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MARRI LAXMAN REDDY INSTITUTE OF TECHNOLOGY AND MANAGEMENT

Outcome Based Education (OBE) Manual

Department of Mechanical Engineering

Regulation: UGR20

Contents

OVERVIEW

Outcome Based Education (OBE) is an educational model that forms the base of a quality education system. There is no single specified style of teaching or assessment in OBE. All educational activities carried out in OBE should help the students to achieve the set goals. The faculty may adapt the role of instructor, trainer, facilitator, and/or mentor, based on the outcomes targeted.

OBE enhances the traditional methods and focuses on what the Institute provides to students. It shows the success by making or demonstrating outcomes using statements "able to do" in favor of students. OBE provides clear standards for observable and measurable outcomes.

National Board of Accreditation (NBA) is an authorized body for the accreditation of higher education institutions in India. NBA is also a full member of the Washington Accord. NBA accredited programs and not the institutions.

Higher Education Institutions are classified into two categories by NBA

Tier – 1: Institutions consists of all IITs, NITs, Central Universities, State Universities and Autonomous Institutions. Tier - 1 institution can also claim the benefits as per the Washington Accord.

Tier-2: Institutions consist of affiliated colleges of universities.

What is Outcome Based Education (OBE)?

Institutions adopting OBE try to bring changes to the curriculum by dynamically adapting to the requirements of the different take holders like Students, Parents, Industry Personnel and Recruiters. OBE is all about feedback and outcomes.

Four levels of outcomes from OBE are:

1. Program Educational Objectives (PEOs)
2. Program Specific Outcomes (PSOs)
3. Program Outcomes (POs)
4. Course Outcomes (COs)

Why OBE?

1. International recognition and global employment opportunities.
2. More employable and innovative graduates with professional and soft skills, social responsibility and ethics.
3. Better visibility and reputation of the technical institution among stakeholders.
4. Improving the commitment and involvement of all the stakeholders.
5. Enabling graduates to excel in their profession and accomplish greater heights in their careers.
6. Preparing graduates for the leadership positions and challenging them and making them aware of the opportunities in the technology development.

Benefits of OBE

Clarity: The focus on outcome creates a clear expectation of what needs to be accomplished by the end of the course.
Flexibility: With a clear sense of what needs to be accomplished, instructors will be able to structure their lessons around the students' needs.
Comparison: OBE can be compared across the individual, class, batch, program and institute levels.
Involvement: Students are expected to do their own learning. Increased student's involvement allows them to feel responsible for their own learning, and they should learn more through this individual learning.

- Teaching will become a far more creative and innovative career
- Faculty members will no longer feel the pressure of having to be the "source of all knowledge".
- Faculty members shape the thinking and vision of students towards a course.

India, OBE and Accreditation:

From 13 June 2014, India has become the permanent signatory member of the Washington Accord Implementation of OBE in higher technical education also started in India. The National Assessment and Accreditation Council (NAAC) and National Board of Accreditation (NBA)are the autonomous bodies for promoting global quality standards for technical education in India. NBA has started accrediting the programs running with OBE from 2013.

The National Board of Accreditation mandates establishing a culture of outcome-based education in institutions that offer Engineering, Pharmacy, and Management program Reports of outcome analysis help to find gaps and carryout continuous improvements in the education system of an Institute, which is very essential.

1. Vision, Mission, Quality Policy, Philosophy & Core Values

Vision

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

Mission

M1: To provide innovative and sustainable technology solutions to solve a wide range of complex scientific and technological challenges in the Mechanical Engineering field.

M2: To enhance employability, leadership skills, and research capabilities through industry collaboration and experiential learning.

M3: To nurture students as ethical and resilient professionals committed to lifelong learning.

M4: To promote excellence in emerging interdisciplinary fields to support sustainable global progress.

Quality Policy

Our policy is to nurture and build diligent and dedicated community of engineers providing a professional and unprejudiced environment, thus justifying the purpose of teaching and satisfying the stake holders.

A team of well qualified and experienced professionals ensure quality education with its practical application in all areas of the Institute.

Philosophy

The essence of learning lies in pursuing the truth that liberates one from the darkness of ignorance and Marri Laxman Reddy Institute of Technology and management firmly believes that education is for liberation.

Contained therein is the notion that engineering education includes all fields of science that plays a pivotal role in the development of world-wide community contributing to the progress of civilization. This institute, adhering to the above understanding, is committed to the development of science and technology in congruence with the natural environs. It lays great emphasis on intensive research and education that blends professional skills and high moral standards with a sense of individuality and humanity. We thus promote ties with local communities and encourage transnational interactions in order to be socially accountable. This accelerates the process of transfiguring the students into complete human beings making the learning process relevant to life, instilling in them a sense of courtesy and responsibility.

Core Values

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

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

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

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

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

2. Program Educational Objectives (PEOs)

Program Educational Objectives (PEOs) should be defined by the PAQIC after taking feedback from all stake holders. PEOs are a promise by the department to the aspiring students about what they will achieve once they join the program. PEO assessment is not made compulsory by NBA as it is quite difficult to measure in the Indian context. NBA assessors usually do not ask for PEO assessment. PEOs are about professional and career accomplishment after 4 to 5 years of graduation. PEOs can be written from different perspectives like Career, Technical Competency, and Behavior. While writing the PEOs, do not use technical terms as it will be read by prospective students who want to join the program. Three to five PEOs are recommended.

Program Educational Objective - I: To develop a strong foundation in mechanical engineering principles for analyzing, designing, and innovating engineering solutions.

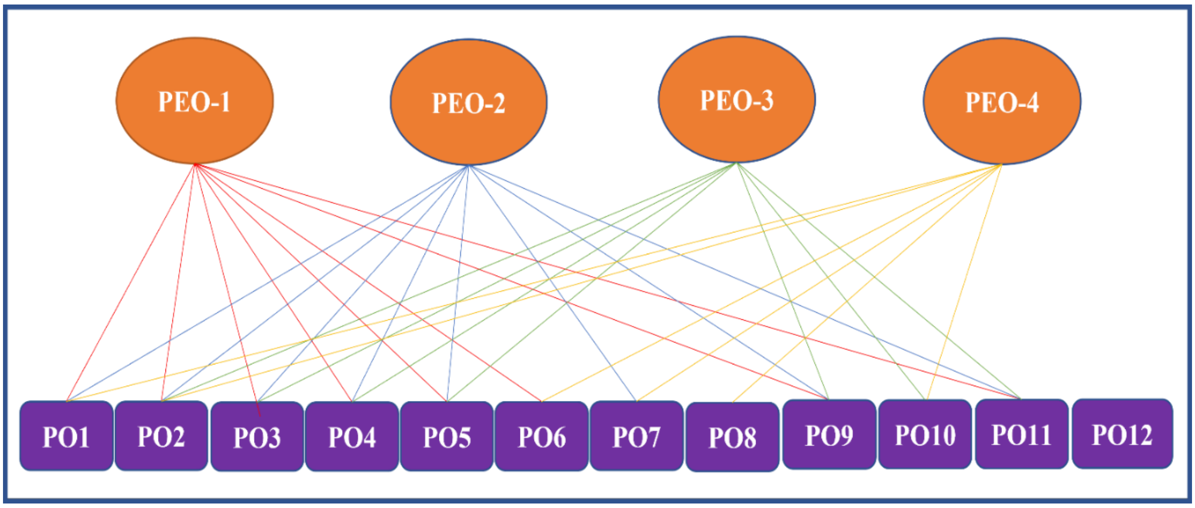
Program Educational Objective - II: To equip graduates with skills and knowledge to address industry challenges and contribute effectively to societal needs.

Program Educational Objective - III: To foster the ability to collaborate across multidisciplinary teams while upholding professional ethics and responsibility.

Program Educational Objective - IV: To promote lifelong learning, adaptability, and leadership skills for continuous personal and professional growth in a dynamic environment.

