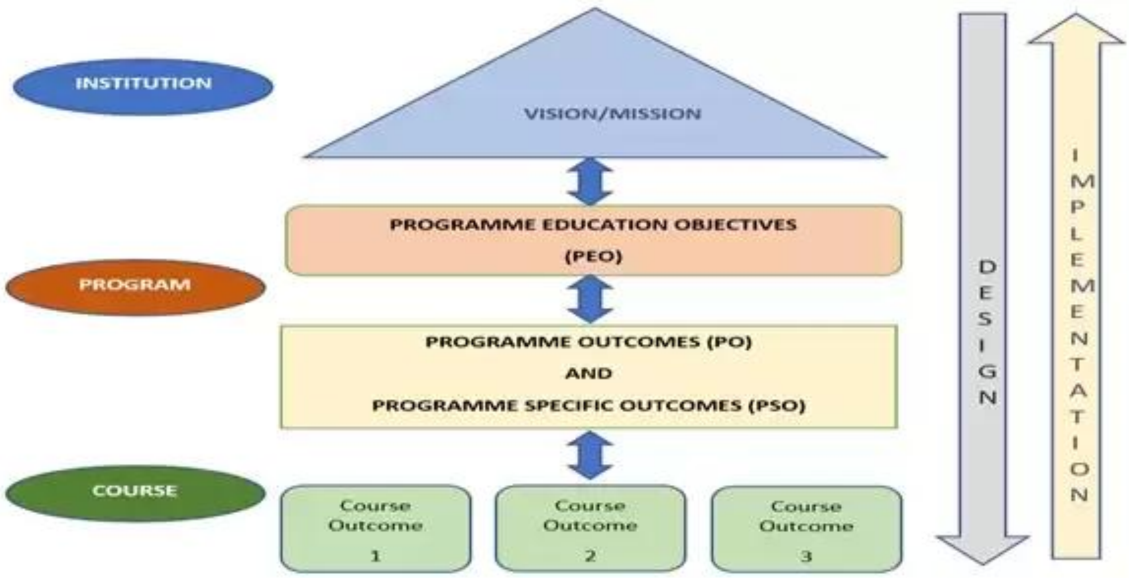

Figure1: OBE process

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 Programs?

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

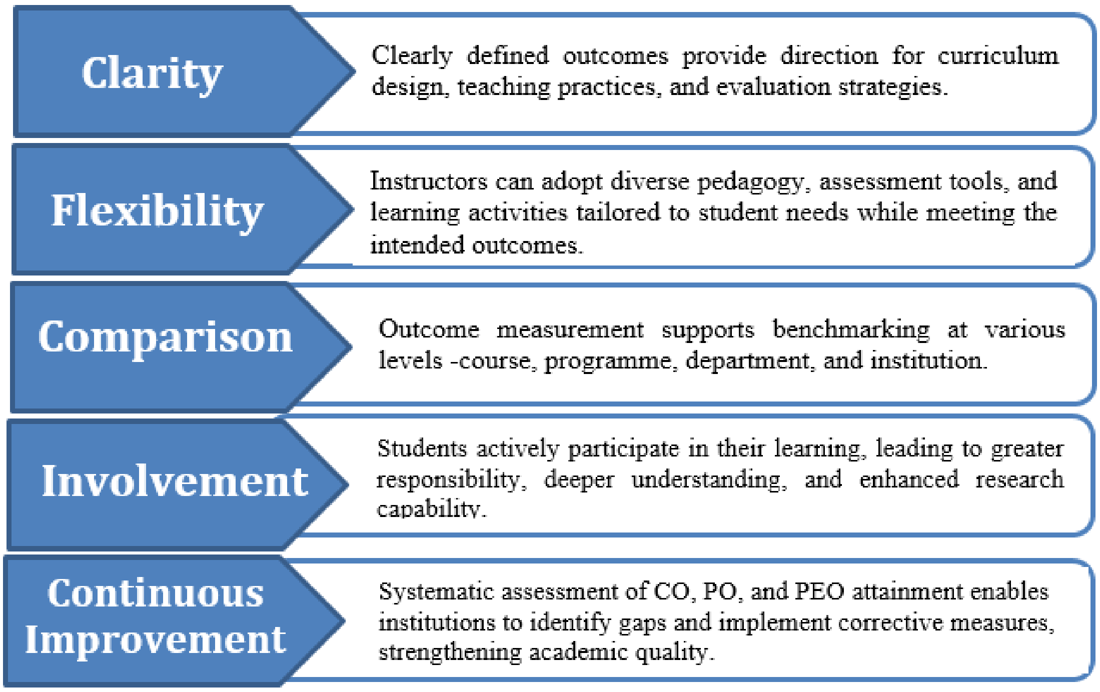

Figure 2: Benefits of Outcome Based Education

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 programs 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 programs 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, program, 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)

POs represent the graduate attributes as defined by the NBA, while some reflect 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, Analyse, 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 analysed to identify strengths and areas for improvement.

Curriculum Gap Analysis

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

Program Outcome Attainment Review

PO attainment levels are compared for the past three academic years. Remedial actions are proposed and implemented based on the analysis.

Program Educational Objectives (PEO) Assessment

PEO attainment is assessed periodically using alumni feedback, employer surveys, and higher studies/placement data.

Vision, Mission & PEOs of the Department

2.1 Vision of the Department

The Mechanical Engineering Department strives to foster innovation, excellence, and leadership in education and research, advancing sustainable development globally.

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2.2 Mission of the Department

DM1: To provide innovative and sustainable technology solutions to solve a wide range of complex scientific and technological challenges in the Mechanical Engineering field.

DM2: To enhance employability, leadership skills, and research capabilities through industry collaboration and experiential learning.

DM3: To nurture students as ethical and resilient professionals committed to lifelong learning.

DM4: To promote excellence in emerging interdisciplinary fields to support sustainable global progress.

2.3 Program Educational Objectives (PEOs)

PEO1: To develop a strong foundation in mechanical engineering principles for analyzing, designing, and innovating engineering solutions.

PEO2: To equip graduates with skills and knowledge to address industry challenges and contribute effectively to societal needs.

PEO3: To foster the ability to collaborate across multidisciplinary teams while upholding professional ethics and responsibility.

PEO4 → To promote lifelong learning, adaptability, and leadership skills for continuous personal and professional growth in a dynamic environment.

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 CAD/CAM. 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 in Advanced Design and Manufacturing Technologies, including comprehensive knowledge of design methods, 3D printing processes, and related tools to support modern manufacturing.

PO4
Application of Engineering Principles

Solve complex engineering challenges using computational and digital manufacturing tools, considering global issues and perspectives.

PO5
Design and Sustainability

Apply advanced knowledge, techniques, and skills along with CAD/CAM technologies to address engineering and manufacturing challenges, emphasizing innovation and sustainable development.

PO6
Lifelong Learning and Professional Development

Engage in life-long learning and professional development to adapt to evolving technologies and industry practices.

