Outcome Based Education (OBE) Manual

Department of

MECH (CAD & CAM)

Regulation : PG R24

OVERVIEW ⟩⟩⟩⟩

Outcome Based Education (OBE) is the foundation of quality assurance in higher technical education, especially in postgraduate programs like M.Tech.

Unlike traditional models that focus on syllabus completion, OBE emphasizes what students can do at the end of the program.

Key Focus of OBE

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

Role of Faculty in OBE

Faculty members function as:

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

OBE Framework – Levels of Outcomes

The OBE system is structured across four key levels:

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

These outcomes ensure graduates develop:

- Advanced technical expertise
- Research and innovation capability
- Professional ethics and social responsibility
- Lifelong learning skills

Why OBE for M. Tech Programs?

- Facilitates international recognition of qualifications
- Enhances global employability and mobility
- Produces highly skilled and research-oriented graduates
- Strengthens industry relevance and leadership potential
- Improves institutional reputation and accreditation readiness
- Encourages stakeholder participation (students, faculty, alumni, industry)

Key Features of Outcome Based Education

- Transparent and measurable learning achievement
- Improved student engagement and ownership of learning
- Strong linkage between curriculum, assessment, and outcomes
- Continuous improvement through feedback and analysis
- Alignment with global engineering standards
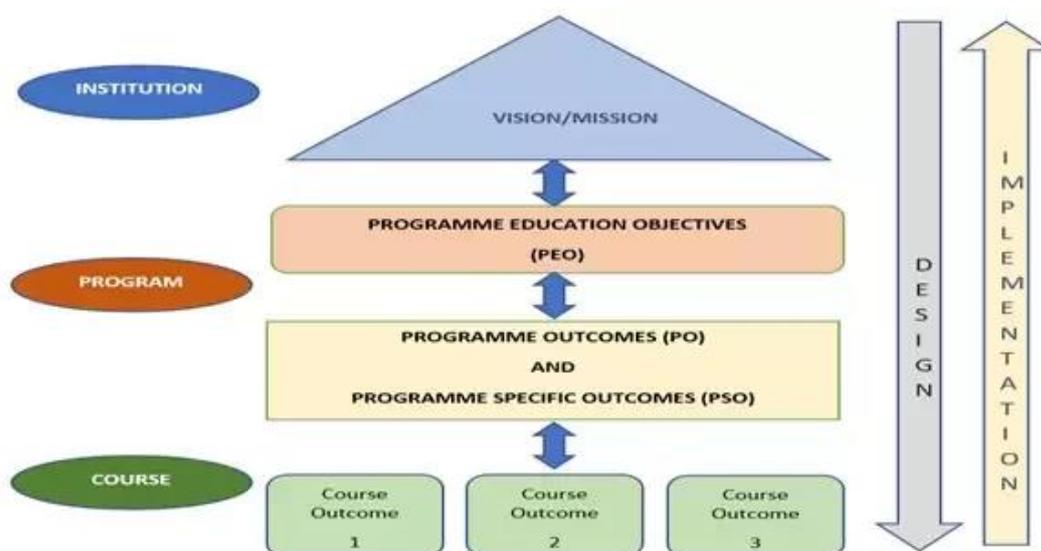
The concept of OBE gained global recognition through international accreditation frameworks such as the Washington Accord (1989), which emphasized that engineering education should be outcome-oriented rather than input-oriented. The Accord established equivalence of accredited engineering programs among signatory countries based on the achievement of outcomes and graduate attributes rather than traditional curriculum content or duration.

India became a permanent signatory to the Washington Accord in 2014 through the National Board of Accreditation (NBA). This marked a major shift in India's higher education evaluation system—from a system based on syllabus and content coverage to one that measures the attainment of Course Outcomes (COs), Program Outcomes (POs), and Program Educational Objectives (PEOs).

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

- **2013:** Introduction of the first comprehensive OBE-based accreditation format aligned with Washington Accord graduate attributes.
- **2017:** Inclusion of CO–PO mapping, assessment tools, and continuous improvement metrics.
- **2021:** Integration of digital evidence, innovation, entrepreneurship, and sustainability indicators into the Self-Assessment Report (SAR).
- **2024:** Launch of Graduate Attributes and Professional Competencies, emphasizing knowledge attributes (K1–K6 levels), skills, and attitudes in accordance with international educational standards.
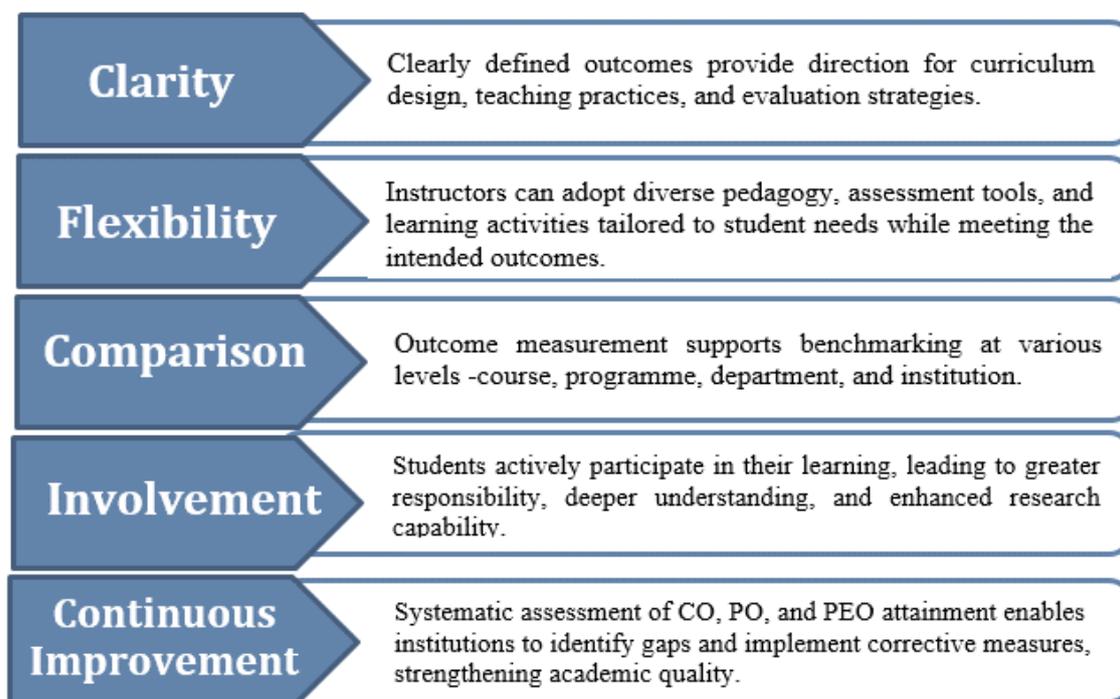
Benefits of Outcome-Based Education

Clarity — Clearly defined outcomes provide direction for curriculum design, teaching practices, and evaluation strategies.

Flexibility — Instructors can adopt diverse pedagogy, assessment tools, and learning activities tailored to student needs while meeting the intended outcomes.

Comparison — Outcome measurement supports benchmarking at various levels -course, programme, department, and institution.

Involvement — Students actively participate in their learning, leading to greater responsibility, deeper understanding, and enhanced research capability.

Continuous Improvement — Systematic assessment of CO, PO, and PEO attainment enables institutions to identify gaps and implement corrective measures, strengthening academic quality.

Figure 2: Benefits of Outcome Based Education

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.

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.

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.

PHILOSOPHY

At Marri Laxman Reddy Institute of Technology and Management, we believe that the true essence of meaningful education lies in the pursuit of truth—one that removes ignorance and empowers individuals. Education is viewed not merely as the transfer of knowledge, but as a powerful instrument for liberation, empowerment, and societal transformation.