2.1. Mapping of program educational objectives to program outcomes and program specific outcomes:

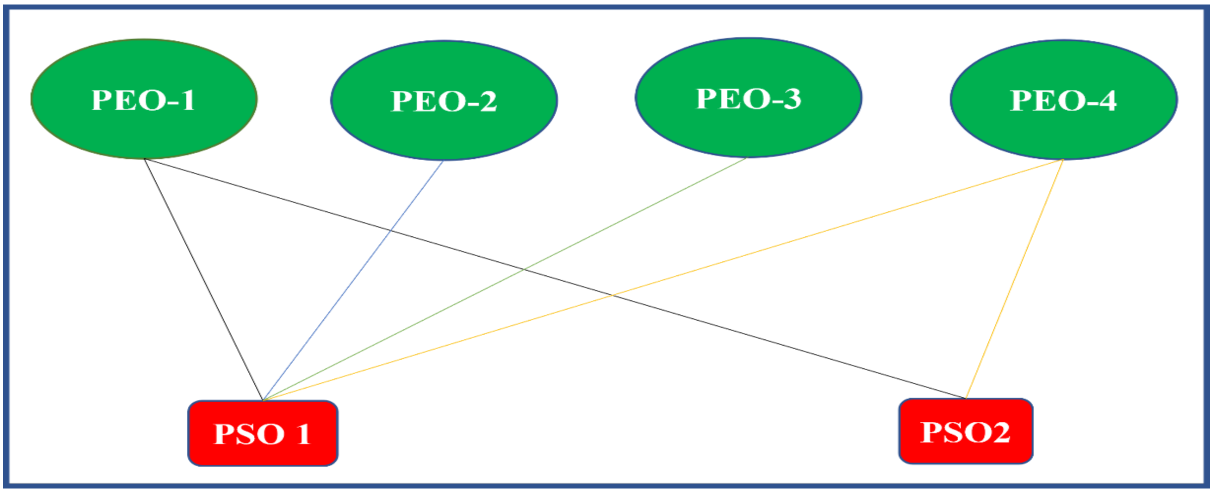
The following Figure 1 shows the correlation between the PEOs and the Pos



PEO-I	PEO-II	PEO-III	PEO-IV
PO:1,2,3,4,5,6,9,11	**PO:**1,2,3,4,5,7,9,11	**PO:**2,3,4,5,9,10,11	**PO:**1,2,6,7,8,10,

FIGURE 1: Correlation between the PEOs and the Pos

The following Figure2 shows the correlation between the PEOs and the PSOs



PEO-I	PEO-II	PEO-III	PEO-IV
PSO:1,2	PSO:1,2	PSO:1	PSO:2

FIGURE 2: Correlation between the PEOs and the PSOs

3. Program Out comes (POs)

A Program Learning Outcome is broad in scope and describes what a student should be able to do at the end of the program. POs are aligned with the graduate attributes specified in the **Washington Accord**. POs should be specific, measurable, and achievable.

The **NBA** has defined **12 POs**, which are common for all institutions in India.

In the syllabus book given to students, there should be a clear mention of **course objectives** and **course outcomes**, along with a **CO-PO course articulation matrix** for all the courses.

B. Tech (MECH) – PROGRAM OUTCOMES (PO's)	
A graduate of the Mechanical Engineering Program will be demonstrated:	
PO1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2	**Problem Analysis:** Identify, formulate, review research literature, and analyse complex engineering problems, reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, as well as cultural, societal, and environmental considerations.

PO4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods, including the design of experiments, analysis and interpretation of data, and synthesis of information, to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, andmodernengineeringandITtoolsincludingpredictionandmodelingtocomplex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal, and cultural issues, and the consequent responsibilities relevant to professional engineering practice.
PO7	**Environment and Sustainability:** Understand the impact of professional engineering solutions in societal and environmental contexts, and demonstrate knowledge of and the need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics, responsibilities, and norms of engineering practice.
PO9	**Individual and Teamwork:** Function effectively as an individual, as well as a member or leader in diverse teams and multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and society at large. This includes the ability to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
PO11	**Project Management and Finance:** Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work as a member and leader in a team to manage projects in multidisciplinary environments.
PO12	**Life-Long Learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

4. Program Specific Outcomes (PSOs)

Program Specific Outcomes (PSOs) are statements that describe what the graduates of a specific engineering program should be able to do.

A list of PSOs written for the Department of Mechanical Engineering is given below.

B. Tech (MECH) – PROGRAM SPECIFIC OUTCOMES (PSO's)	
A graduate of the Mechanical Engineering Program will demonstrate:	
PSO1	Students acquire necessary technical skills in mechanical engineering that make them employable graduate.
PSO2	An ability to impart technological inputs towards development of society by becoming an entrepreneur.

5. Relation between the Program Educational Objectives and the POs

Broad relationship between the program objectives and the program outcomes is given in the following Table below:

PEO's→ ↓PO's		**(1) Success in Mechanical Engineering**	**(2) Industrial awareness and research**	**(3) Successful employment and professional ethics**	**(4) Being a leader professional and societal environment**
PO1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	1		1
PO2	Identify, formulate, review research literature, and Analyse complex engineering problems, reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	3	1	1

PO3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, as well as cultural, societal, and environmental considerations.	3	1	2	
PO4	Use research-based knowledge and research methods, including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	3	1	
PO5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.	2	1	2	
PO6	Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to professional engineering practice.	1			3
PO7	Understand the impact of professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of and need for sustainable development.		1		3
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.				2

PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	1	2	
PO10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.			2	3
PO11	Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work as a member and leader in a team, to manage projects in multidisciplinary environments.	1	1	3	
PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.				

6. Relation between the Program Specific Outcomes and the Program Educational Objectives

PEO's→ **↓PSO's**		**(1) Success in Mechanical Engineering**	**(2) Industrial awareness and research**	**(3) Successful employment and professional ethics**	**(4) Being a leader professional and societal environment**
PSO 1	Students acquire necessary technical skills in mechanical engineering that make them employable graduate.	3	3	2	1
PSO 2	An ability to impart technological inputs towards development of society by becoming an entrepreneur.	2		3	2

Relationship between Program Specific Outcomes and Program Educational Objectives Key: 3 = High; 2 = Medium; 1= Low

Note:

- The assessment process of Pos and PSOs can be direct or indirect.
- The direct assessment will be done through interim assessment by conducting continuous internal exam and semester end exams.
- The indirect assessment on the other hand could be done through student's program exit questionnaire, alumni survey and employment survey.

7. Blooms Taxonomy

Bloom's taxonomy is considered the global language for education. Bloom's Taxonomy is frequently used by teachers in writing course outcomes as it provides a ready-made structure and a list of action verbs. The stages ascend in complexity and what they demand of students.

First, students need to simply remember information provided to them—but reciting something doesn't demonstrate having learned it, only memorization. With understanding comes the ability to explain the ideas and concepts to others. The students are then challenged to apply the information and use it in new ways, helping to gain a deeper understanding of previously covered material and demonstrating it moving forward.

Questioning information is a vital part of learning, and both analysis and evaluation do just this. Analyzing asks a student to examine the information in a new way, and evaluation demands the student appraise the material in a way that lets them defend or argue against it as they determine.

The final step in the revised taxonomy is creating, which entails developing a new product or point of view. How does this learned information impact your world? How can it be used to impact not just your education but the way you interact with your surroundings? By utilizing Bloom's Taxonomy, students are not going to forget the information as soon as the class ends—rather, they retain and apply the information as they continue to grow as a student and in their careers, staying one step ahead of the competition.

7.1. Incorporating Critical Thinking Skills into Course Outcome Statements

Many faculty members choose to incorporate words that reflect critical or higher-order thinking into their learning outcome statements. Bloom (1956) developed a taxonomy outlining the different types of thinking skills people use in the learning process. Bloom argued that people use different levels of thinking skills to process different types of information and situations. Some of these are basic cognitive skills (such as memorization) while others are complex skills (such as creating new ways to apply information). These skills are often referred to as critical thinking skills or higher-order thinking skills.

Bloom proposed the following taxonomy of thinking skills. All levels of Bloom's taxonomy of thinking skills can be incorporated into expected learning outcome statements. Recently, Anderson and Krathwohl (2001) adapted Bloom's model to include language that is oriented towards the language used in expected learning outcome statements. A summary of Anderson and Krathwohl's revised version of Bloom's taxonomy of critical thinking is provided in Figure 3.

FIGURE3: Revised version of Bloom's taxonomy

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

Remember: Recalling relevant terminology, specific facts, or different procedures related to information and/or course topics. At this level, a student can remember something but may not really understand it.