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 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**.**

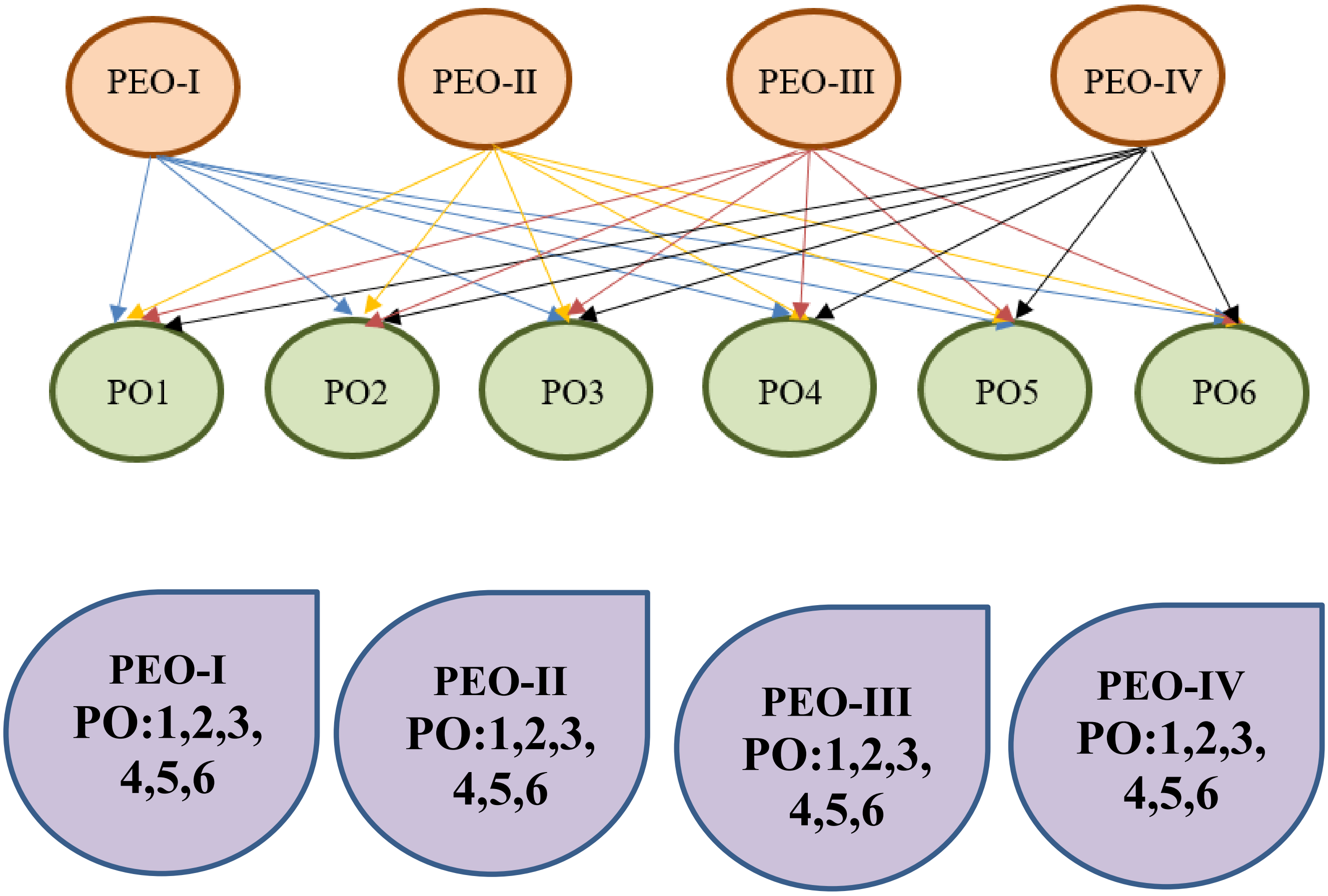


Figure 4: Correlation between the PEOs and the POs

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) Strong Foundation in ME principles	(2) Industry & societal problem solving	(3) Teamwork, ethics & responsibility	(4) Lifelong learning & leadership
PO1	Independently carry out research investigation and development work to solve practical problems	3	3	2	2
PO2	Write and present a substantial technical report/document.	3	2	2	2
PO3	Demonstrate a degree of mastery in Advanced Design and Manufacturing Technologies, including comprehensive knowledge of design methods, 3D printing processes, and related tools to support modern manufacturing	3	3	3	2
PO4	Solve complex engineering challenges using computational and digital manufacturing tools, considering global issues and perspectives.	3	3	3	2
PO5	Apply advanced knowledge, techniques, and skills along with CAD/CAM technologies to address engineering and manufacturing challenges, emphasizing innovation and sustainable development.	3	2	2	3

PO6	Engage in life-long learning and professional development to adapt to evolving technologies and industry practices.	3	2	3	3

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),
- Comprehensive Assessment Tool (CAT), Assignments/Quiz and
- Semester-end examinations.

Indirect Assessment is carried out through:

- Program Exit Surveys from post graduate 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.

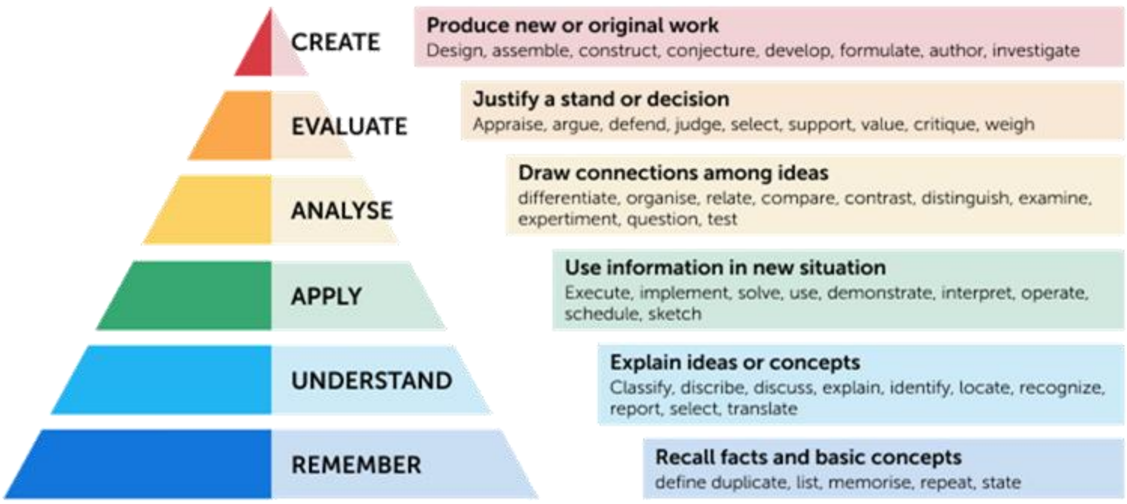


Figure 5: Blooms Taxonomy

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, Analyse, 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.