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

CORE VALUES

Excellence:	Integrity:	Inclusiveness:
All activities are conducted according to the highest international standards.	Adheres to the principles of honesty, trust worthiness, reliability, transparency and accountability.	To show respect for ethics, cultural and religious diversity, and freedom of thought.

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

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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 POs reflect the discipline specific skills defined by department 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, 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 OF THE DEPARTMENT

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

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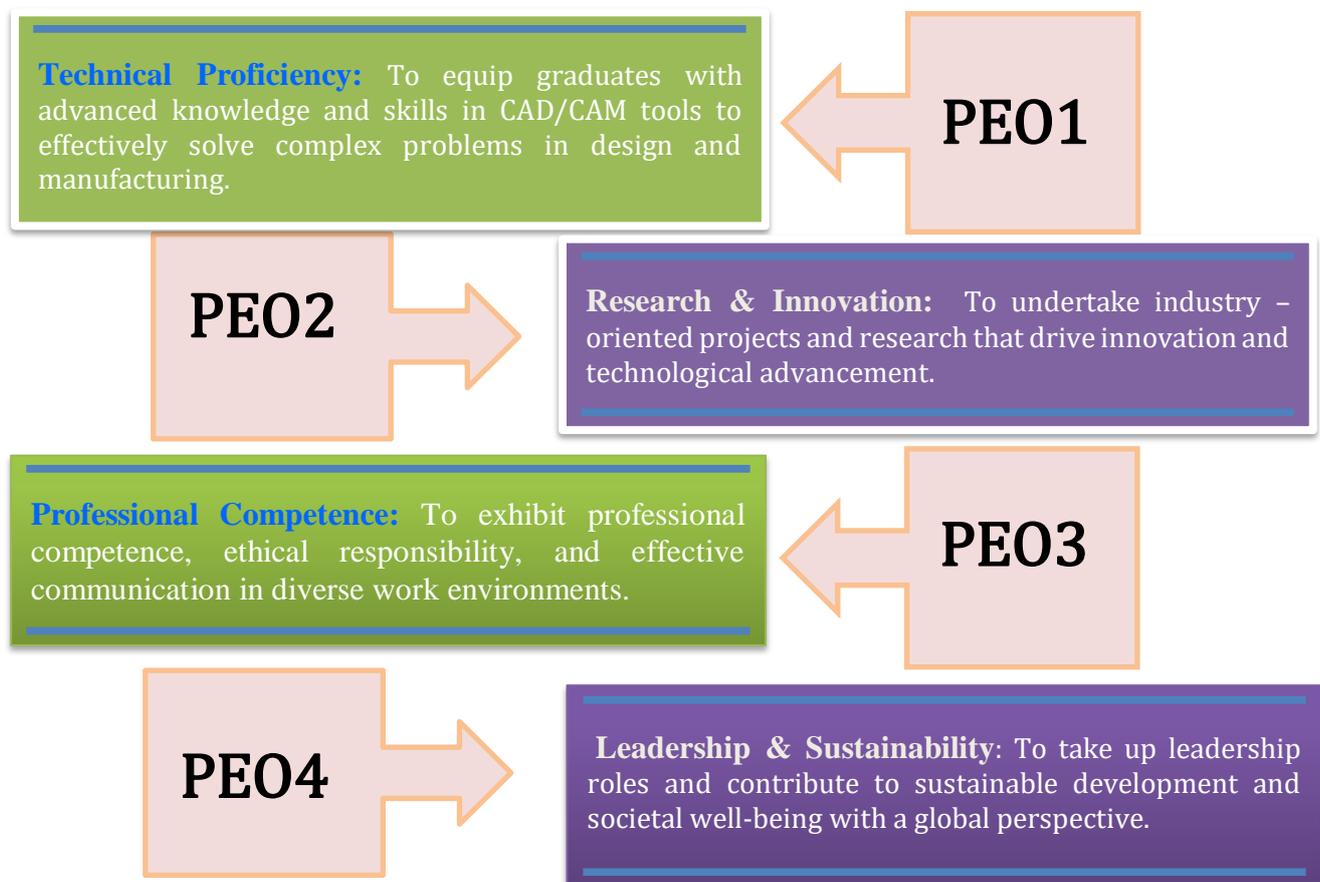
DM2: To enhance employability, leadership skills, and research capabilities through industry collaboration and experimental learning.

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

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

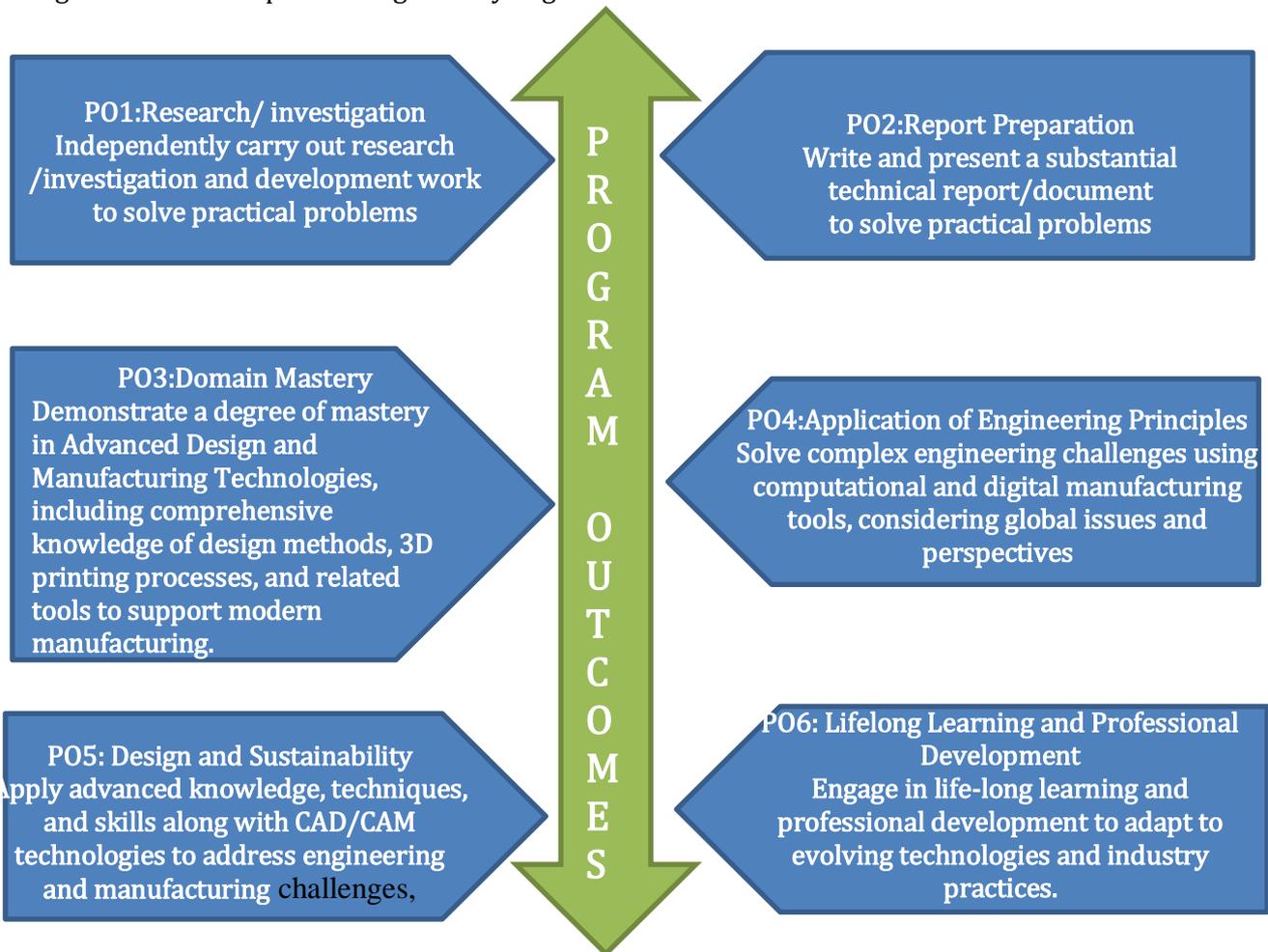## PROGRAM EDUCATIONAL OBJECTIVES

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.