Understand – The ability to grasp the meaning of information (facts, definitions, concepts, etc.) that has been presented.

Apply – Being able to use previously learned information in different situations or in problem-solving.

Analyse – The ability to break information down into its component parts. Analysis also refers to the process of examining information in order to make conclusions regarding cause and effect, interpreting motives, making inferences, or finding evidence to support statements/arguments.

Evaluate – Being able to judge the value of information and/or sources of information based on personal values or opinions.

Create– The ability to creatively or uniquely apply prior knowledge and/or skills to produce new and original thoughts, ideas, processes, etc. At this level, students are involved in creating their own thoughts and ideas.

7.3 List of Action Words Related to Critical Thinking Skills

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

writing COs for our courses.

The cognitive process dimensions - categories:

Lower Order of Thinking (LOT)			Higher Order of Thinking (HOT)		
Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Interpreting Illustrating Classifying Summarizing Inferring (concluding) comparing explaining	Recognizing (identifying) Recalling (retrieving)	Executing Implementing	Differentiating Organizing Attributing	Checking (Coordinating) detecting, testing, monitoring) Critiquing (judging)	Planning Generating Producing (constructing)

The Knowledge Dimension			
Concrete Knowledge → Abstract knowledge			
Factual	**Conceptual**	**Procedural**	**Metacognitive**
• Knowledge of terminologies • Knowledge of specific details and elements.	• Knowledge of classifications and categories • Knowledge of principles and generalizations • Knowledge of theories, models and structures	• Knowledge of subject specific skills and algorithms • Knowledge of subject specific techniques and methods • Knowledge of criteria for determining when to use appropriate procedures	• Strategic Knowledge • Knowledge about cognitive task, including gap propriate contextual and conditional Knowledge • Self-Knowledge

Action Verbs for Course Out comes

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 off acts and ideas by organizing, comparing, translating, interpreting, giving descriptions, and Stating main ideas.	Solve problem s to 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

8. Guidelines for writing Course Outcome Statements:

Well-written course outcomes involve the following parts:

1. Action verb
2. Subject content
3. Level of achievement as per BTL
4. Modes of performing task (if applicable)

8.1. Course Outcomes (COs)

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

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

8.2. Developing Course Outcomes

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

Limit the course outcomes to 5-6 statements for the entire course [more detailed outcomes can be developed for individual units, assignments, chapters, etc. if the instructor(s) wish (es)].

Focus on overarching knowledge and/or skills rather than small or trivial details.

Emphasize knowledge and skills that are central to the course topic and/or discipline.

Create statements that have a student focus rather than an instructor-centric approach. (Example:

Student-focused outcome: —Upon completion of this course, students will be able to list the names of the 28 states and 8 union territories.‖

Instructor-centric objective (to avoid): —One objective of this course is to teach the names of the 28 states and 8 union territories.‖).

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

Incorporate and/or reflect the institutional and departmental mission.

Include various ways for students to show success (e.g., outlining, describing, modelling, depicting, etc.) rather than using a single statement such as ―At the end of the course, students will know‖ as the stem for each expected outcome statement.

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

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

Course outcome statements at the course level describe:

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

Course outcomes have three major characteristics:

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

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

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

8.3. Relationship of Course Outcome to Program Outcome

Learning outcomesformula:
STUDENTS SHOULD BE ABLE TO + BEHAVIOR + RESULTING EVIDENCE

The Course Outcomes need to link to the Program Outcomes.

For example, you can use the following template to help you write an appropriate course level learning outcome.

"Upon completion of this course students will be able to (knowledge, concept, rule or skill you expect them to acquire) by (how will they apply the knowledge or skill/how will you assess the learning)."

8.4. Characteristics of Effective Course Outcomes

Well written course outcomes:

- Describe what you want your students to learning your course.
- A realigned 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

8.5. Examples of Effective Course Outcomes

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

- Critically review the methodology of a research study published in a scholarly sociology journal.
- Design a web site using HTML and Java Script.
- Describe and present the contributions of women to American history.
- Recognize the works of major Re-naissance artists.
- Facilitating a group to achieve agreed – Up on goals.
- Determine and apply the appropriate statistical procedures to analyze the results of simple experiments.
- Develop an individual learning plan for a child with a learning disability.
- Produce a strategic plan for a small manufacturing business.
- Analyseacharacter'smotivationandportraythatcharacterbeforeanaudience.
- Differentiate among five major approaches to literary analysis.
- List the major ethical issues one must consider when planning a human-subjects study.
- Locate and critically evaluate information on current political issues on the Web.
- List and describe the functions of the major components of the human nervous system.
- Correctly classify rock samples found in...
- Conduct a systems analysis of a group interaction.
- Demonstrate active listening skills when interviewing clients.
- Apply social psychological principles to suggest solutions to contemporary social problems.

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

The table below provides three examples.

S. No	Condition	Observable Behavior	Standard
1	Given a list of drugs	The student will be able to classify each item as amphetamine or barbiturate.	With at least70% accuracy
2	Immediately following a fifteen-minute discussion on a topic.	The student will be able to summarize in writing the major issues being discussed.	Mentioning at least three of the five major topics.
3	Given an algebraic equation with one unknown.	The student will be able to correctly solve a simple linear equation.	Within a period of five minutes.

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

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

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

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

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

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

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

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

An Introspection - Examine Your Own Course Outcomes

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

Write Your Course Outcomes!

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

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

8.6. CO-PO Course Articulation Matrix (CAM)Mapping

A **Course Articulation Matrix** shows the educational relationship (Level of Learning achieved) between course outcomes and program outcomes for a course. This matrix strongly indicates whether the students are able to achieve the course learning objectives. The matrix can be used for any course and is a good way to evaluate a course syllabus.

Table 1 provides information about the action verbs used in the Program Outcomes (POs) and the nature of POs, stating whether the POs are technical or non-technical.

You need to understand the intention of each PO and the **Bloom's Taxonomy level** to which each of the section verbs in the POs correlates. Once you have understood the POs, you can write the **Course Outcomes (COs)** for a course and see to what extent each of those COs correlates with the POs.

TABLE 9: Process for mapping the values for CO-PO Matrix

Experiential learning	Experie nt ial learning	Experiential learning	Experiential learning	Experiential learning
Technical	PO1	Apply	L3	Bloom's L1 to L4 for theory courses. Bloom'sL1toL5forlaboratory courses. Bloom'sL1toL6for Project work, experiential learning
	PO2	Identify	L2	
		Formulate	L6	
		Review	L2	
	PO3	Design	L6	
		Develop	L3, L6	
	PO4	Analyze	L4	
		Interpret	L2, L3	
		Design	L6	
	PO5	Create	L6	
		Select	L1, L2, L6	
		Apply	L3	
Non-Technical	PO6	**Thumb Rule:** If Bloom's L1 Action Verbs of a CO: Correlates with any of PO6 to PO12, then assign 1. If Bloom's L2 to L3 Action Verbs of a CO: Correlates with		
	PO7			
	PO8			
	PO9			
	PO10			

	PO11	Any of PO6 to PO12, then assign 2.
	PO12	If Bloom's L4 to L6 Action Verbs of a CO: Correlates with any of PO6 to PO12, then assign3

At the end, the Program Outcomes (POs) can be calculated using various descriptors that you may define. The mapping of Course Outcomes (COs) towards a PO is evaluated using descriptors such as High, Medium, Low, etc.

Observations:

1. The first five Program Outcomes (POs) are purely technical in nature, while the other POs are non-technical.
2. For theory courses, while writing the Course Outcomes (COs), you need to restrict yourself between Bloom's Level 1 to Level 4. However, if it is a programming course, restrict yourself between Bloom's Level 1 to Level 3, but for other courses, you can go up to Bloom's Level 4.
3. For laboratory courses, while composing COs, you need to restrict yourself between Bloom's Level 1 to Level 5.
4. Only for mini-projects and main projects, you may extend up to Bloom's Level 6 while composing COs.
5. For a given course, the course in-charge must involve all other professors who teach that course and ask them to come up with the CO-PO mapping. The course in-charge must take the average value of all these CO-PO mappings and finalize the values. Alternatively, the course in-charge can proceed with what the majority of faculty members prefer. Ensure that none of the professors handling the course discuss with each other while marking the CO-PO values.
6. If you want to match your COs with non-technical POs, correlate the action verbs used in the COs with the thumb rule given in the table and map the values. (This applies only for mapping COs to non-technical POs).