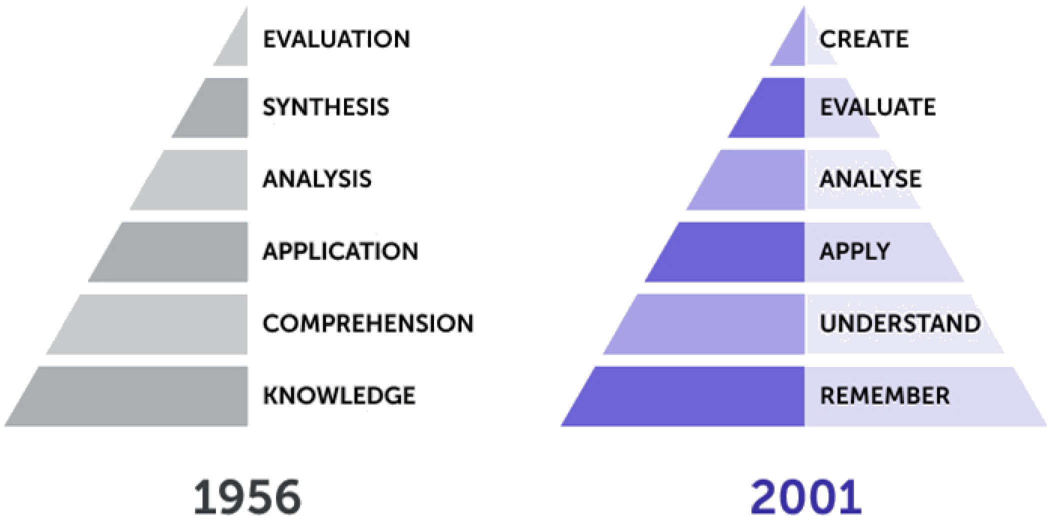


Figure 6: Blooms Taxonomy (Original and Revised)

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.

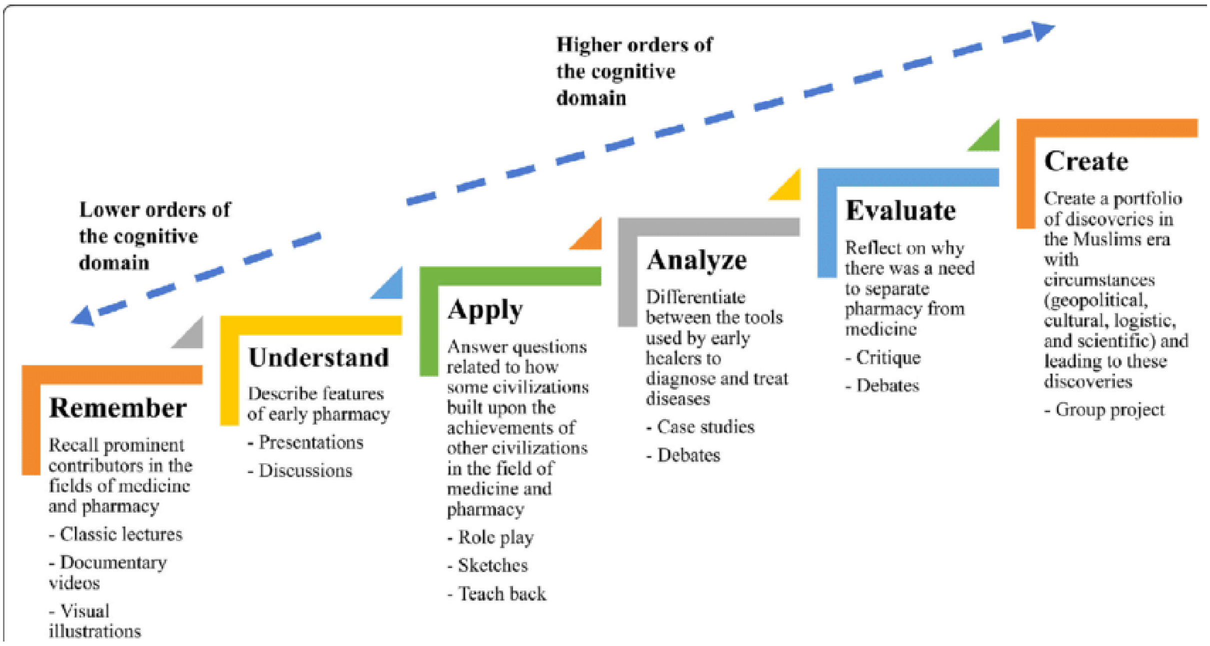


Figure 7: The cognitive process dimensions – categories

Table 2: The Knowledge Dimension

KNOWLEDGE DIMENSION		**Remember**	**Understand**	**Apply**	**Analyse**	**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 original 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 learning style theory to own learning	Create original 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)

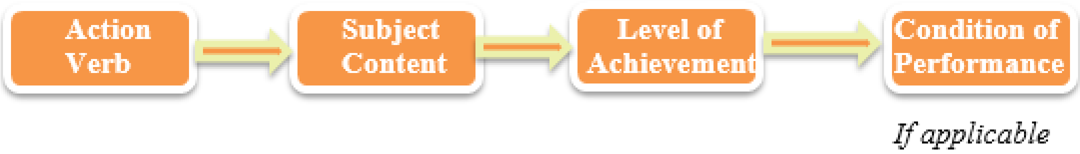
A Course Outcome is a formal statement of what students are expected to learn in a course. When creating Course Outcomes, remember that the outcomes should clearly state what students will do or produce to determine and/or demonstrate their learning. Course learning outcome statements refer to specific 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 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** comprehensive knowledge of advanced design methods, digital manufacturing processes, and modern tools such as CAD/CAM and 3D printing.)

Student-focused outcome: "Upon completion of this course, students will be able to **Demonstrate** comprehensive knowledge of advanced design methods, digital manufacturing processes, and modern tools such as CAD/CAM and 3D printing by explaining theoretical principles, analyzing mechanical and load conditions, modeling component and system behavior, and illustrating solutions through engineering drawings, simulations, or design applications."

Instructor-centric objective (to avoid): "One objective of this course is to teach students the concepts of computer-aided design and computer-aided manufacturing (CAD/CAM), including geometric modeling, tool path generation, CNC programming, and integration of design and manufacturing processes for efficient product development."

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** advanced design principles and manufacturing techniques to analyze and solve practical engineering problems independently.
- **Prepare** and presenting technical reports and documentation effectively using appropriate engineering standards and tools.
- **Demonstrate** comprehensive knowledge of advanced design methods, digital manufacturing processes, and modern tools such as CAD/CAM and 3D printing.
- **Utilize** computational and digital manufacturing tools to solve complex engineering problems while considering global and industrial perspectives.
- **Develop** innovative and sustainable engineering solutions by applying advanced technologies and modern manufacturing practices.
- **Recognize** the need for continuous learning and professional development to keep pace with emerging technologies and industry trends.
- **Analyze** and select appropriate materials, manufacturing processes, and design strategies for advanced engineering applications.
- **Integrate** modern engineering tools and simulation techniques to evaluate design performance and improve manufacturing efficiency.
- **Apply** systematic problem-solving approaches and professional practices to work effectively on 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 Behaviour	Standard

1	Given a mechanical component with specific design requirements and constraints	The student will be able to explain geometric modelling concepts, design intent, and distinguish between parametric and non-parametric modelling approaches.	Correctly addressing at least 80% of identified modelling criteria.
2	Given a component drawing and manufacturing specifications	The student will be able to generate CAD models and develop appropriate CNC tool paths using CAM software.	Generated tool paths and machining parameters meeting design requirements ±5% of manufacturing tolerances.
3	Using a CAD assembly model with defined material and process parameters	The student will be able to analyse manufacturability, identify interferences, and evaluate assembly feasibility.	Correct identification of design or assembly issues with appropriate corrective measures.