Technical Proficiency: To equip graduates with advanced knowledge and skills in CAD/CAM tools to effectively solve complex problems in design and manufacturing.

PEO1

PEO2

Research & Innovation: To undertake industry –oriented projects and research that drive innovation and technological advancement.

Professional Competence: To exhibit professional competence, ethical responsibility, and effective communication in diverse work environments.

PEO3

PEO4

Leadership & Sustainability: To take up leadership roles and contribute to sustainable development and societal well-being with a global perspective.

PROGRAM OUTCOMES

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 to solve practical problems

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,

PO6: Lifelong Learning and Professional Development
Engage in life-long learning and professional development to adapt to evolving technologies and industry practices.

PROGRAM OUTCOMES

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

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RELATION BETWEEN PEOs AND POs

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

PEO-I   PEO-II   PEO-III   PEO-IV

PO1   PO2   PO3   PO4   PO5   PO6

PEO-I
PO:1,2,3,
4,5,6

PEO-II
PO:1,2,3,
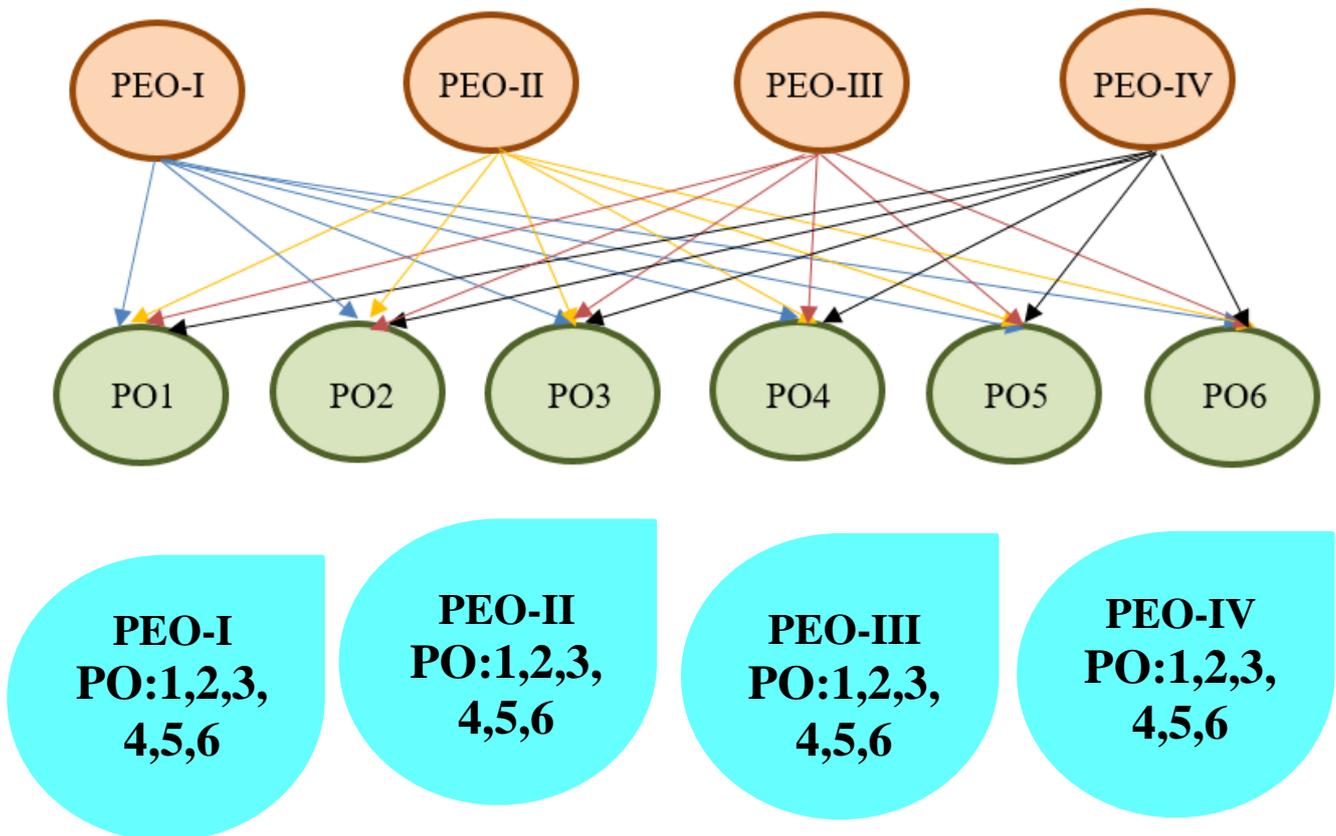4,5,6

PEO-III
PO:1,2,3,
4,5,6

PEO-IV
PO:1,2,3,
4,5,6

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) Technical Proficiency	(2) Research& Innovation	(3) Professional Competence	(4) Leadership& Sustainability
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

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Note: PO assessment is carried out through both direct and indirect assessment procedures.
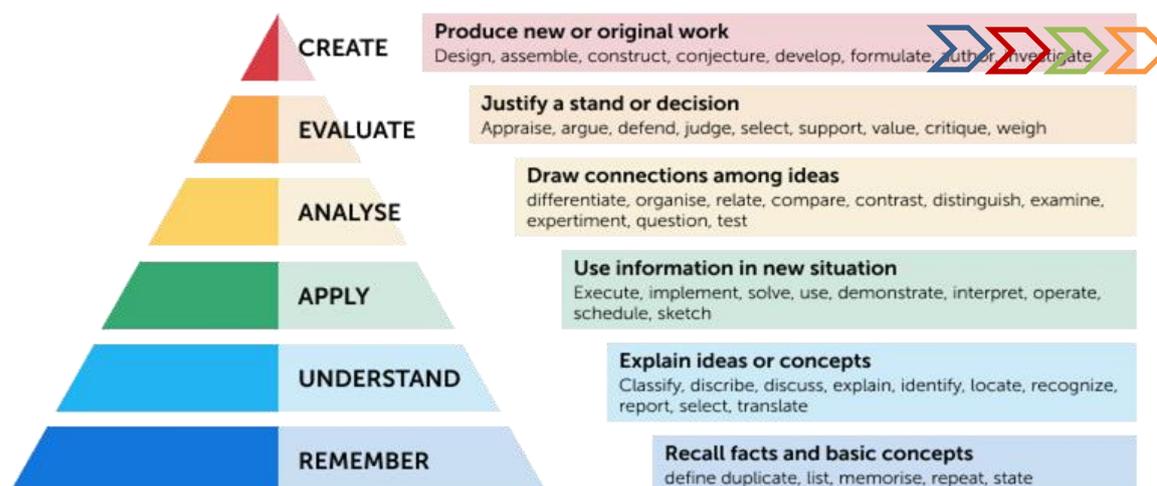
Direct Assessment is conducted through:
- Continuous Internal Evaluation (CIE),
- CAT and Assignments/Quiz, and
- Semester-end examinations.