8.7. Tips for Assigning the values while mapping Cos to PO s.

1. Select action verbs for a Course Outcome (CO) from different Bloom's levels based on the importance of the particular CO for the given course.
2. Stick to a single action verb while composing COs, but you may use multiple action verbs if the need arises.
3. You need to justify the marking of values in the CO-PO articulation matrix. Use a combination of words found in the COs, POs, and your course syllabus for writing the justification. Restrict yourself to one or two lines.
4. Values for the CO-PO (technical POs in particular) matrix can be assigned by:

(a) Judging the importance of the particular CO in relation to the PO s. If the CO matches strongly with a particular PO criterion, assign 3; if it matches moderately, assign 2; if the match is low, assign 1; otherwise, mark with a ―-‖ symbol.

(b) If an action verb used in a CO appears at multiple Bloom's levels, then you need to judge which Bloom's level is the best fit for that action verb.

8.8. Method for Articulation

1. Identify the key competencies of POs/PSOs 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/PSO 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/PSOs, and your course syllabus for writing the justification.
3. Create a table listing the number of key competencies for CO-PO/PSO 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/PSO mapping with reference to the maximum given Key Attributes for Assessing Program Outcomes.
5. Finally, prepare a Course Articulation Matrix (CO-PO/PSO Mapping) with COs and POs and COs and PSOs 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 (C%)	**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)**

9.Key Competencies for Assessing Program Outcomes:

PO No.	NBA Statement / Vital Features	Key Components	No. of Key Components
PO1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems **(Engineering Knowledge).**	1. **Scientific Principles:** Application of scientific principles and methodologies. 2. **Mathematical Principles:** Utilization of mathematical concepts in problem-solving. 3. **Interdisciplinary Integration:** Integration of knowledge from various engineering disciplines. 4. **Engineering Specialization:** Application of specialized engineering knowledge in complex engineering problems.	**4**
PO 2.	Identify, formulate, review research literature, and analyze complex engineering problems, reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences **(Problem Analysis).**	1. **Identity:** Recognizing and defining complex engineering problems or opportunities. 2. **Formulate:** Structuring and abstracting the problem for systematic analysis. 3. **Review:** Examining research literature 4. **Analyze:** Investigating problems using data collection and relevant methodologies. 5. **First Principles:** Applying mathematical, natural, and engineering sciences in problem-solving. 6. **Substantiated Conclusions:** Ensuring accuracy and reliability through validation. 7. **Experimental Design:** Planning and conducting experiments for problem analysis. 8. **Solution Development:** Implementing and testing solutions through experimentation. 9. **Interpretation:** Evaluating results to draw meaningful engineering conclusions. 10. **Documentation:** Recording findings systematically for future reference and learning.	**10**
PO 3.	Design solutions for complex Engineering problems and design system components or	1. **Design:** Investigate and define a problem while identifying constraints, including environmental, sustainability, health, and	**10**

	processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations **(Design/Development of Solutions).**	safety considerations. 2. **Solutions:** Understand customer and user needs while considering factors such as aesthetics. 3. **System Components:** Identify and manage cost drivers in engineering solutions. 4. **Processes:** Use creativity to develop innovative engineering solutions. 5. **Specified Needs:** Ensure fitness for purpose across production, operation, maintenance, and disposal. 6. **Public Health & Safety:** Manage the design process and evaluate outcomes for safety and risk assessment. 7. **Cultural Considerations:** Understand the commercial and economic context of engineering processes. 8. **Societal Considerations:** Apply management techniques to achieve engineering objectives in a broader context. 9. **Environmental Considerations:** Promote sustainable development through engineering activities. **11. Appropriate Considerations:** Beaware of legal frameworks governing engineering activities, including personnel, health, safety, and environmental risks.	
PO 4.	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. **(Conduct Investigations of Complex Problems).**	1. **Research-Based Knowledge:** Gain a deep understanding of materials, equipment, processes, and products through research to address engineering problems effectively. 2. **Research Methods:** Develop essential laboratory and workshop skills to carry out experimental investigations and gather reliable data. 3. **Design of Experiments:** Address complex problems in various engineering contexts, including operations, management, and technology development. 4. **Analysis:** Leverage technical literature and reliable information sources. 5. **Interpretation of Data:** Follow appropriate codes of practice and industry standards when analyzing and	**10**

		interpreting experimental data. 6. **Synthesis:** Ensure high-quality results by integrating various data sources and considering quality control during engineering investigations. 7. **Valid Conclusions:** Draw valid conclusions by addressing technical uncertainties through sound reasoning and scientific principles. 8. **Engineering Principles:** Apply fundamental engineering principles to analyze and interpret key engineering processes and challenges. 9. **Modelling Techniques:** Use analytical and modeling techniques to identify, classify, and describe the performance of engineering systems and components. **10. Quantitative Methods:** Employ analytical software and quantitative methods efficiently and accurately.	
PO 5.	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).**	1. **Create:** Develop engineering solutions using modern tools across various disciplines. 2. **Select:** Identify appropriate prediction and modeling tools for diverse engineering applications. 3. **Apply:** Utilize IT tools in engineering analysis, design, and decision-making. 4. **Techniques:** Implement simulation tools in different engineering fields.	**4**
PO 6.	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant To the professional engineering practice **(The Engineer and Society).**	1. **Contextual Knowledge:** Understand the commercial and economic context of engineering processes. 2. **Management Techniques:** Apply management strategies in engineering objectives within this context. 3. **Sustainable Development:** Promote sustainable development through engineering activities. 4. **Legal Awareness:** Recognize relevant legal requirements governing engineering practices, including health, safety, and environmental risks. **5. Professional Ethics:** Uphold high standards of professional and ethical conduct in engineering.	**5**

PO 7.	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development. **(Environment and Sustainability).**	1. **Socio-Economic Impact:** Understand the socio-economic effects of engineering solutions on society. 2. **Political Impact:** Recognize the political implications and responsibilities of engineering solutions. 3. **Environmental Impact:** Assess the environmental consequences of engineering practices and solutions. 4. **Sustainability:** Demonstrate the importance of sustainable development in engineering solutions.	**4**
PO 8.	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice **(Ethics).**	1. **Ethical Judgement:** Make informed decisions based on ethical principles, using professional codes of ethics to guide actions and evaluate the ethical aspects of practice. 2. **Integrity:** Demonstrate a strong sense of trust and integrity, standing firm in one's values while acting responsibly and ethically. 3. **Fairness and Equity:** Ensure fair treatment and equity in all professional activities, valuing diversity and respecting others' perspectives. 4. **Professional Responsibility:** Adhere to the norms of engineering practice by committing to high ethical standards and demonstrating ethical behavior in all professional engagements.	**4**

PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **(Individual and Teamwork).**	1. **Independence:** Work effectively as an individual, taking ownership of tasks and driving progress independently. 2. **Maturity:** Demonstrate maturity by focusing on goal achievement, requiring minimal external motivation. 3. **Self-Direction:** Approach vaguely defined problems with systematic problem-solving skills to find solutions. 4. **Team Collaboration:** Engage in teamwork during various activities, including hands-on labs and multidisciplinary projects. 5. **Adaptability:** Participate in diverse team settings, adjusting to different roles and projects such as mini projects and design tasks. 6. **Project Management:** Understand and apply principles of teamwork and project management to effectively complete assignments and projects. 7. **Peer Evaluation:** Contribute to team dynamics by evaluating and reflecting on individual and group performance. 8. **Building Relationships:** Foster teamwork and lasting relationships, contributing to both academic success and post-graduation professional networks. 9. **Organizational Integration**: Collaborate with individuals across all levels of an organization, demonstrating adaptability and interpersonal skills. **10. Effective Communication:** Develop strong relationships through positive interactions, showcasing an ability to get along with others and work cohesively in teams.	**10**