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, 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
$0 \le C \le 5\%$	No correlation	0
$5\% < C \le 40\%$	Low/Slight correlation	1
$40\% < C < 60\%$	Moderate correlation	2
$60\% \le C < 100\%$	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 CAD/CAM 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 collected, analysed, and interpreted 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 in Advanced Design and Manufacturing Technologies, including comprehensive knowledge of design methods, 3D printing processes, and related tools to support modern manufacturing.	1. Apply advanced design methodologies. 2. Demonstrate proficiency in additive manufacturing. 3. Integrate automation and digital manufacturing tools. 4. Analyze and optimize manufacturing systems. 5. Incorporate emerging smart technologies. 6. Promote sustainability and advanced material utilization.	6

PO 4.	Solve complex engineering challenges using computational and digital manufacturing tools, considering global issues and perspectives.	1. Modeling and Simulation for Problem Solving. 2. Digital Manufacturing Tools and Technologies. 3. Global and Sustainable Perspectives. 4. Emerging Technologies for Complex Challenges.	4
PO 5.	Apply advanced knowledge, techniques, and skills along with CAD/CAM technologies to address engineering and manufacturing challenges, emphasizing innovation and sustainable development.	1. Advanced Modeling and CAD/CAM Integration. 2. Innovative Design and Product Development. 3. Manufacturing Process Optimization. 4. Sustainable Manufacturing Practices. 5. Prototyping and Validation with Emerging Technologies. 6. Global and Ethical Perspectives in Engineering.	6
PO 6.	Engage in life-long learning and professional development to adapt to evolving technologies and industry practices.	1. Continuous Knowledge Upgradation. 2. Research and Innovation Skills. 3. Adaptation to Digital Transformation. 4. Interdisciplinary Learning. 5. Professional Skill Development. 6. Global and Ethical Awareness. 7. Self-Directed and Lifelong Learning. 8. Adaptability to Industry Practices.	8

6.3 Program Outcomes Attained through course modules:

Courses offered in CAD/CAM Curriculum (MLRS-R22) and POs attained through course modules for I, II, III and IV semesters.

Table 7: CO-PO articulation Matrix for M. Tech ADVANCED CAD (MLRS R 22) regulation

Code	Subject	PO					
		1	2	3	4	5	6
I M. Tech –I Semester							
2214001	Advanced CAD	2.40	2.40	2.60	2.60	2.20	2.80
2214002	Additive Manufacturing	2.40	2.40	2.40	1.80	2.00	2.60
2214011	Finite Element and Boundary Element Method	2.80	2.60	2.60	2.40	2.20	2.80
2214012	Experimental Stress Analysis	2.60	2.20	2.80	2.60	2.00	2.40
2214013	Green Manufacturing	2.40	1.80	2.60	2.40	2.20	2.40

2214014	Automation in Manufacturing	2.60	2.40	2.60	2.20	2.00	1.80
2214015	Computer Aided Process Planning	2.40	2.00	2.60	2.40	2.00	2.20
2214016	Industrial Robotics	2.40	2.00	2.60	2.40	2.20	2.60
2211234	RM&IPR	2.60	2.80	2.40	2.40	2.20	2.80
2214040	ACAD LAB	2.60	2.40	2.60	2.40	2.60	2.80
2214041	3D Printing Lab	2.60	2.20	2.80	2.60	2.00	2.80
2210401	English for Research Paper Writing	2.40	2.80				2.80
I M. Tech –II Semester							
2224003	Computer Integrated Manufacturing	2.20	2.40	2.20	2.20	2.00	2.80
2224004	Simulation Modelling &Analysis	2.00	2.20	2.40	2.00	1.80	2.60
2224017	Intelligent Manufacturing systems	2.60	2.40	2.60	2.20	2.00	2.80
2224018	IOT & Industry 4.0	2.20	2.00	2.60	2.40	1.80	2.20
2224019	Optimization Techniques & Applications	2.20	2.00	2.60	2.20	1.80	2.40
2224020	Mechatronics	2.20	2.40	2.80	2.40	2.00	2.40
2224021	MEMS	2.60	2.00	2.80	2.40	2.00	2.40
2224022	Fuzzy logic & Neural Networks	2.40	2.00	2.80	2.40	2.20	2.40
2224044	Mini project with Seminar	3.00	3.00	3.00	3.00	3.00	3.00
2224042	Simulation of Manufacturing systems Lab	2.80	2.60	2.60	2.80	2.40	2.80
2224043	CAM Lab	2.80	2.40	2.80	2.60	2.40	2.80
2220006	Pedagogy Studies	2.00	2.40				2.60
II M. Tech –I Semester							
2234023	Design For Manufacturing & Assembly	2.40	2.20	2.60	2.40	1.80	2.40
2234024	Composite Materials	2.60	2.20	2.60	2.60	2.00	2.60
2234025	Artificial Intelligence & Manufacturing	2.40	1.80	2.60	1.80	1.60	2.60
2235503	Fundamentals of Nano Technology	2.00	1.80	2.40	2.20	1.80	2.60
2232076	Dissertation Work Review – I	3.00	3.00	3.00	3.00	3.00	3.00
II M. Tech –II Semester							
2242077	Dissertation Work Review – III	3.00	3.00	3.00	3.00	3.00	3.00
2242078	Dissertation Viva -Voce	3.00	3.00	3.00	3.00	3.00	3.00

Methods for measuring Learning

There are many 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 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 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 analysed 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 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 at least 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 American Society of Mechanical Engineers (ASME), Institution of Mechanical Engineers (IMechE), Society of Automotive Engineers (SAE), Indian Society of Mechanical Engineers (ISME), and the Institution of Engineers (India) [IE(I)] is explained to the students, and they are encouraged to become members of these professional bodies to promote continuous learning and professional development. Student and faculty chapters of these societies are established to foster a strong technical, research-oriented, and entrepreneurial environment within the department. These professional societies play a vital role in promoting excellence in mechanical engineering education, research, innovation, public service, and professional practice, thereby enhancing students' technical competence and preparedness to meet industry and societal challenges.

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 is illustrated in Table.

Table 8: CO-PO Mapping

<table>
<tr><th>Assessment Method</th><th>Assessment Tool</th><th>Weightage in CO attainment</th></tr>
<tr><td rowspan="2">Direct Assessment</td><td>Continuous Internal Evaluation (CIE)</td><td rowspan="2">80%</td></tr>
<tr><td>Semester End Examination</td></tr>
</table>

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.