Indirect Assessment is carried out through:
- Program Exit Surveys from graduating students,
- Alumni Surveys, and
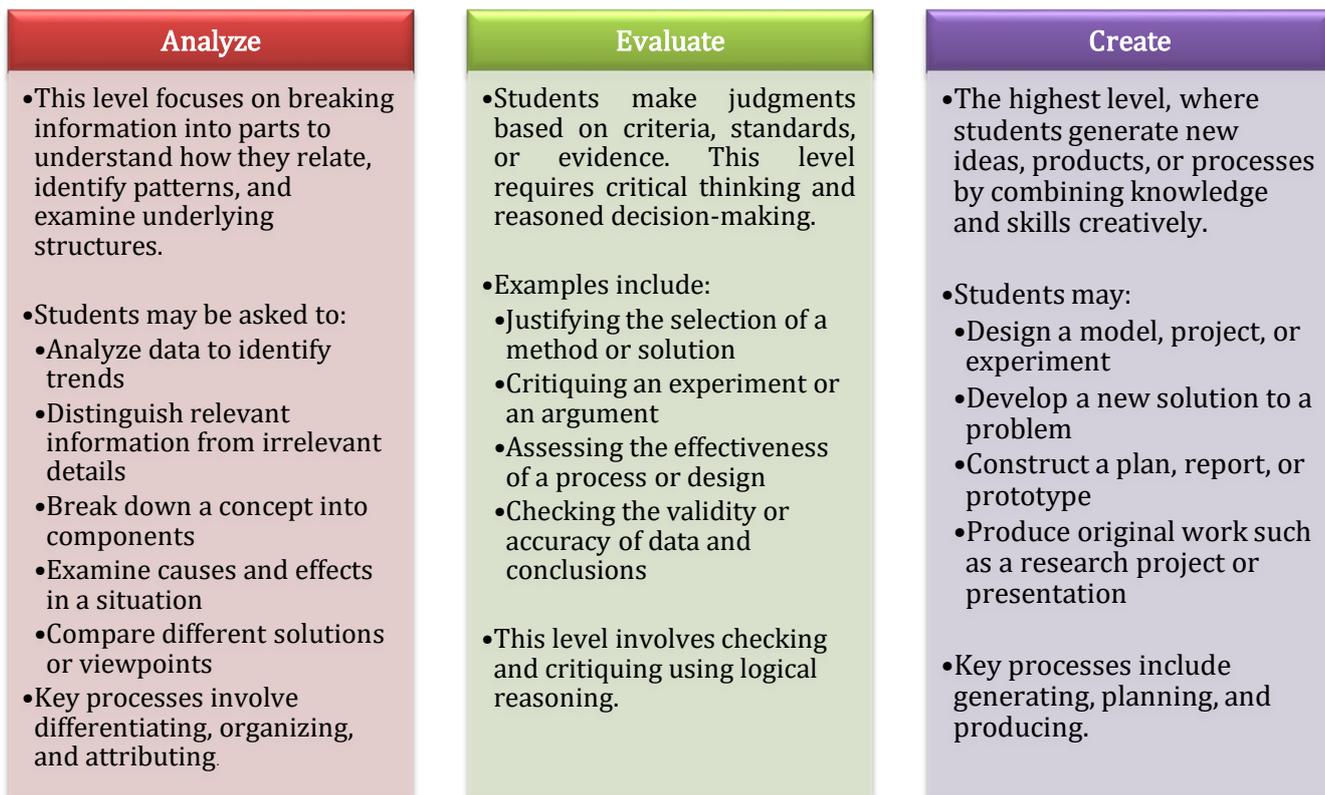- Employer/Employment Surveys.

About Blooms Taxonomy

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


DIFFERENT LEVELS OF THINKING SKILLS IN BLOOMS TAXONOMY

Remember	Understand	Apply
•This is the foundation of learning, where students recall basic information such as facts, definitions, formulas, events, and important concepts.	•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.	•Students use their knowledge in practical or new situations. This requires using learned concepts, formulas, rules, or methods in real-life or academic problems.
•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	•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.	•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 recognizing and recalling information from memory.		•This level includes executing (using knowledge in familiar contexts) and implementing (using it in new contexts).

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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.

LOWER AND HIGHER ORDER BLOOMS TAXONOMY ⟫⟫⟫⟫⟫

Bloom's Taxonomy is broadly classified into Lower-Order Cognitive Skills and Higher-Order Cognitive Skills. The lower-order levels—Remember, Understand, and Apply—develop foundational knowledge, comprehension, and basic application skills. The higher-order levels—Analyze, Evaluate, and Create—focus on critical thinking, judgment, and creativity, enabling students to examine relationships and generate original solutions. This distinction supports balanced course design and helps educators write clear, measurable Course Outcomes aligned with teaching and assessment.
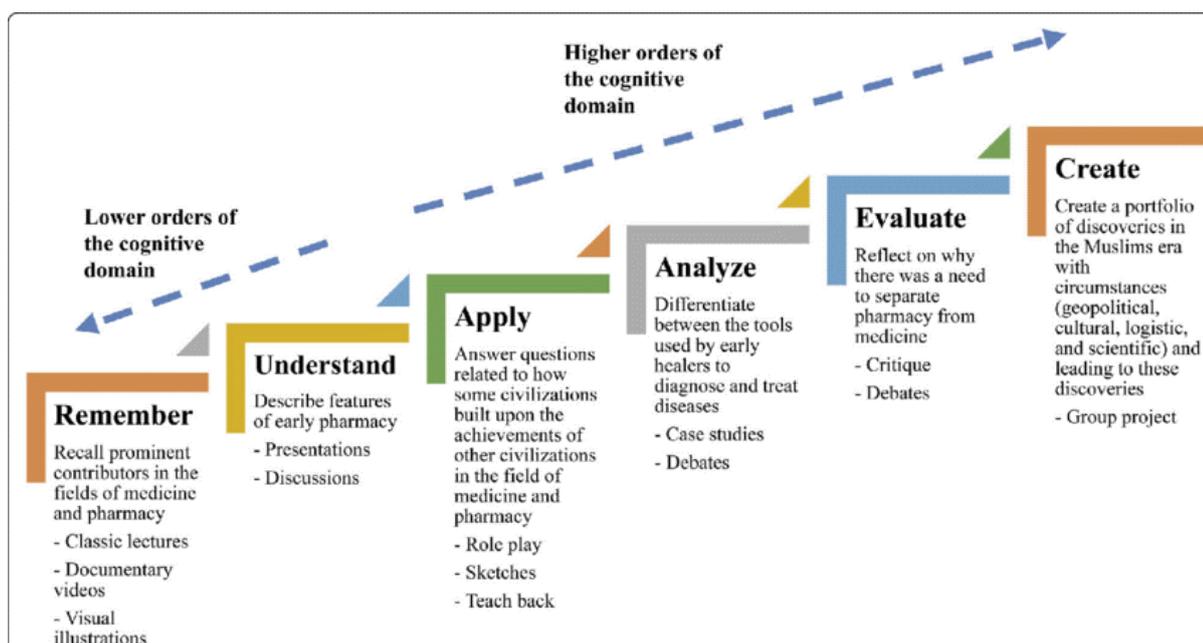
KNOWLEDGE DIMENSION

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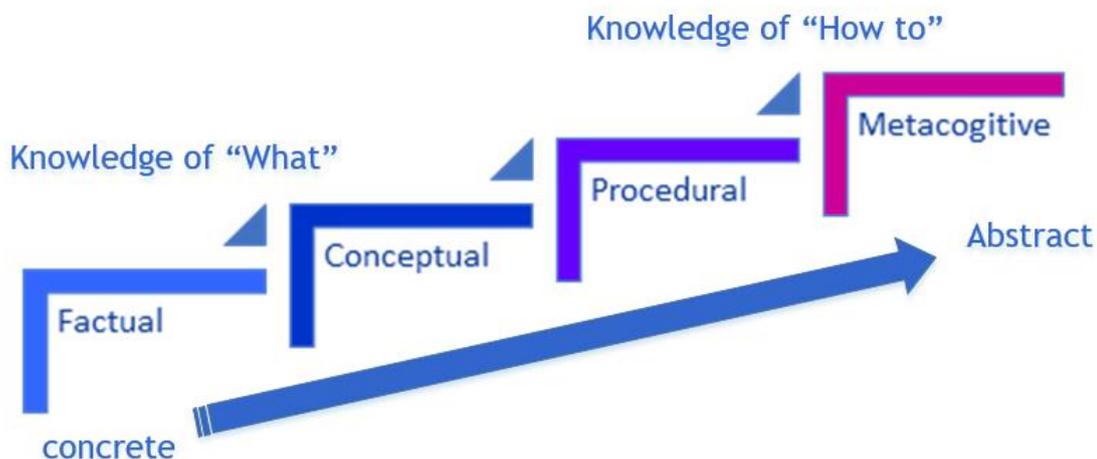

Table 2: The Knowledge Dimension

KNOWLEDGE DIMENSION	Remember	Understand	Apply	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 particular learning style theory to own learning	Create original learning style theory

BLOOMS TAXONOMY ACTION VERBS

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

KNOWLEDGE AND ATTITUDE PROFILE

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

WK1 — A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social science

WK2 — Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

WK3 — A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

WK4 — Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at therefore front of the discipline.