PO10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions **(Communication).**	1. **Clarity:** Communicate complex engineering concepts clearly and concisely in written reports and design documentation. 2. **Grammar and Punctuation:** Ensure high standards of grammar and punctuation in written communication, maintaining professionalism and clarity. 3. **References:** Properly reference sources in written communication, ensuring accuracy and academic integrity. 4. **Speaking Style:** Deliver oral presentations effectively, with appropriate speaking style to engage the audience and convey technical information clearly. 5. **Subject Matter**: Demonstrate a deep understanding of the subject matter, clearly communicating complex ideas during oral discussions and presentations.	**5**
PO11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage rejects and in multi-disciplinary Environments. **(Project Management and Finance).**	1. **Scope Definition:** Define the project scope clearly to ensure alignment with objectives and requirements. 2. **Critical Success Factors:** Identify and prioritize critical success factors necessary for project completion and success. 3. **Deliverables:** Ensure the timely delivery of project outputs, meeting the predefined objectives and quality standards. 4. **Work Breakdown Structure:** Develop and organize a structured breakdown of tasks and activities to achieve project goals. 5. **Scheduling:** Create and manage schedules to ensure tasks are completed on time and milestones are met. 6. **Budget Management:** Develop and manage project budgets, ensuring that resources are used efficiently and within financial constraints. 7. **Quality Assurance**: Apply quality control measures to ensure that project deliverables meet the required standards. 8. **Human Resources Planning:** Plan and allocate human resources effectively,	**10**

		ensuring the right skills and team dynamics. 9. **Stakeholder Management:** Identify and manage stakeholders, ensuring their needs and expectations are addressed throughout the project. 10. **Risk Management:** Develop a risk register and apply strategies to identify, assess, and mitigate project risks.	
PO12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change **(Life - Long Learning).**	1. **Professional Certificate:** Pursue professional, Academic, Global certifications. 2. **Advanced Education:** Begin and work towards advanced programs to further deepen knowledge. 3. **Continuous Learning:** Stay updated on industry trends and emerging technologies to remain relevant in the field. 4. **Skill Acquisition:** Learn at least 2–3 new significant skills annually to ensure continuous growth and development. 5. **Training Commitment:** Dedicate time for formal training for a standard duration of training each year. 6. **Personal Development:** Engage in ongoing self-improvement efforts to enhance both personal and professional growth. 7. **Adaptability:** Be adaptable to technological changes by actively pursuing new learning opportunities and challenges. 8. **Networking:** Build a network with industry peers and professionals to stay informed and grow knowledge through collaboration.	**8**

10. Key Competencies for Assessing Program Specific Outcomes:

PSO	NBA statement/Vital features	No. of vital features
PSO1	Students acquire necessary technical skills in mechanical engineering that make them employable graduate. 1. Technical and Engineering Skills. 2. Adaptability and Lifelong Learning.	2
PSO2	An ability to impart technological inputs towards development of society by becoming an entrepreneur. 1. Innovation and Problem-Solving. 2. Entrepreneurial and Leadership Skills.	2

11. Program Outcomes and Program Specific outcomes Attained through course modules:

Courses offered in Mechanical Engineering Curriculum (MLRS-R22) and POs/PSOs attained through course modules for I, II, III, IV, V, VI, VII and VIII semesters.

Course Code	Course Title	POS												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
I B. Tech – I Semester															
2010001	Engineering Mathematics I	✓	✓	✓	✓								✓	✓	
2010007	Engineering Physics	✓	✓	✓			✓							✓	
2010501	Programming For Problem Solving	✓	✓	✓	✓									✓	
2010072	Engineering Physics Lab	✓	✓	✓	✓									✓	
2010571	Programming For Problem Solving Lab	✓	✓	✓	✓	✓								✓	
2010371	Engineering Drawing Practice	✓	✓	✓	✓								✓	✓	
I B. Tech – II Semester															
2020002	Engineering Mathematics II	✓	✓	✓	✓								✓	✓	
2020008	Engineering Chemistry	✓	✓	✓			✓							✓	
2020009	Communicative English									✓	✓	✓		✓	✓
2020502	Data Structures	✓	✓	✓	✓	✓								✓	

2020073	Engineering Chemistry Laboratory	✓	✓	✓	✓									✓	
2020074	Communicative English Language Laboratory	✓	✓	✓	✓	✓									✓
2020372	Engineering Work Shop	✓	✓	✓	✓									✓	
2020572	Data Structures Laboratory	✓	✓	✓	✓	✓								✓	
2020021	Environmental Science	✓					✓								
II B. Tech – I Semester															
2030202	Basic Electrical and Electronic Engineering	✓	✓	✓	✓									✓	
2020301	Engineering Mechanics	✓	✓	✓	✓		✓						✓	✓	✓
2030311	Thermodynamics	✓	✓										✓	✓	✓
2030005	Probability Distributions& Complex Variables	✓	✓	✓	✓								✓	✓	
2030505	Python Programming	✓	✓	✓	✓								✓	✓	
2030374	Machine Drawing Practice	✓	✓	✓		✓							✓	✓	✓
2030272	Basic Electrical and Electronics Engineering Lab	✓	✓	✓										✓	
2030273	Fuels And Lubrication Lab	✓	✓	✓										✓	
2030575	Python Programming Lab	✓	✓	✓	✓	✓								✓	✓
2030022	Gender Sensitization						✓	✓	✓						
II B. Tech – II Semester															
2030312	Mechanics of Solids	✓	✓	✓	✓		✓						✓	✓	✓
2040313	Metallurgy and Material Science	✓	✓	✓	✓								✓	✓	✓
2040314	Kinematics of Machinery	✓	✓	✓	✓		✓							✓	✓
2040315	Thermal Engineering – I	✓	✓	✓									✓	✓	
2040316	Production Technology	✓	✓	✓	✓								✓	✓	✓

2040375	Production Technology Lab	√	√	√	√								√	√	√
2040376	Material Science and Mechanics of Solids Lab	√	√	√	√								√	√	√
2040023	Constitution of India						√	√	√						
2040377	Thermal Engineering Lab	√	√	√	√								√		
2040024	OOPS Through C++Lab	√	√	√	√	√								√	
III B. Tech – I Semester															
2050317	Design of Machine Members-I	√	√	√	√		√						√	√	√
2050318	Metrology And Machine Tools	√	√											√	√
2050319	Dynamics of Machinery	√	√	√			√						√	√	√
2050320	Thermal Engineering-II	√	√	√									√	√	
2050321	Fluid Mechanics and Hydraulics Machinery	√	√	√										√	√
2050344	Non-destructive Evaluation	√	√	√										√	√
2050378	Kinematics And Dynamics of Machinery Lab	√	√	√										√	√
2050379	Metrology And Machine Tools Lab	√	√	√									√	√	√
2050380	Fluid Mechanics and Hydraulics Machinery Lab	√	√	√									√		
2050027	Data Science	√	√	√	√	√								√	√
III B. Tech – II Semester															
2060010	Business Economics & Financial Analysis	√					√	√	√			√		√	√
2060322	Heat Transfer	√	√	√	√	√								√	√
2060323	Design Of Machine Members II	√	√	√	√		√						√	√	√
2060503	Database Management Systems	√	√	√	√									√	

2060346	Finite Element Method	✓	✓	✓	✓		✓						✓	✓	✓
2060075	Advanced English Language Communication Skills Laboratory									✓	✓		✓		✓
2060381	Heat Transfer Lab	✓	✓	✓	✓								✓	✓	✓
2060382	CADD And MATLAB	✓	✓	✓		✓								✓	✓
2060028	Machine Learning	✓	✓	✓	✓	✓								✓	✓
2060025	Professional Ethics						✓	✓	✓						
IV B. Tech – I Semester															
2070324	CAD/CAM	✓	✓	✓		✓							✓	✓	✓
2070325	Instrumentation and Control Systems	✓	✓	✓										✓	
2070350	Robotics	✓	✓	✓									✓	✓	✓
2070353	Refrigeration and Airconditioning	✓	✓	✓										✓	✓
2066611	Computer Networks	✓	✓	✓	✓									✓	
2070385	Industry Oriented Mini Project/ Summer Internship	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2070386	Project Stage- I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2070383	CAD/CAM Lab	✓	✓	✓	✓	✓				✓	✓		✓	✓	✓
2070384	Instrumentation and Control Systems Lab	✓	✓			✓									✓
IV B. Tech – II Semester															
2080103	Disaster Management						✓	✓							
2080357	Additive Manufacturing Technologies	✓	✓	✓	✓									✓	✓
2080362	Composite Materials	✓	✓	✓	✓									✓	✓
2080587	Technical Seminar	✓	✓		✓	✓	✓	✓	✓					✓	✓
2080588	Project Stage-II	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

12 Methods for measuring Learning Outcomes and Value Addition:

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

i) Continuous Internal Assessment (CIA).
ii) Semester end examination (SEE)
iii) Laboratory and project work
iv) Course exit survey
v) Program exit survey
vi) Alumni survey
vii) Employer survey
viii) Course expert committee
ix) Department Advisory Board
x) Faculty meetings
xi) Professional Societies

The above assessment indicators are detailed below.