- CIE 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	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	Presentation	Twice in a	40	Presentation

S No	Courses	Components	Frequency	Max. Marks	Evidence
	Work		semester		
		Semester End Examination	Once in a semester	60	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
	Direct Assessment	CO attainment of courses	80%

POs Attainment	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.

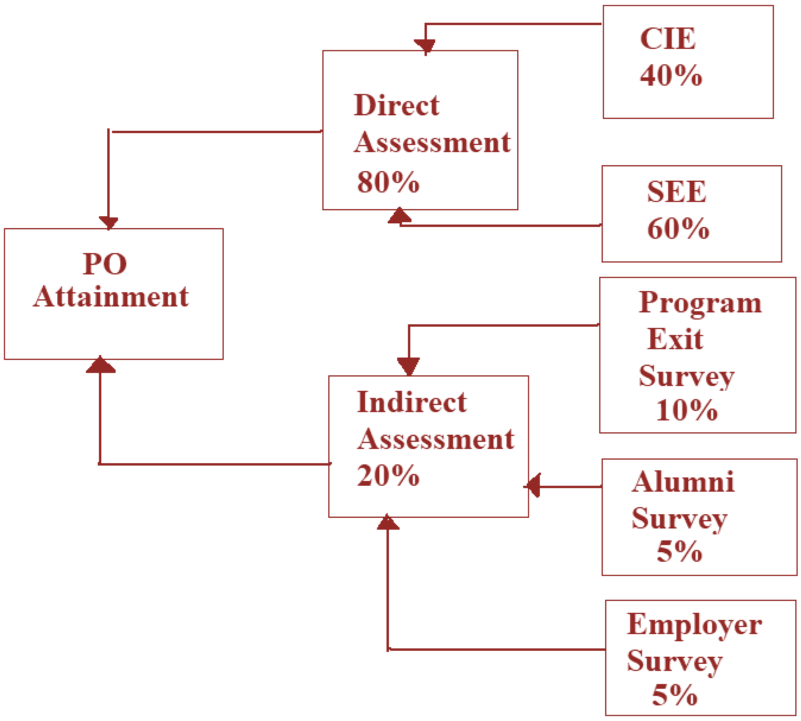


Figure3: Evaluation process of POs attainment

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

ADVANCED CAD

COURSE DESCRIPTOR

1	**Department**	MECHANICAL ENGINEERING
2	**Course Name**	ADVANCED CAD
3	**Course Code**	2214001
4	**Year/Semester**	I/I
5	**Regulation**	MLRS-R22
6	**Course Offered**	Odd Semester
7	**Course Coordinator**	Dr. S. P. Jani
8	**Date Approved by BOS**	
9	**Course Webpage**	www.mlritm.ac.in/

10.Structure of the Course

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

11. Credits of the Course

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

12. Type of the Course

PC	PE	AC	MPS	PS
√	-	-	-	-

13. Total Hours Offered

Lectures	Tutorials	Practicals
48	-	-

14. Prerequisites/ Co-requisites

Level	Course Code	Semester	Prerequisites
PG	-	-	

15. Course Overview

This course provides an in-depth study of Advanced Computer-Aided Design (CAD), focusing on the principles, tools, and applications of geometric modelling in engineering. It introduces CAD tools, graphics standards, and software requirements, followed by fundamentals of geometric construction and modelling. Students will learn wireframe modelling with analytic and synthetic curve representations such as Bezier, B-Spline, and NURBS, along with techniques for curve manipulation. The course covers surface modelling, including analytic and synthetic surfaces with methods for classification, representation, and manipulation, as well as solid modelling using boundary representation, constructive solid geometry, Euler operators, sweeping techniques, and feature modelling. Further, it addresses geometric transformations, projections, hidden surface removal, shading, and rendering for visualization. Emphasis is also placed on evaluation of CAD software, international data exchange formats like IGES and STEP, and the application of dimensioning and tolerances (linear, angular, MMC, LMC, RFS).

16. Course Objectives

The students will try to learn:

1	The fundamental knowledge of CAD tools, graphics standards, and geometric modelling techniques for engineering applications.
2	The ability to model engineering components using wireframe, surface, and solid modelling techniques.
3	The ability to apply geometric transformations, projections, and visualization techniques for accurate 2D/3D representation
4	The familiarity with CAD data exchange formats, dimensioning, and tolerancing practices in line with international standards.
5	The CAD methodologies in solving engineering and manufacturing challenges with emphasis on innovation and sustainability.

17. Course Outcomes

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

CO1 — **Apply** the CAD process and geometric modelling concepts to effectively perform design tasks..

CO2 — **Develop** and manipulate wireframe models, parametric curves using analytic and synthetic curve representations.

CO3 — **Evaluate** surface entities and parametric surface representation methods using analytic and synthetic approaches.

CO4 — **Analyze** solid modeling techniques including boundary representation, CSG, sweeping methods, and feature modeling for effective 3D representation

CO5 — **Utilize** CAD transformations, visualization, data exchange and dimensioning concepts in design problems.

18. Employability Skills

Skill Category	Description	Relevance to Course
Problem-Solving Skills	Develops ability to identify design challenges and propose efficient designs.	Designing components for domains like automotive, aerospace, healthcare, and agriculture.
Analytical Thinking	Encourages analysis of geometric models, from wireframe to solid representation, requiring critical evaluation of design alternatives and accuracy in parametric definitions.	Wireframe, surface modelling, solid modelling nurture the ability to break down complex geometry into analysable parts, fostering logical reasoning and precision in engineering.
Software & Hardware Integration	Learners gain hands-on experience with CAD software tools and understand their integration with hardware (like graphic systems, input/output devices) to render models effectively.	Implementing CAD tools & transformations directly contribute, enabling students to bridge theoretical design concepts with practical software-hardware execution.
Collaboration & Teamwork	Fosters teamwork in developing, CAD-based projects often involve group design tasks, where different team members handle wireframes, surfaces, solids, or visualization aspects, requiring coordination.	Participation in group projects and labs students practice collaborative workflows, sharing models, resolving design conflicts, and combining outputs into unified 3D representations.
Adaptability & Continuous Learning	CAD tools and techniques evolve rapidly. The course encourages students to adapt to new design modules, software updates, and advanced modelling standards.	Staying updated with CAD software's promote flexibility and readiness to upgrade knowledge, aligning with industry demands.
System Design Thinking	Beyond individual modelling skills, student develops to think holistically about engineering systems, integrating multiple CAD techniques to design complete and functional products.	Establish a framework where learners not only creating models but also envision their role in a larger design and manufacturing system, supporting innovation and sustainable engineering practices.

19. Content Delivery / Instructional Methodologies

PowerPoint Presentation	√	**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 examinations.

Each CIE 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 CIE examinations shall be taken as the final marks for CIE examination.