WK5 — Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

WK6 — Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.

WK7 — Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

WK8 — Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

WK9 — Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitude

KNOWLEDGE AND ATTITUDE PROFILE KEY INDICATORS ⟫⟫⟫⟫

Table 3: Key Indicator of Knowledge and Attitude Profile

WK No.	Knowledge & Attitude Profile	Key Indicators	No of Key Indicators
WK1	Engineering Knowledge & Natural Sciences	❖ Utilizes principles of physics to solve complex engineering problems. ❖ Employs concepts of chemistry in the analysis of engineering materials and processes. ❖ Uses mathematical principles for the formulation and solution of engineering problems. ❖ Integrates concepts from social sciences to address societal, environmental, and human factors in engineering practice. ❖ Employs discipline-specific engineering fundamentals for analysis, design, and problem-solving in specialized domains.	5
WK2	Mathematical, Statistical & Data Analysis	❖ Applies algorithms and numerical methods for engineering analysis. ❖ Uses statistical principles to summarize data and draw valid conclusions. ❖ Performs data cleaning, exploration, visualization, and ethical data handling. ❖ Interprets, evaluates, and compares analytical results using appropriate tools.	4
WK3	Modelling & System Analysis	❖ Develops analytical models of engineering systems. ❖ Develops numerical and empirical models to predict system behaviour. ❖ Uses physical models to test and validate engineering assumptions. ❖ Evaluates model accuracy and validity of assumptions.	4
WK4	Computational Tools & Digital Systems	❖ Uses computer systems to store and manage large datasets ❖ Applies computational tools for simulation and modelling. Uses data visualization techniques for effective analysis and interpretation. ❖ Evaluates limitations of computational tools and results.	3
WK5	Problem Identification & Engineering Analysis	❖ Identifies constraints, requirements, and secondary impacts of engineering problems. ❖ Formulates accurate and realistic problem statements ❖ Applies analytical methods for problem investigation. ❖ Validates assumptions and analytical outcomes.	4
WK6	Engineering Design, Sustainability & Safety	❖ Develops innovative and sustainable design solutions. ❖ Evaluates feasibility considering technical, economic, environmental, and societal factors. ❖ Conducts life-cycle analysis for sustainability assessment. ❖ Identifies hazards and applies risk mitigation strategies.	5

		❖ Ensures compliance with environmental and safety regulations.	
WK7	Engineering Management & Professional Practice	❖ Applies engineering management principles in decision-making. ❖ Performs economic analysis for project implementation. ❖ Manages resources, time, and budget effectively. ❖ Demonstrates professional responsibility in practice.	4
WK8	Research, Investigation & Critical Thinking	❖ Reviews current research literature to identify research gaps. ❖ Designs and executes experiments and investigations. ❖ Applies qualitative and quantitative research methods. ❖ Analyses data and considers sources of error. ❖ Draws and justifies valid conclusions. ❖ Evaluates emerging technologies, including Generative AI.	6
WK9	Ethics, Law, Diversity & Inclusivity	❖ Demonstrates ethical responsibility and professional integrity. ❖ Applies laws, regulations, and professional codes in practice. ❖ Identifies and justifies ethical courses of action. ❖ Respects diversity and promotes inclusivity in professional environments. ❖ Evaluates ethical implications of new and emerging technologies.	5

PO-WK MAPPING

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

Table 4: PO-WK Mapping

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

COMPLEX ENGINEERING PROBLEMS

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

Key features of Complex Engineering Problems

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

CHARACTERISTICS OF COMPLEX ENGINEERING PROBLEMS

Table 5: Characteristics of complex engineering problems

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

ADOPTING UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS

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

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

INTEGRATION OF SDGS WITHIN THE M. TECH PROGRAM

S. No.	Keyword / Aspect of Complex Engineering Problems	Relevant Program Outcomes (POs)	Linked UN SDGs	Justification of Linkage (CAD/CAM Context)
1	Depth of knowledge required	PO3 – Domain Mastery, PO4 – Application of Engineering Principles	SDG 4, SDG 9, SDG 7, SDG 6	In the CAD/CAM context, depth of knowledge enables achievement of PO3 and PO4 by applying advanced design, simulation, and manufacturing principles to solve complex engineering problems efficiently. This supports the SDGs by promoting sustainable innovation, energy efficiency, and

				resource-optimized industrial development.
2	Range of conflicting requirements	PO5 – Design and Sustainability, PO6 – Lifelong Learning & Professional Development	SDG 4, SDG 8, SDG 10, SDG 11	Managing a range of conflicting requirements—such as cost, quality, sustainability, safety, and productivity—supports PO5 and PO6 by encouraging sustainable design practices and continuous professional development to adapt to evolving technologies. This aligns with the SDGs by promoting inclusive education, economic growth, reduced inequalities, and sustainable industrial and urban development.
3	Depth of analysis required	PO1 – Research / Investigation, PO4 – Application of Engineering Principles	SDG 4, SDG 9, SDG 12	Depth of analysis requires thorough research, simulation, and validation of design and manufacturing processes, supporting PO1 and PO4 through systematic investigation and application of engineering principles. This contributes to the SDGs by fostering quality technical education, industrial innovation, and responsible production practices.
4	Familiarity of issues	PO1 – Research / Investigation, PO6 – Lifelong Learning & Professional Development	SDG 4, SDG 13, SDG 15, SDG 14	Familiarity with emerging design, manufacturing, and environmental issues strengthens PO1 and PO6 by encouraging continuous research, skill enhancement, and adaptation to new technologies. This supports the SDGs by promoting quality education, climate action, and sustainable use of terrestrial and marine resources through responsible engineering practices.
5	Extent of applicable codes	PO4 – Application of Engineering Principles, PO5 – Design and Sustainability	SDG 4, SDG 9, SDG 16	Adherence to applicable design codes, standards, and safety regulations strengthens PO4 and PO5 by ensuring engineering solutions are technically sound, sustainable, and compliant with industry norms. This aligns SDGs by promoting quality education, resilient industrial development, and strong institutional frameworks through standardized engineering practices.

6	Stakeholder involvement & conflicting needs	PO2 – Report Preparation, PO5 – Design and Sustainability	SDG 4, SDG 5, SDG 11, SDG 16	Stakeholder involvement and managing conflicting needs enhance PO2 and PO5 by requiring clear technical reporting, collaborative communication, and sustainable design decisions that balance cost, safety, quality, and environmental concerns. This supports the SDGs by promoting inclusive education, gender equality, sustainable communities, and transparent institutional practices.
7	Interdependence of components	PO1 – Research / Investigation, PO3 – Domain Mastery, PO5 – Design and Sustainability	SDG 4, SDG 1, SDG 2, SDG 3, SDG 12	Understanding the interdependence of components strengthens PO1, PO3, and PO5 by enabling detailed investigation, strong domain knowledge, and sustainable system-level design optimization. This supports the SDGs by promoting quality education, improved productivity, responsible production, and technologies that contribute to better livelihoods, food systems, and health outcomes.
8	Collaboration, outreach & global responsibility	PO2 – Report Preparation, PO6 – Lifelong Learning & Professional Development	SDG 4, SDG 17	Collaboration, outreach, and global responsibility strengthen PO2 and PO6 by promoting effective technical communication, interdisciplinary teamwork, and continuous professional development in line with global engineering standards. This aligns with the SDGs by supporting quality education and fostering global partnerships for sustainable technological advancement.