12.1. Continuous Internal Assessment (CIA)

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

2.2. Semester End Examination (SEE)

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

12.3. Laboratory and Project Works

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

12.4. Course Exit Surveys

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

12.5. Programme Exit Survey

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

12.6. Alumni Survey

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

12.7. Employer Survey

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

12.8. Course Expert Committee

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

12.9. Department Advisory Board

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

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

12.10. Faculty Meetings

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

12.11. Professional Societies

The Department of Mechanical Engineering actively promotes professional engagement through student chapters of recognized bodies such as the Society for Automotive Engineers (SAE) and the American Society for Mechanical Engineers (ASME). These professional bodies function as structured co-curricular platforms within the college, organizing technical talks, workshops, seminars, and industry interaction sessions to enhance students' technical competence and professional awareness. Regular activities conducted under SAE and ASME facilitate knowledge dissemination in hands-on training, workshops, distinguished lectures, and competitions, which help them develop problem-solving skills and address complex engineering challenges. Participation in these bodies fosters leadership qualities, ethical practices, teamwork, and continuous professional development among students, contributing to their overall academic and professional growth.

13. CO-Assessment processes and tools:

Course outcomes are evaluated based on two approaches namely direct and indirect assessment methods. The direct assessment methods are based on the Continuous Internal Assessment (CIA) and Semester End Examination (SEE) whereas the indirect assessment methods are based on the course end survey and program exit survey provided by the students, Alumni and Employer.

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

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

13.1. 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.

- Continuous internal examination, semester end examinations, Assignment includesassignment,5 minutes videos, seminars etc.) are used for CO calculation.
- The attainment values are calculated for individual courses and are formulated and summed for assessing the PO s.
- Performance in Assignment is indicative of the student's communication skills.

13.2. Indirect Assessment:

S. No	Courses	Components	Frequency	Max. Marks	Evidence
1	Core/ Elective	Continuous Internal Examination	Twice in a semester	25	Answer script
		Assignment	One Assignment per unit.	5	Assignment
		Semester End Examination	Once in a semester	70	Answer script
2	Laboratory	Observation and Result	Once in a week	05	Work sheets
		Record	Once in a week	05	Work sheets
		Viva	Once in a week	05	Work sheets
		Internal laboratory assessment	Twice in a semester	15	Answer script
		Semester End Examination	Once in a semester	70	Answer script
3	Project Work	Presentation	Twice in a semester	30	Presentation
		Semester End Examination	Once in a semester	70	Thesis report

4	Technical Seminar	Semester End Examination	Twice in a semester	100	Seminar report

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.

TABLE 15: 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.

14. PO/PSO-Assessment tools and Processes

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

1. Direct method
2. Indirect method

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

TABLE 16: Attainment of PO / PSOs

	Assessment	Tools	Weight
POs/PSOs Attainment	Direct Assessment	CO attainment of courses	80%
	Indirect Assessment	Student 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/PSOs.

14.1 PO Direct Attainment is calculated using the following rubric:

PO Direct Attainment = (Strength of CO-PO) * CO attainment / Sum of CO-PO strength. The below figure represents the evaluation process of POs/PSOs attainment through course outcome attainment.

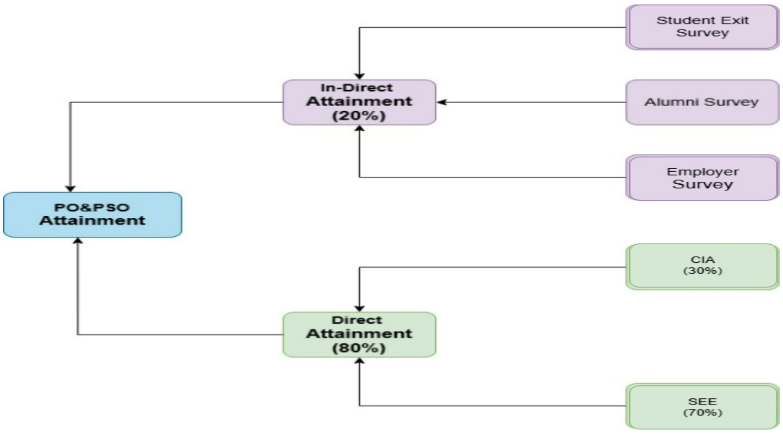


FIGURE 4: Evaluation process of POs / PSOs attainment

15. 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 Descriptor‖ contains the following contents:

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

15.1Course Descriptor:

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

METROLOGY AND MACHINE TOOLS

1	**Department**	MECHANICAL ENGINEERING							
2	**Course Name**	METROLOGY AND MACHINE TOOLS							
3	**Course Code**	2050318							
4	**Year/Semester**	III/I							
5	**Regulation**	MLRS-R20							
6	**Structure of the course**	Theory				Practical			
		Lecture 3	Tutorials 0	Practical 0	Credit 3	L 0	T 0	P 0	C 1
7	**Type of course**	BS ×	HS ×	ES ×	PC ✓	PE ×	OE ×	CC ×	MC ×
8	**Course Offered**	Odd Semester	✓	Even Semester	×				
9	Total lecture, tutorial and practical hours for this course Offered (16 weeks of teaching per semester)								
	Lectures: 48 Hours	**Tutorials:** 0 hours	**Practical:** 0 hours						
10	**Course Coordinator**	Mrs. K CHAITANYA							
11	**Date Approved by BOS**	20-03-2021							
12	**Course Webpage**	www.mlritm.ac.in/							
13	**Prerequisites/Co-requisites**	Level	Course Code	Semester	Prerequisites				
		-	2040316	IV	Production Technology.				

14. COURSE OVERVIEW

Manufacturing Technology is an instructional program that prepares individuals to shape metal parts on machine tools such as lathes, grinders, drill presses, milling machines and shapers. This course includes instruction in safety, making computations related to work dimensions testing feeds and speeds of machines using precision measuring instruments. Metrology is highly valuable for the students and practitioners, specifically from mechanical and allied engineering stream. This course is designed to impart the knowledge about the various machining processes like turning, shaping, planning, drilling, milling and grinding and to develop measurement procedures, conduct metrological experiments.

15. COURSE OBJECTIVES

The students will try to learn:

- The fundamental concepts of the metal cutting principles to study the behavior of various machining processes.
- The importance of tool materials, cutting parameters, cutting fluids and tool wear

mechanisms for optimized machining.

- The principles of linear and angular measuring instruments for accurate measurement of a given component
- The mechanics of machining process and optimization of various significant parameters in order to yield the optimum machining.

16. COURSE OUTCOMES

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

CO No	Course Outcomes
CO 1	Explain the elements of the metal cutting process, including geometry of single-point tools, chip formation, cutting tool materials, and tool wear, in assessing machinability and surface finish in machining operations.
CO 2	Analyse the principles of working, types, and operations performed by drilling, boring, shaping, slotting, and planning machines in determining the appropriate machine for specific manufacturing tasks.
CO 3	Apply the principles of milling, grinding, and gear cutting in selecting the appropriate machines, cutting tools, abrasives, and methods of operation for efficient machining of parts and gears.
CO 4	Evaluate the application of limits, fits, and tolerances in the designing and manufacturing process, including the use of limit gauges and measurement tools in ensuring precision in component fitting and assembly.
CO 5	Assess surface finish quality and alignment using advanced metrology techniques, including surface roughness measurement, laser interferometry, and machine tool alignment tests, in improving manufacturing accuracy and quality control.