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)	30 Marks	30 Marks	40 Marks	60 Marks	100 Marks
Assignment	5 Marks	5 Marks			
CAT (Concept video/Tech-talk/certificate)	5 Marks	5 Marks			
Total Marks	**40 Marks**	**40 Marks**	**40 Marks**	**60 Marks**	**100 Marks**

21. Course content - Number of modules: Five:

Module	Module Description	No. of Lectures
MODULE 1	**CAD Tools**: Definition of CAD Tools, Graphics standards, Graphics software: requirements of graphics software, Functional areas of CAD, Efficient use of CAD software. Basics of Geometric Modelling: Requirement of geometric 3D Modelling, Geometric models, Geometric construction methods, Modelling facilities desired.	No. of Lectures: 7
MODULE 2	**Geometric Modelling**: Classification of wireframe entities, Curve representation methods, Parametric representation of analytic curves: line, circle, arc, conics, Parametric representation of synthetic curves: Hermite cubic curve, Bezier curve, B-Spline curvewire, NURBS, Curve manipulations.	No. of Lectures:9
MODULE 3	**Surface Modelling**: Classification of surface entities, Surface representation methods, Parametric representation of analytic surfaces: plane surface, ruled surface, surface of revolution, tabulated cylinder, Parametric representation of synthetic curves: Hermite cubic surface, Bezier surface, B-Spline surface, Blending surface, Surface manipulations.	No. of Lectures: 11
MODULE 4	**Solid Modelling**: Geometry and topology, Boundary representation, The Euler-Poincare formula, Euler operators, Constructive solid geometry: CSG primitives, Boolean operators, CSG expressions, Interior, Exterior, closure, Sweeping: linear and non-linear, Solid manipulations, feature modelling.	No. of Lectures: 10
MODULE 5	**Transformatio**ns:2-D and 3-D transformations: translation, scaling, rotation, reflection, concatenation, homogeneous coordinates, Perspective projection, orthotropic projection, isometric projection, Hidden surface removal, shading, rendering. Evaluation Criteria: Evaluation criteria of CAD software, Data exchange formats: GKS, IGES, PHIGS, CGM, STEP Dimensioning and tolerances: Linear, angular, angular dimensions,	No. of Lectures: 11

	maximum material condition (MMC), Least material condition (LMC), Regardless of feature size (RFS).	

TEXT BOOKS:

1 CAD/CAM Concepts and Applications/ Alavala/ PHI.

2. Mastering CAD/CAM / IbrhimZeid / McGraw Hill International.

3. CAD/CAM Principles and Applications/ P.N. Rao/TMH/3rd Edition

REFERENCES BOOKS:

1. CAD/CAM /Groover M.P./ Pearson education
2. CAD / CAM / CIM, Radhakrishnan and Subramanian/ New Age
3. Principles of Computer Aided Design and Manufacturing/ Farid Amirouche/ Pearson
4. Computer Numerical Control Concepts and programming/ Warren S Seames/ Thomson.

ELECTRONIC RESOURCES

Resource Type	Title/Description	Link
Online Courses	**Swayam:** Computer Aided design by Prof. Anoop chawla | IIT Delhi	https://nptel.ac.in/courses/112102102
	Swayam: Over view of CAD/CAM by Prof. P.V. Madhusudan rao | IIT Delhi	https://nptel.ac.in/courses/112102101
You Tube DSS Lectures-MLRITM		

22. COURSE PLAN

S. No.	Topics to be covered	COs	Reference
1	Definition of CAD Tools	CO 1	T1:1.1
2	Graphics standards, Graphics software:	CO 1	T1:1.2
3	Requirements of graphics software	CO 1	T1:1.4,2.9
4	Functional areas of CAD	CO 1	R1:2.1
5	Efficient use of CAD software.	CO 1	T1:2.3,4
6	Requirement of geometric 3D Modelling	CO 1	T1:2.5
7	Geometric models	CO 1	T1:2.7
8	Geometric construction methods	CO 1	R1:2.8
9	Modelling facilities desired	CO 1	T1:3.1
10	Definition of CAD Tools (**Active Learning – 1 Flipped Class)**	CO1	T1:1.1
11	Classification of wireframe entities	CO 2	T2:2.1.1,2.1.2

12	Curve representation methods	CO 2	T2:2.1.3
13	Parametric representation of analytic curves	CO 2	T2:2.1.4
14	Parametric representation of synthetic curves	CO 2	T2:2.1.5
15	Curve manipulations	CO 2	T2:2.5
16	Summary of Wire frame modelling (**Active Learning - 2 Collaborative Learning)**	CO 2	R2:4.1
17	Classification of surface entities	CO 3	T2:3.1
18	Surface representation methods	CO 3	T2:3.2
19	Parametric representation of analytic surfaces	CO 3	T2:3.3
20	Parametric representation of synthetic curves	CO 3	T1:4.1
21	Bezier surface, ,.	CO 3	T1:4.2
22	B-Spline surface	CO 3	T2:2.5
23	Blending surface	CO 3	T1:4.3
24	Surface manipulations (**Active Learning -3: Muddiest Point)**	CO 3	T1:4.4
25	Geometry	CO 4	R3:5.1
26	Boundary representation	CO 4	R3:5.2
27	Euler-Poincare formula	CO 4	R3:5.2
28	Constructive solid geometry	CO 4	R3:5.3
29	CSG expressions	CO 4	R3:5.4
30	Interior,	CO 4	R3:5.4
31	Exterior	CO 4	R3:5.5
32	Closure	CO 4	T1:3.3
33	Euler operators,	CO 4	T1:3.4
34	Topology	CO 4	T1:3.4
35	Sweeping: linear	CO 4	T1:3.7
36	Sweeping: non-linear	CO 4	T1:3.5
37	Solid manipulations,	CO 4	T1:3.5
38	Feature modelling. (**Active Learning - 4 Think Pair Share)**	CO 4	T1:6.3
39	Geometry	CO 4	R3:5.1
40	2-D and 3-D transformations	CO 5	T1:3.6
41	Homogeneous coordinates	CO 5	T1:5.1
42	Hidden surface removal, shading, rendering	CO 5	T1:5.2
43	Evaluation criteria of CAD software	CO 5	T1:13.1
44	Data exchange formats	CO 5	T1:14.1
45	GKS, IGES, PHIGS, CGM, STEP	CO 5	T1:14.3
46	Linear, angular, angular dimensions	CO 5	T1:13.3,14.4
47	MMC & LMC	CO 5	T1:8.1
48	Regardless of feature size (**Active Learning - 5 Stump Your Partner)**	CO 5	T1:8.2,8.3

23. 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 (CAD/CAM)	Demonstrate a degree of mastery in Advanced Design and Manufacturing Technologies, including comprehensive knowledge of design methods, 3D printing processes, and related tools to support modern manufacturing.	6
PO4	Application of Engineering Principles	Solve complex engineering challenges using computational and digital manufacturing tools, considering global issues and perspectives.	4
PO5	Modern Tools & Societal Impact	Apply advanced knowledge, techniques, and skills along with CAD/CAM technologies to address engineering and manufacturing challenges, emphasizing innovation and sustainable development.	6
PO6	Lifelong Learning & Adaptability	Engage in life-long learning and professional development to adapt to evolving technologies and industry practices.	8