COURSE OUTCOMES

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.

Guidelines for Writing Course Outcome Statements

Effective Course Outcomes are structured using the following components:

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

Action Verb	→	Subject Content	→	Level of Achievement	→	Condition of Performance

If applicable

Developing Effective Course Outcomes

When formulating Course Outcomes, the following best practices should be followed:

- ❖ Limit outcomes to 5–6 statements per course
- ❖ Focus on core knowledge and essential skills
- ❖ Avoid trivial or overly detailed content
- ❖ Use student-centred language
- ❖ Emphasize **l**earning results**,** not teaching activities
- ❖ Align outcomes with departmental and institutional mission
- ❖ Include multiple ways students can demonstrate learning (analyse, model, design, evaluate, present, etc.)
- ❖ Ensure outcomes are observable, measurable, and assessable

Relationship of Course Outcome to Program Outcome

Course Outcomes are systematically mapped to Program Outcomes (POs) to ensure that each course contributes meaningfully to the overall program objectives.

> **Learning outcomes formula:**
>
> **STUDENTS SHOULD BE ABLE TO + BEHAVIOR + RESULTING EVIDENCE**

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.

Examples of Effective Course Outcomes

Examples of Effective Course Outcomes: Course: Advanced CAD (2414001)

A structured and measurable approach to stating Course Outcomes involves three essential components:

- **Condition** – the context or tools provided
- **Observable Behaviour** – the action performed by the student
- **Standard** – the level of acceptable performance

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

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

S. No	Condition	Observable Behavior	Standard
1	Given a mechanical component with specific design requirements and constraints	The student will be able to explain geometric modeling concepts, design intent, and distinguish between parametric and non-parametric modeling approaches.	Correctly addressing at least 80% of identified modeling 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 $\pm 5\%$ of manufacturing tolerances.
3	Using a CAD assembly model with defined material and process parameters	The student will be able to analyze manufacturability, identify interferences, and evaluate assembly feasibility.	Correct identification of design or assembly issues with appropriate corrective measures.
4	Given components subjected to manufacturing constraints	The student will be able to select suitable manufacturing processes and optimize design features for efficient production.	Appropriate process selection based on design and manufacturing considerations.
5	Provided with industrial CAD/CAM case studies.	The student will be able to illustrate design-to-manufacturing workflows.	Accurate interpretation and presentation of workflow supported by design

CO-PO 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.

Observations

- ❖ For theory courses, COs should generally be designed within Bloom's Levels 1 to 4.
- ❖ 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.
- ❖ For laboratory courses, COs may be framed within Bloom's Levels 1 to 5.
- ❖ Only in mini-projects and major projects may COs be designed up to Bloom's Level 6.

❖ 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.

❖ When correlating COs with POs, ensure that the action verbs in the COs align with the intent and scope defined in the POs.

Method for Articulation

1. Identify the key competencies of POs for each CO and create a corresponding mapping table by assigning marks in the corresponding cell. One important observation is that the first five POs are purely technical in nature, while the other POs are non-technical.

2. Justify each CO-PO mapping with a justification statement and recognize the number of vital features mentioned in the justification statement that match the given Key Attributes for Assessing Program Outcomes. Use a combination of words found in the COs, POs, and your course syllabus for writing the justification.

3. Create a table listing the number of key competencies for CO-PO mapping with reference to the maximum given Key Attributes for Assessing Program Outcomes.

4. Create a table displaying the percentage of key competencies for CO-PO mapping with reference to the maximum given Key Attributes for Assessing Program Outcomes.

5. Finally, prepare a Course Articulation Matrix (CO-PO Mapping) with COs and POs on a scale of 0 to 3, where:
   - 0 = No correlation (marked as "-")
   - 1 = Low/slight correlation
   - 2 = Medium/moderate correlation
   - 3 = Substantial/high correlation

The correlation is based on the following strategy:

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

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 collection, analyses, and interpretation systematically. 5. Innovative approaches are applied to engineering problem-solving. 6. Results are validated against established theories and standards	6
PO 2.	Write and present a substantial technical report/document	1. Technical reports, dissertations, and papers are well-structured. 2. Referencing and academic integrity practices are properly maintained. 3. Content is presented with clarity, precision, and logical flow. 4. Oral communication and presentation skills are effectively demonstrated. 5. Digital tools are used for documentation and visualization. 6. Research findings are communicated to both technical and non-technical audiences.	6
PO 3.	Demonstrate a degree of mastery in Advanced Design and Manufacturing Technologies, including comprehensive knowledge of design methods, 3D printing processes, 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

CO-PO Articulation Matrix

Courses Mapped to each PO for the Courses offered in M. Tech CAD/CAM (MLRS-R24) are given below table.7.

Table 7: Courses Mapped to PO for M. Tech CAD/CAM (MLRS R 24) regulation

	I M. Tech –I Semester						
2414001	Advanced CAD	√	√	√	√	√	√
2414002	Additive Manufacturing	√	√	√	√	√	√
2414011	Finite Element and Boundary Element Method	√	√	√	√	√	√
2414012	Experimental Stress Analysis	√	√	√	√	√	√
2414013	Green Manufacturing	√	√	√	√	√	√
2414014	Automation in Manufacturing	√	√	√	√	√	√
2414015	Computer Aided Process Planning	√	√	√	√	√	√
2414016	Industrial Robotics	√	√	√	√	√	√
2411234	RM&IPR	√	√	√	√	√	√
2414040	ACAD LAB	√	√	√	√	√	√
2414041	3D Printing Lab	√	√	√	√	√	√
2410401	English for Research Paper Writing	√	√				√
	I M. Tech –II Semester						
2424003	Computer Integrated Manufacturing	√	√	√	√	√	√
2424004	Simulation Modelling &Analysis	√	√	√	√	√	√
2424017	Intelligent Manufacturing systems	√	√	√	√	√	√
2424018	IOT & Industry 4.0	√	√	√	√	√	√
2424019	Optimization Techniques & Applications	√	√	√	√	√	√
2424020	Mechatronics	√	√	√	√	√	√
2424021	MEMS	√	√	√	√	√	√
2424022	Fuzzy logic & Neural Networks	√	√	√	√	√	√
2424044	Mini project with Seminar	√	√	√	√	√	√
2424042	Simulation of Manufacturing systems Lab	√	√	√	√	√	√
2424043	CAM Lab	√	√	√	√	√	√
2420006	Pedagogy Studies	√	√				√
	II M. Tech –I Semester						
2434023	Design For Manufacturing & Assembly	√	√	√	√	√	√
2434024	Composite Materials	√	√	√	√	√	√
2434025	Artificial Intelligence & Manufacturing	√	√	√	√	√	√
2435503	Fundamentals of Nano Technology	√	√	√	√	√	√

2432076	Dissertation Work Review – I	√	√	√	√	√	√
2442077	Dissertation Work Review – III	√	√	√	√	√	√
2442078	Dissertation Viva -Voce	√	√	√	√	√	√

METHODS FOR MEASURING LEARNING OUTCOMES

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 Assessment (CIA).
ii) Semester end examination (SEE)
iii) Laboratory and project work
iv) Course End survey
v)   Program exit survey
vi) Alumni survey
vii) Employer survey
viii) Program Assessment and Quality Improvement Committee (PAQIC)
ix) Department Advisory Board (DAB)
x)   Faculty meetings