17. COURSE LEARNING OUTCOME (CLOs)

1	Geometry of single point tools.	CLO 1	Explain Tool Geometry and Its Significance	CO1	Understand
2	Chip formation and types of chips.	CLO 2	Explore Different Types of Chips	CO1	Understand
3	Mohr's circle, Merchant cricle,	CLO 3	Introduce Mohr's Circle and Merchant Circle	CO1	Apply
4	Types of Boring machines and applications	CLO 4	Understand the distinctions between horizontal and vertical boring machines.	**CO2**	Analyze
5	Shaping, slotting and	CLO 5	Learn about the specifications of shaping, slotting, and planing machines,	CO2	Understand
6	planning machines	CLO 6	including stroke length, cutting speed, feed rates, and workpiece dimensions.	CO2	Evaluate

7	Grinding – theory of grinding	CLO 7	Understand the fundamental principles of grinding.	**CO3**	Understand
8	classification of grinding machines.	CLO 8	Differentiate between various types of grinding machines	CO3	Apply
9	Types of abrasives, bonds.	CLO 9	Learn about different types of abrasive materials used in grinding	CO3	Create
10	Interchangeability and selective assembly.	CLO 10	Appreciate the significance of interchangeability in manufacturing and the role of selective assembly.	**CO4**	Understand / Apply
11	Limit Gauges: Taylor's principle,	CLO 11	Understand how these gauges are used to check the acceptability of dimensions within specified tolerances.	CO4	Analyze
12	Design of GO- and NO-GO gauges Measurement of angles,	CLO 12	Understand the principles behind designing GO- and NO-GO gauges.	CO4	Create
13	Machine Tool Alignment Tests on lathe	CLO 13	Learn about alignment tests	**CO5**	Analyze
14	milling and drilling machines.	CLO 14	Learn about alignment tests conducted on machines to ensure their accuracy.	CO5	Analyze
15	Lasers in metrology - Advantages of lasers	CLO 15	Understand how lasers revolutionize measurement technology.	CO5	Analyze

18. EMPLOYABILITY SKILLS

Example: Communication skills / Programming skills / Project based skills/

The acquisition of skills in the metrology and machine tools enhances an individual's employability by creating opportunities across various industries. In the manufacturing sector, for example, a deep understanding of machine tools is crucial for optimizing automotive systems and streamlining production processes. These skills contribute to improving machine efficiency, reducing downtime, and enhancing product quality, which are critical for maintaining competitiveness in industries that rely on automation and advanced mechanical systems.

19. CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES

✓	Power Point Presentation	✓	Chalk & Talk	✓	Assignments	✓	MOOC
✓	ALP	x	Seminars	x	Mini Project	✓	Videos

20. EVALUATION METHODOLOGY

The performance of a student in a course will be evaluated for 100 marks each, with 30 marks allotted for CIA (Continuous Internal Evaluation and Assignments) and 70 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 (25 Marks) consists of two parts

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

ii) **Part – B** for 15 marks (Descriptive answer Type) with a total duration of 1.5 hours as follows:

The average of two midterm examinations shall be taken as the final marks for midt erm examinations.

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

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

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

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

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

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

21. COURSE CONTENT - NUMBER OF MODULES

Module	Module Description	No. of Lectures
Module 1	Metal cutting: Introduction, elements of cutting process — Geometry of single point tools. Chip formation and types of chips. Mohrs cricle, Merchant cricle, cutting tool materials, tool wear, tool life, surface finish, cutting fluids and Machinability. Engine lathe — Principle of working, types of lathe, specifications.Taper turning– Lathe attachments. Capstan and Turret lathe – Single spindle and multi-spindle automatic lathes – tool layouts	10
Module 2	Drilling and Boring Machines – Principles of working, specifications, types, operations performed; twist drill. Types of Boring machines and applications. Shaping, slotting and planing machines - Principles of working.	8
Module 3	Milling machines – Principles of working – Types of milling machines – Geometry of milling cutters – methods of indexing. Operations on milling machine. Grinding — theory of grinding — classification of grinding machines. Types of abrasives, bonds. Selection of a grinding wheel. Lapping, honing and broaching machines, comparison and Constructional features, - Gear cutting, gear hobbing and gear shaping — gear finishing methods.	8
Module 4	Limits, fits and tolerances- Unilateral and bilateral tolerance system, hole and shaft basis system. Interchangeability and selective assembly. Limit Gauges: Taylor's principle, Design of GO- and NO-GO gauges Measurement of angles, Bevel protractor, Sine bar. Measurement of flat surfaces, straight edges, surface plates, optical flat and auto collimator.	10
Module 5	Surface Roughness Measurement: Roughness, Waviness. CLA, RMS, Rz Values. Methods of measurement of surface finish, Talysurf. Screw thread measurement, Gear measurement; Machine Tool Alignment Tests on lathe, milling and drilling machines. Lasers in metrology - Advantages of lasers – Laser scan micrometers; Laser interferometers – Applications – Straightness, Alignment; Ball bar tests.	9

TEXT BOOKS:

1. Dr. R. Kesavan, Dr. R. Kesavan," Machine Tools" Laxmi publications, 2nd Edition, 2016.
2. N. K Mehta," Metal Cutting and Design of Cutting Tools, Jigs and Fixtures", McGrawHill Education, 1st Edition,2014.
3. T. L. Chaudhary," Metal Cutting and Mechanical Tool Engineering", Khanna Publishers, 5th Edition, 2013.
4. R. K. Jain, Engineering Metrology, Khanna Publishers, 1st Edition, 2013.4. R. K. Jain, Engineering Metrology, Khanna Publishers, 1st Edition, 2013.

REFERENCES:

1. Yuan S W, "Foundations of fluid Mechanics", Prentice-Hall, 2nd Edition, 1987.

22. ELECTRONIC RESOURCES

Resource Type	Title/Description	Link
Online Courses	Machine tools	https://nptel.ac.in/courses/112105171/1

23. COURSE PLAN

S. No	Unit No	L. No	Topic	COs	Text Book
1	Unit - I	LH 1	Metal cutting: Introduction, elements of cutting process	CO1	T1/R1
2		LH 2	Geometry of single point tools.	CO1	T1/R1
3		LH 3	Chip formation and types of chips.	CO1	T1/R1
4		LH 4	Mohr's circle, Merchant cricle, cutting tool materials	CO1	T1/R1
5		LH 5	tool wear, tool life, surface finish,	CO1	T1/R1
6		LH 6	cutting fluids and Machinability.	CO1	T1/R1
7		LH 7	Engine lathe – Principle of working, types of lathes, specifications	CO1	T1/R1
8		LH 8	Taper turning– Lathe attachments. Capstan and Turret lathe	CO1	T1/R1
9		LH 9	Single spindle and multi-spindle	CO1	T1/R1
10		LH 10	automatic lathes tool layouts.	CO1	T1/R1
11	Unit - II	LH 11	Drilling and Boring Machines	CO2	T1/R1
12		LH 12	Principles of working,	CO2	T1/R1
13		LH 13	specifications, types,	CO2	T1/R1
14		LH 14	operations performed; twist drill.	CO2	T1/R1
15		LH 15	Types of Boring machines and applications.	CO2	
16		LH 16	Shaping, slotting and	CO2	T1/R1
17		LH 17	planing machines	CO2	T1/R1
18		LH 18	Principles of working.	CO2	T1/R1
19	Unit - III	LH 19	Milling machines – Principles of working	CO3	T1/R1
20		LH 20	Types of milling machines	CO3	T1/R1
21		LH 21	Geometry of milling cutters methods of indexing.	CO3	T1/R1
22		LH 22	Operations on milling machine.	CO3	T1/R1