24. HOW PROGRAM OUTCOMES ARE ASSESSED

PO No.	**NBA Statement / Vital Features**			
	Graduate Attributes	**Program Outcomes**	**Strength**	**Proficiency Assessed by**
PO1	Research / Investigation	An ability to independently carry out research /investigation and development work to solve practical problems	3	CIE/PPT/ SEE/ Objective /quiz/ Assignments
PO2	Report Preparation	An ability to write and present a substantial technical report/document	3	CIE/ Quiz/ SEE/ Assignments/ Tech-Talk/ Viva-Voce/ Internship Report
PO3	Domain Mastery (CAD/CAM)	Demonstrate a degree of mastery in Advanced Design and Manufacturing Technologies, including comprehensive knowledge of design methods, 3D printing processes, and related tools to support modern manufacturing.	3	CIE/ Quiz/ SEE/ Assignments/ Tech-Talk/ Viva-Voce/ Internship Report
PO4	Application of Engineering Principles	Solve complex engineering challenges using computational and digital manufacturing tools, considering global issues and perspectives.	2	CIE/ Quiz/ SEE/ Assignments/ Tech-Talk/ Viva-Voce/ Internship Report

PO5	Modern Tools & Societal Impact	Apply advanced knowledge, techniques, and skills along with CAD/CAM technologies to address engineering and manufacturing challenges, emphasizing innovation and sustainable development.	2	CIE/ Quiz/ SEE/ Assignments/ Tech-Talk/ Viva-Voce/ Internship Report
PO6	Lifelong Learning & Adaptability	Engage in life-long learning and professional development to adapt to evolving technologies and industry practices.	2	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: Apply CAD concepts and functional modules to configure graphic standards, and utilising CAD tools effectively in engineering design tasks.	PO1	1.Research problems in CAD/CAM are clearly identified and defined. 2.Literature review highlights research gaps and suitable methods. 3.Experiments or simulations are conducted using appropriate tools.	3
	PO 2	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.	3
	PO3	1. Apply advanced design methodologies. 2. Demonstrate proficiency in additive	3

		manufacturing. 3.Integrate automation and digital manufacturing tools	
	PO4	1. Modelling and Simulation for Problem Solving. 2.Digital Manufacturing Tools and Technologies.	2
	PO5	1. Advanced Modelling and CAD/CAM Integration. 2. Innovative Design and Product Development. 3. Manufacturing Process Optimization.	2
	PO6	1. Continuous Knowledge Upgradation. 2. Research and Innovation Skills. 3. Adaptation to Digital Transformation. 4. Interdisciplinary Learning	4
CO2: Develop and manipulating wireframe and curve models using both analytic and synthetic parametric representations.	**PO1**	1.Wireframe and curve modelling allows students to represent complex geometries precisely, helping in identifying structural behaviour, load paths, and boundary conditions for research problems. 2. By studying analytic and synthetic parametric representations, students can evaluate the limitations of existing modelling techniques, thereby identifying gaps and suitable approaches in structural analysis. 3. Wireframe and parametric models serve as strong visual aids that simplify complex ideas, supporting effective oral communication and technical presentations.	4
	PO2	1. Wireframe and curve models provide precise graphical representations that enhance the structure of technical documents, making reports and dissertations more systematic. 2. Analytic and synthetic curve models improve the clarity and precision of complex geometry representation, enabling logical flow in technical presentations and documentation. 3. Content is presented with clarity, precision, and logical flow	4
	PO3	1. Wireframe and parametric curve modelling enable application of advanced design techniques such as generative design, free-form surface creation, and optimisation of complex geometries. 2. Wireframe and curve models form the foundation for CAD/CAM integration, allowing smooth transition from design to automated CNC or robotic manufacturing processes.	4

		3. Wireframe and parametric representations support lightweight, material-efficient designs, helping reduce waste and enabling the use of advanced sustainable materials. 4.Proficiency in CAD-based digital tools, ensuring advanced visualization of engineering concepts.	
	PO4	1. Parametric models are directly used in CAD/CAM workflows. 2. additive manufacturing, ensuring compatibility with modern digital manufacturing tools.	3
	PO5	1. Wireframe and curve parametric models are the building blocks for advanced surface modelling and ensure seamless CAD/CAM integration for automated manufacturing. 2. Curve and wireframe models allow evaluation of manufacturability, minimization of design complexity. 3.optimization of processes before physical production.	3
	PO6	1. Wireframe and curve modelling involves advanced parametric techniques, encouraging students to keep upgrading their knowledge with the latest CAD features and tools. 2. Wireframe and curve modelling finds applications across mechanical, civil, aerospace, and materials engineering, promoting interdisciplinary applications of CAD. 4.Proficiency in CAD-based digital tools, ensuring advanced visualization of engineering concepts.	4
CO3: Construct complex surfaces using parametric representation of analytic and synthetic	**PO1**	1. Complex surface modelling allows precise representation of curved geometries in structural components, helping define research problems related to aerodynamics, stress distribution, and material performance. 2. By studying existing surface modelling methods, students can identify gaps in traditional approaches and justify the adoption of parametric analytic and synthetic representations for better accuracy and flexibility. 3. Parametric surface construction facilitates design optimisation, free-form geometry creation, and generative methods, encouraging innovative approaches to solving complex engineering challenges. 4. Simulation results generated from surface models—such as stress contours, deformation, or fluid flow—can be systematically extracted and interpreted to provide meaningful engineering insights.	3
	PO2	1. Parametric surface models provide detailed visuals and data that strengthen the structure and clarity of technical documentation, dissertations, and research papers.	3

		2. Surface models and 3D visualisations act as strong communication aids, simplifying complex concepts and supporting clear oral presentations 3.use of advanced CAD tools for constructing surfaces, ensuring proficiency in digital documentation and visual representation.	
	PO3	1. Constructing complex parametric surfaces equips students with advanced modelling techniques such as free-form design, generative modelling, and topology optimisation. 2. Parametric surface models serve as the foundation for preparing accurate STL/AMF files, ensuring manufacturable designs for 3D printing and additive manufacturing. 3. CAD models that can be directly integrated with CAM, CNC, and robotic systems, supporting automation in digital manufacturing workflows. 4. Parametric surfaces enable simulation and optimisation of aerodynamic/structural performance, improving system efficiency.	4
	PO4	1. Parametric surface construction allows learners to simulate real-world geometries, test structural/aerodynamic behaviour, and solve complex design challenges through accurate virtual models. 2. Emphasizes CAD/CAM integration where surface models are directly utilized in CNC machining, additive manufacturing, and automated production pipelines. 3. By developing lightweight, precise, and resource-efficient surface models, surface modelling promotes sustainable design approaches with applications across aerospace, automotive, and biomedical sectors.	2
	PO5	1. Constructing parametric surfaces develops expertise in CAD and CAM platforms, ensuring seamless transition of models from design to manufacturing. 2. By enabling precision modelling, material wastage is reduced, aligning with sustainability principles in modern engineering practice. 3. Parametric surfaces provide accurate definitions for machining and tooling, helping optimize production processes with minimal errors and higher efficiency.	3
	PO6	1. Complex surface modelling requires keeping pace with evolving CAD/CAM tools, encouraging students to continually update technical knowledge. 2. Parametric surfaces are relevant to aerospace, automotive, civil, and biomedical domains, encouraging learners to integrate knowledge across disciplines.	5