Table 8: CO-PO Mapping

Assessment Method	Assessment Tool	Weightage in CO attainment
Direct Assessment	Continuous Internal Assessments (CIA-1and CIA-2)	80%
	Semester End Examination	
Indirect Assessment	Course End Survey	20%

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 examination, semester end examinations, Assignment, and open coding platforms/ Concept video /Case study/Application/Poster presentation/ Tech talk (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.
- Open coding platforms / Concept video /Case study/Application/Poster presentation/ Tech talk 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 Examination (CIE)	Twice in a semester	20	Answer script
		QUIZ	Twice in a semester	10	Multiple Choice Questions in Anvaya LMS
		Comprehensive Assessment Tool (CAT)	Twice in a semester	10	Scripts/PPT/student videos
		Semester End Examination	Once in a semester	60	Answer script
2	Laboratory	Day to day evaluation	Once in a week	10	Observation and record
		Viva-voce/Tutorial/Case study/Application/Poster presentation	Twice in a semester	10	Work sheets

		Design/software/hardware Model presentation/App development/Prototype presentation	Once in a semester	10	Presentation
		Internal practical examination	Twice in a semester	10	Answer script
		Semester End Examination	Once in a semester	60	Answer script
3	Dissertation Work	Presentation	Twice in a semester	40	Presentation
		Semester End Examination	Once in a semester	60	Thesis report
4	Mini Project with Seminar	Semester End Examination	Twice in a semester	100	Seminar report

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.

PO Assessment tools and Processes

The institute has the following methods for assessing the attainment of POs.
1. Direct method
2. Indirect method

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

Table11: Attainment of PO

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

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

7.1   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.

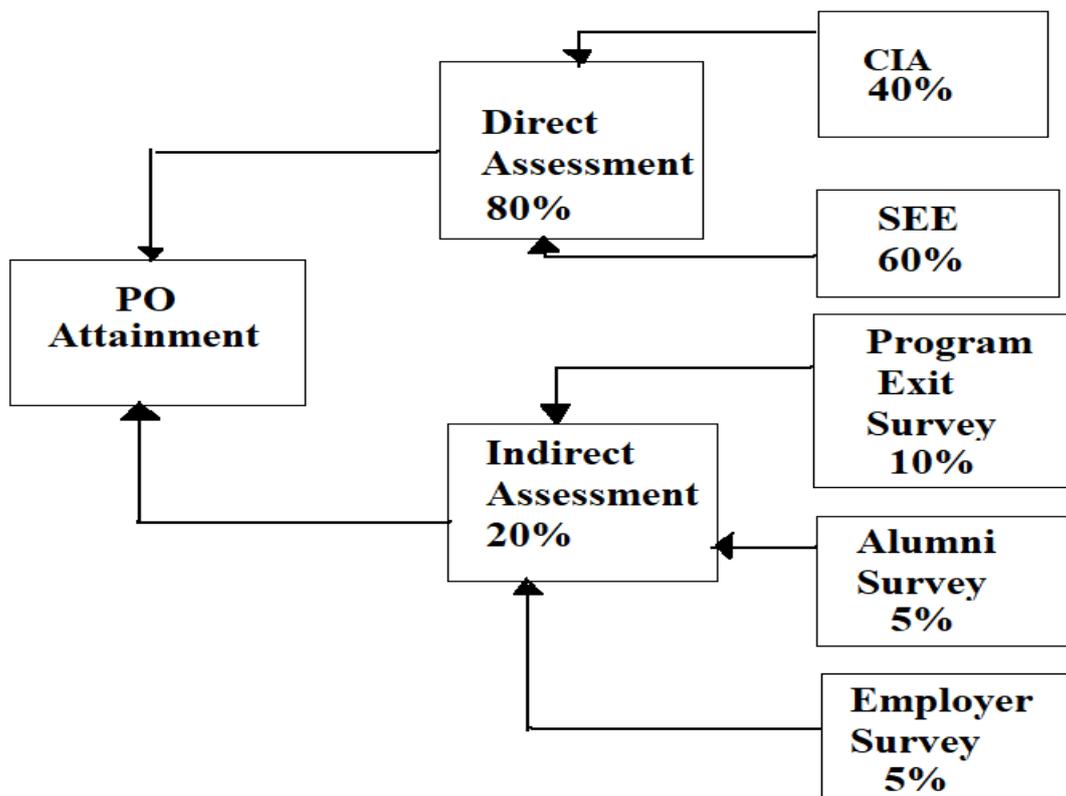**Figure3: Evaluation process of POs attainment**

COURSE DESCRIPTION

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
- ❖ 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

MARRI LAXMAN REDDY
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(AN AUTONOMOUS INSTITUTION)
(Approved by AICTE, New Delhi & Affiliated to JNTUH, Hyderabad)
Accredited by NAAC with 'A' Grade & Recognized Under Section2(f) & 12(B)of the UGC act,1956

ADVANCED CAD

COURSE DESCRIPTOR

1	**Department**	MECHANICAL ENGINEERING
2	**Course Name**	ADVANCED CAD
3	**Course Code**	2414001
4	**Year/Semester**	I/I
5	**Regulation**	MLRS-R24
6	**Course Offered**	Odd Semester
7	**Course Coordinator**	Dr. S. P. Jani
8	**Date Approved by BOS**	06-07-24
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).
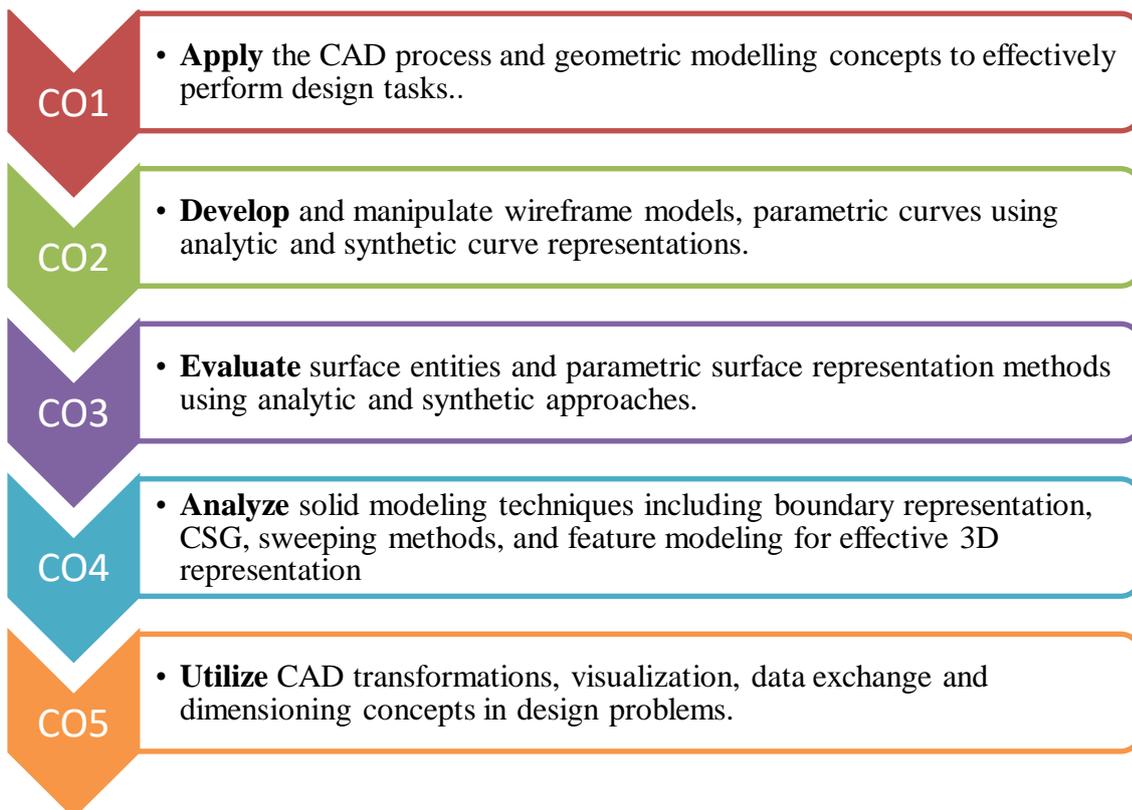
16. Course Objectives

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. Cognitive Levels

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

19. 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.