23		LH 23	Grinding – theory of grinding	CO3	T1/R1
24		LH 24	classification of grinding machines.	CO3	T1/R1
25		LH 25	Types of abrasives, bonds. Selection of a grinding wheel.	CO3	T1/R1
26		LH 26	Lapping, honing and broaching machines,	CO3	T1/R1
27		LH 27	comparison and Constructional features,	CO3	T1/R1
28		LH 28	Gear cutting, gear hobbing and gear shaping gear finishing methods.	CO3	T1/R1
29	**Unit - IV**	LH 29	Limits, fits and tolerances-	CO4	T1/R1
30		LH 30	Unilateral and bilateral tolerance system,	CO4	T1/R1
31		LH 31	hole and shaft basis system.	CO4	T1/R1
32		LH 32	Interchangeability and selective assembly.	CO4	T1/R1
33		LH 33	Limit Gauges: Taylor's principle,	CO4	T1/R1
34		LH 34	Design of GO- and NO-GO gauges Measurement of angles,	CO4	T1/R1
35		LH 35	Bevel protractor, Sine bar.	CO4	T1/R1
36		LH 36	Measurement of flat surfaces,	CO4	T1/R1
37		LH 37	straight edges, surface plates, optical flat and auto collimator.	CO4	T1/R1
38	**Unit - V**	LH 38	Surface Roughness Measurement: Roughness, Waviness.	CO5	T1/R1
39		LH 39	CLA, RMS, Rz Values.	CO5	T1/R1
40		LH 40	Methods of measurement of surface finish, Talysurf.	CO5	T1/R1
41		LH 41	Screw thread measurement, Gear measurement;	CO5	T1/R1
42		LH 42	Machine Tool Alignment Tests on lathe milling and drilling machines.	CO5	T1/R1
43		LH 43	Lasers in metrology - Advantages of lasers	CO5	T1/R1
44		LH 44	Laser scan micrometers; Laser interferometers– Applications	CO5	T1/R1
45		LH 45	Straightness, Alignment; Ball bar tests.	CO5	T1/R1

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

PO NO	NBA Statement / Vital Features		
	Graduate Attributes	**Program Outcomes**	**No. of key competencies**
PO1	Engineering knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	4
PO2	Problem analysis	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	10
PO3	Design/development of solutions	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	10
PO4	Conduct investigations of complex problems:	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	10
PO5	Modern tool usage	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	4

PO6	The engineer and society	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice	5
PO7	Environment and sustainability	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	4
PO8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	4
PO9	Individual and team work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	10
PO10	Communication	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	5
PO11	Project management and finance	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	10
PO12	Life-long learning	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	8

PO NO	**NBA Statement / Vital Features**	
	Program Specific Outcomes	**No. of key competencies**
PSO1	Students acquire necessary technical skills in mechanical engineering that make them employable graduate.	2
PSO2	An ability to impart technological inputs towards development of society by becoming an entrepreneur.	2

25. HOW PROGRAM OUTCOMES ARE ASSESSED

PO NO	NBA Statement / Vital Features			
	Graduate Attributes	Program Outcomes	Strength	Proficiency Assessed by
PO1	Engineering knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/PPT/ Objective / quiz /SEE/ Assignments
PO2	Problem analysis	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/PPT/ Objective / quiz /SEE/ Assignments
PO3	Design/development of solutions	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	1	CIE/PPT/ Objective / quiz /SEE/ Assignments
PO4	Conduct investigations of complex problems:	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.		CIE/PPT/ Objective / quiz /SEE/ Assignments
PO5	Modern tool usage	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1	CIE/PPT/ Objective / quiz /SEE/ Assignments
PO6	The engineer and society	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice	1	CIE/PPT/ Objective / quiz /SEE/ Assignments
PO7	Environment and sustainability	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	1	CIE/PPT/ Objective / quiz /SEE/ Assignments
PO8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.		CIE/PPT/ Objective / quiz /SEE/ Assignments
PO9	Individual and team work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	CIE/PPT/ Objective / quiz /SEE/ Assignments

PO10	Communication	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	CIE/PPT/ Objective / quiz /SEE/ Assignments
PO11	Project management and finance	Demonstrate knowledge and understanding of the engineering management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	1	CIE/PPT/ Objective / quiz /SEE/ Assignments
PO12	Life-long learning	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	CIE/PPT/ Objective / quiz /SEE/ Assignments

26. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

PO NO	NBA Statement / Vital Features		
	Program Specific Outcomes	Strength	Proficiency Assessed by
PSO1	Students acquire necessary technical skills in mechanical engineering that make them employable graduate.	2	CIE/PPT/ Objective / quiz /SEE/ Assignments
PSO2	An ability to impart technological inputs towards development of society by becoming an entrepreneur.	1	CIE/PPT/ Objective / quiz /SEE/ Assignments

3 = High; 2 = Medium; 1 = Low

27. MAPPING OF EACH CO WITH PO(s), PSO(s)

Course Outcomes (COs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	Y	Y											Y	Y
CO 2	Y	Y											Y	Y
CO 3	Y	Y											Y	Y
CO 4	Y	Y											Y	Y
CO 5	Y												Y	

28. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING

Course Outcomes (COs)	Program Outcomes (POs) / Number of Vital Features												Program Specific Outcomes (PSOs) / Number of Vital Features	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
	4	10	10	10	4	5	4	4	10	5	10	8	2	2
CO 1	3	5											1	1
CO 2	3	5											1	1
CO 3	3	5											1	1
CO 4	3	5											1	-
CO 5	3												1	2

29. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO/ PSO)

Cours Outcomes (CO s)	Program Outcomes (POs) / Number of Vital Features												Program Specific Outcomes (PSOs) / Number of Vital Features	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
	4	10	10	10	4	5	4	4	10	5	10	8	2	2
CO 1	75	50											50	50
CO 2	75	50											50	50
CO 3	75	50											50	50
CO 4	75	50											50	50
CO 5	75												50	

30. COURSE ARTICULATION MATRIX (PO – PSO MAPPING)

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

0 - 0≤ C≤ 5% – No correlation,

1- 5 <C≤ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

Course Outcomes (COs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs) / Number of Vital Features	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	3	2											**1**	**2**
CO 2	3	2											**1**	**1**
CO 3	3	2											**1**	**1**
CO 4	3	2											**1**	**1**
CO 5	3	-											**1**	
TOTAL	15	8											5	5
AVERAGE	3	2											1	1

31. ASSESSMENT METHODOLOGY DIRECT

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

32. ASSESSMENT METHODOLOGY INDIRECT

✓	Course End Survey (CES)

33. RELEVANCE TO SUSTAINABILITY GOALS

x	1		
x	2		

x	3	GOOD HEALTH AND WELL-BEING	
✓	4	QUALITY EDUCATION	Provides strong technical foundation in machining, metrology, and manufacturing processes. Develops industry-relevant skills in metal cutting, grinding, gear cutting, and measurement systems. Promotes practical competency in precision engineering and tool design. Supports skill-based employability in manufacturing and production industries.
x	5	GENDER EQUALITY	
x	6	CLEAN WATER AND SANITATION	
x	7	AFFORDABLE AND CLEAN ENERGY	
✓	8	DECENT WORK AND ECONOMIC GROWTH	Enhances knowledge of machinability, tool life, cutting fluids, and productivity optimization. Supports efficient manufacturing leading to higher industrial output. Improves workforce skills in machine tools, CNC-related fundamentals, and metrology. Encourages safe and efficient workshop practices.
✓	9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	Covers advanced manufacturing techniques (gear hobbing, broaching, grinding). Includes precision measurement systems (laser interferometers, ball bar tests, auto collimators). Promotes innovation in tool materials and cutting technology. Supports development of high-precision components required in aerospace, automotive, and energy sectors.
x	10	REDUCED INEQUALITIES	
x	11	SUSTAINABLE CITIES AND COMMUNITIES	

✓	12	RESPONSIBLE CONSUMPTION AND PRODUCTION	Tool wear and tool life concepts reduce material waste. Proper election of cutting fluids minimizes environmental impact. Understanding limits, fits, and tolerances ensures interchangeability and reduces rejection rates. Surface finish measurement helps in optimizing material usage and energy consumption. Grinding wheel selection reduces resource wastage and improves sustainability.
✓	13	CLIMATE ACTION	Efficient machining reduces energy consumption. Sustainable cutting fluid management reduces pollution. Precision manufacturing reduces rework and carbon footprint.
x	14	LIFE BELOW WATER	
x	15	LIFE ON LAND	
x	16	PEACE, JUSTICE AND STRONG INSTITUTIONS	
x	17	PARTNERSHIPS FOR THE GOALS	