		3. Students understand the societal and environmental impacts of design choices, ensuring engineering solutions that are ethical and sustainable. 4. Exposure to industrial CAD/CAM standards makes learners adaptable to industry workflows, enhancing employability and professional readiness. 5. Exposure to advanced modelling prepares students for global design standards and emphasizes ethical considerations such as safety, inclusivity, and environmental impact.	
CO4: Analyse and modelling solids using techniques like B-rep, CSG, and sweeping for effective representation of 3D models.	**PO1**	1. Solid modelling through B-rep, CSG, and sweeping allows precise definition of structural geometry, aiding in the identification of potential stress points or design bottlenecks. 2. Reviewing existing modelling techniques helps students recognize limitations of older approaches and motivates adoption of advanced parametric or hybrid modelling. 3. Simulations using CAD platforms validate solid models, ensuring that B-rep and CSG techniques are implemented with accuracy in engineering applications. 4. Modelling output data, including dimensions, material properties, and load responses, is systematically interpreted to refine and validate solid models. 5. Solid models are cross-checked with industrial benchmarks and international standards, ensuring credibility and practical reliability.	3
	PO2	1. Clear documentation of solid modelling processes ensures effective communication of design workflows and results. While reporting methods and results, correct referencing of CAD/CAM techniques upholds ethical research standards. 2. Complex surface and solid representations are described in stepwise, logically organized formats for easy comprehension. Students present solid models, explain geometry construction, and defend their design choices in academic and professional forums.	3
	PO3	1. Use of B-rep and CSG techniques represents modern design methodologies for creating highly accurate 3D solids. 2. Solid models created are directly exportable for 3D printing, ensuring practical application in prototyping. 3. By modelling manufacturable solids, potential defects and inefficiencies are identified early, supporting optimization. 4. Solid models serve as a foundation for AI-driven generative design and Industry 4.0 digital	3

		workflows. Accurate representation minimizes wastage, supports lightweight designs, and promotes use of eco-friendly materials.	
	PO4	1. Solid modelling allows engineers to simulate load conditions and test virtual prototypes before fabrication. 2. Techniques like CSG and B-rep seamlessly integrate with digital manufacturing pipelines. 3. Students understand how solid modelling contributes to sustainable product development and global engineering practices.	3
	PO5	1. Solid modelling links directly to downstream CAM applications, enabling precision manufacturing. 2. B-rep and sweeping techniques allow unique product designs with complex geometries. 3. Solid models highlight manufacturability issues early, reducing time and cost. 4. Better precision in modelling supports material-saving designs, eco-conscious choices, and greener practices.	3
	PO6	1. Solid modelling evolves with software and standards; students adapt by learning new tools. 2. Solid modelling applies to mechanical, civil, aerospace, biomedical, and other domains. 3. Encourages independent exploration of new CAD/CAM features. 4. Exposure to industrial CAD/CAM standards makes learners adaptable to industry workflows, enhancing employability and professional readiness. 5. Exposure to advanced modelling prepares students for global design standards and emphasizes ethical considerations such as safety, inclusivity, and environmental impact.	5
CO5: Demonstrate transformations and visual representations such as 2D/3D transformations, projections, and rendering techniques	**PO1**	1. 2D/3D transformations and rendering help in defining geometric challenges, enabling accurate representation of structural forms. 2. Reviewing visualization and rendering methods exposes gaps in computational graphics and inspires adoption of advanced algorithms. 3. Transformation matrices and rendering outputs are checked against mathematical formulations and industry standards for accuracy. Rendered visualizations and simplified projections make it easier for non-technical stakeholders to understand engineering solutions.	4
	PO2	1. Transformation and rendering processes are documented step by step for academic and professional reporting. 2. Students present 3D models, projections, and rendering techniques clearly to peers and evaluators.	4

	PO3	1. Transformations and rendering support modern workflows such as digital prototyping and virtual product design. 2. Accurate 3D transformations are essential in preparing digital models for 3D printing and rapid prototyping. 3. Visualization helps simulate alternative material use and 4. Eco-friendly design iterations with reduced waste.	4
	PO4	1. 3D projections and rendering are used to simulate and solve real-world structural and mechanical problems. 2. Techniques like real-time rendering and immersive projections help tackle advanced engineering challenges.	3
	PO5	1. Transformations and rendering create digital models that can be directly integrated into CAM workflows. 2. Visualization tools enable creative product design with enhanced aesthetics and usability. 3. Projections help detect clashes, improve fit, and optimize processes before actual manufacturing.	4
	PO6	1. Students stay updated with evolving rendering engines, CAD updates, and visualization technologies. 2. Transformations and visualization are applied across civil, mechanical, aerospace, and biomedical engineering. 3. Encourages independent exploration of rendering techniques, graphics libraries, and CAD features. 4. Skills in projections and rendering align with current industry practices, making students job-ready.	5

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

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

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	50.00	50.00	50.00	50.00	50.00	50.00
CO2	66.67	66.67	66.67	75.00	50.00	66.67
CO3	50.00	50.00	66.67	50.00	50.00	62.50
CO4	50.00	50.00	50.00	75.00	50.00	62.50
CO5	66.67	66.67	66.67	75.00	66.67	62.50

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	2	2	2	2	2	2
CO2	3	3	3	3	2	3
CO3	2	2	3	2	2	3
CO4	2	2	2	3	2	3
CO5	3	3	3	3	3	3
Average	12	12	13	13	11	14

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

X	1		NA

x	2	ZERO HUNGER	NA
x	3	GOOD HEALTH AND WELL-BEING	NA
✓	4	QUALITY EDUCATION	Provides technical knowledge in CAD, surface & solid modelling, and computational tools. Enhances employability and higher education opportunities in engineering & design.
x	5	GENDER EQUALITY	NA
x	6	CLEAN WATER AND SANITATION	NA
x	7	AFFORDABLE AND CLEAN ENERGY	NA
✓	8	DECENT WORK AND ECONOMIC GROWTH	Develops advanced design and manufacturing skills, making students industry-ready. Encourages innovation and supports advanced manufacturing industries.
✓	9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	Promotes use of digital manufacturing, CAD/CAM, 3D printing, and automation. Strengthens infrastructure and supports innovation in product design.
x	10	REDUCED INEQUALITIES	NA

X	11	SUSTAINABLE CITIES AND COMMUNITIES	NA
✓	12	RESPONSIBLE CONSUMPTION AND PRODUCTION	CAD tools optimize material usage, reduce waste, and improve product sustainability. Encourages life-cycle thinking and eco-friendly manufacturing processes.
✓	13	CLIMATE ACTION	By adopting efficient design and manufacturing, carbon footprint is reduced. Supports green design and eco-innovation in product development.
X	14	LIFE BELOW WATER	NA
X	15	LIFE ON LAND	NA
X	16	PEACE, JUSTICE AND STRONG INSTITUTIONS	NA
X	17	PARTNERSHIPS FOR THE GOALS	NA

Signature of Course Coordinator **HOD**