20. Complex Engineering Problems

The **Advanced CAD course** focuses on developing the ability to solve complex engineering design problems through rigorous modeling- and application-based learning. Students apply fundamental principles of wireframe, surface, and solid modeling to create accurate two- and three-dimensional digital representations of engineering components under design constraints. Mandatory assignments and in-class exercises emphasize geometric constructions, coordinate systems, transformations (translation, rotation, scaling), parametric features, and constraint-based modeling for precise design control. Advanced applications include surface continuity, solid feature operations, assemblies, interference checking, and mass-property evaluation. Assessment also covers model optimization, design intent, and data preparation for downstream manufacturing and analysis. All coursework, projects, and examinations are completed individually, ensuring the development of independent design thinking, spatial reasoning, and professional competence in advanced CAD practices.

21. Content Delivery / Instructional Methodologies

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

22. Evaluation Methodology

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

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

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

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

Continuous Internal Examination (CIE)
For theory courses, two Continuous Internal Examinations (CIE-I and CIE-II) shall be conducted in each semester as per the academic calendar. Each Continuous Internal Examination shall be evaluated for 30 marks. To finalize CIE marks these 30 marks will be scale down to 10 marks.
➤ The time duration of each CIE shallbe1hour and 30 minutes.
➤ Question paper pattern for CIE (30Marks) shall be as follows:

PART-A: 5X2M=10M
a. All questions are compulsory.
b. 02 questions from full units and one question from half unit.

PART-B: 4*5=20M
a. There shall be a total of 06 questions.
b. There shall be two questions from each UNIT with internal choice i.e.,
'either' 'or' choice.
c. Student shall answer one question from each UNIT.

Quiz – Online Examination:
Two Quiz examinations shall be online examination consisting of 50 multiple choice questions

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

Semester End Examination (SEE)

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

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

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

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

   i)   **Part – A** for 10 marks (Short Answer Types),
   ii)   **Part – B** for 20 marks (Descriptive answer Type) with a total duration of 1.5 hours as follows:

Total 30 marks will be scale down 10 marks.

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

The semester end examinations (SEE), will be conducted for 60 marks consisting of two parts viz. i) **Part-A** for 10 marks, ii) **Part-B** for 50 marks.

a. Part-A is a compulsory question which consists of ten sub-questions from all units carrying equal marks.

b. Part-B consists of three questions (numbered from 2 to 6) carrying 10 marks each. Each of these questions is from each unit and may contain sub-questions. For each question there will be an "either" "or" choice, which means that there will be two questions from each unit and the student should answer either of the two questions.

c. The duration of Semester End Examination is 3 hours.

23. 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	No. of Lectures: 7

	models, Geometric construction methods, Modelling facilities desired.	
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 curve wire, 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	**Transformation**s: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, maximum material condition (MMC), Least material condition (LMC), Regardless of feature size (RFS).	No. of Lectures: 11

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		

24. 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	
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	
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	
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	
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	

25. 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

26. 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

27. MAPPING OF EACH CO WITH PO(s)

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

28. 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. 3. Content is presented with clarity, precision, and logical flow.	3
	PO3	1. Apply advanced design methodologies. 2. Demonstrate proficiency in additive manufacturing. 3.Integrate automation and digital manufacturing tools	3
	PO4	1. Modelling and Simulation for Problem Solving. 2. Referencing and academic integrity practices are properly maintained.	2
	PO5	1. Advanced Modelling and CAD/CAM Integration. 2. Innovative Design and Product Development. 3. Manufacturing Process Optimization.	3
	PO6	1. Continuous Knowledge Upgradation. 2. Research and Innovation Skills. 3. Adaptation to Digital Transformation.	3
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,	4

		supporting effective oral communication and technical presentations. 4.Experiments or simulations are conducted using appropriate tools.	
	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. 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.	4
	PO4	1. Parametric models are directly used in CAD/CAM workflows. 2. additive manufacturing, ensuring compatibility with modern digital manufacturing tools. 3. Digital Manufacturing Tools and Technologies.	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. 3.Proficiency in CAD-based digital tools, ensuring advanced visualization of engineering concepts. 4. Continuous Knowledge Upgradation	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. 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. 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.	3
	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.By developing lightweight, precise, and resource-efficient surface models, surface modelling promotes sustainable	2

		design approaches with applications across aerospace, automotive, and biomedical sectors.	
	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. 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.	5
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. Modelling output data, including dimensions, material properties, and load responses, is systematically interpreted to refine and validate solid models. 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	3

		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. 3. Students present solid models, explain geometry construction, and defend their design choices in academic and professional forums.	
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. Solid models serve as a foundation for AI-driven generative design and Industry 4.0 digital workflows. Accurate representation minimizes wastage, supports lightweight designs, and promotes use of eco-friendly materials.	3
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. 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. 4. 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. 3. Content is presented with clarity, precision, and logical flow	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.	5

| | 4. Skills in projections and rendering align with current industry practices, making students job-ready.
5. Self-Directed and Lifelong Learning. | |

29. 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

30. 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

31. 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

32. ASSESSMENT METHODOLOGY DIRECT

CIE Exams	✓	SEE	✓	Seminars	-

Objective / quiz	-	Viva-Voce/PPT	✓	MOOCS	-
Assignments	✓	Project	-		

33. ASSESSMENT METHODOLOGY INDIRECT

✓	Course End Survey (CES)

34. POs-WKs Mapping

POs		WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
	No of Indicators	5	4	4	3	4	5	4	6	4
PO1	Research/ investigation	4	4	4	3	4	5	4	6	4
PO2	Report Preparation	1	2	2	2	2	2	1	2	2
PO3	Domain Mastery	4	3	4	2	4	5	3	6	3
PO4	Application of Engineering Principles	5	3	4	3	4	5	4	6	4
PO5	Design and Sustainability	3	3	4	2	4	5	3	6	3
PO6	Lifelong Learning and Professional Development	4	3	4	2	4	5	4	6	5

35. Percentage of POs-WKs Mapping

POs		WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
	No of Indicators	5	4	4	3	4	5	4	6	4
PO1	Research/ investigation	80	100	100	100	100	100	100	100	100
PO2	Report Preparation	20	50	50	67	50	40	25	33	50
PO3	Domain Mastery	80	75	100	67	100	100	75	100	75
PO4	Application of Engineering Principles	100	75	100	100	100	100	100	100	100

PO5	Design and Sustainability	60	75	100	67	100	100	100	100	100
PO6	Lifelong Learning and Professional Development	80	75	100	67	100	100	100	100	80

36. RELEVANCE TO SUSTAINABILITY GOALS

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

✗	1	NO POVERTY	NA
✗	2	ZERO HUNGER	NA
✗	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.
✗	5	GENDER EQUALITY	NA
✗	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
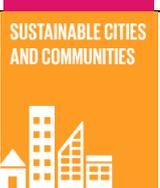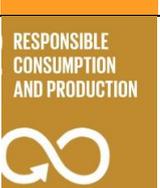
x	16	PEACE, JUSTICE AND STRONG INSTITUTIONS	NA
x	17	PARTNERSHIPS FOR THE GOALS	NA

Signature of Course Coordinator   **HOD**