MLRITM
MARRI LAXMAN REDDY INSTITUTE OF TECHNOLOGY AND MANAGEMENT

Outcome Based Education (OBE) Manual

Department of Mechanical Engineering

Regulation: UGR22

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 –I 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 Stake 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 student's 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 Ac- cord 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

Institute Vision

To be a globally recognized institution that fosters innovation, excellence, and leadership in education, research, and technology development, empowering students to create sustainable solutions for the advancement of society.

Institute Mission

- To foster a transformative learning environment that empowers students to excel in engineering, innovation, and leadership.
- To produce skilled, ethical, and socially responsible engineers who contribute to sustainable technological advancements and address global challenges.
- To Shape future leaders through cutting-edge research, industry collaboration and community engagement.

Quality Policy

- Ensure excellence in education through innovative teaching and continuous improvement.
- Promote ethical, skilled, and employable graduates who drive sustainable technologies.
- Encourage research, industry collaboration, and community engagement for societal benefit.

Vision and Mission of the Department

Vision:

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

Mission:

- To provide innovative and sustainable technology solutions to solve a wide range of complex scientific and technological challenges in the Mechanical Engineering field.
- To enhance employability, leadership skills, and research capabilities through industry collaboration and experiential learning.
- To nurture students as ethical and resilient professionals committed to lifelong learning.
- To promote excellence in emerging interdisciplinary fields to support sustainable global progress.

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.

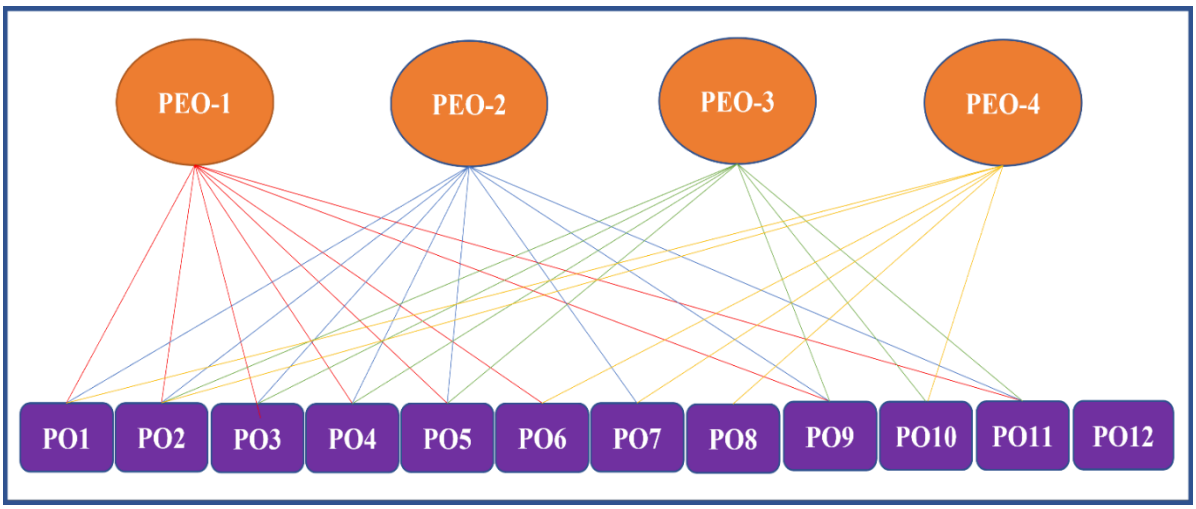
Program Educational Objective - III: To foster the ability to collaborate across multidisciplinary teams while upholding professional ethics and responsibility.

Program Educational Objective - IV: To promote lifelong learning, adaptability, and

leadership skills for continuous personal and professional growth in a dynamic environment.

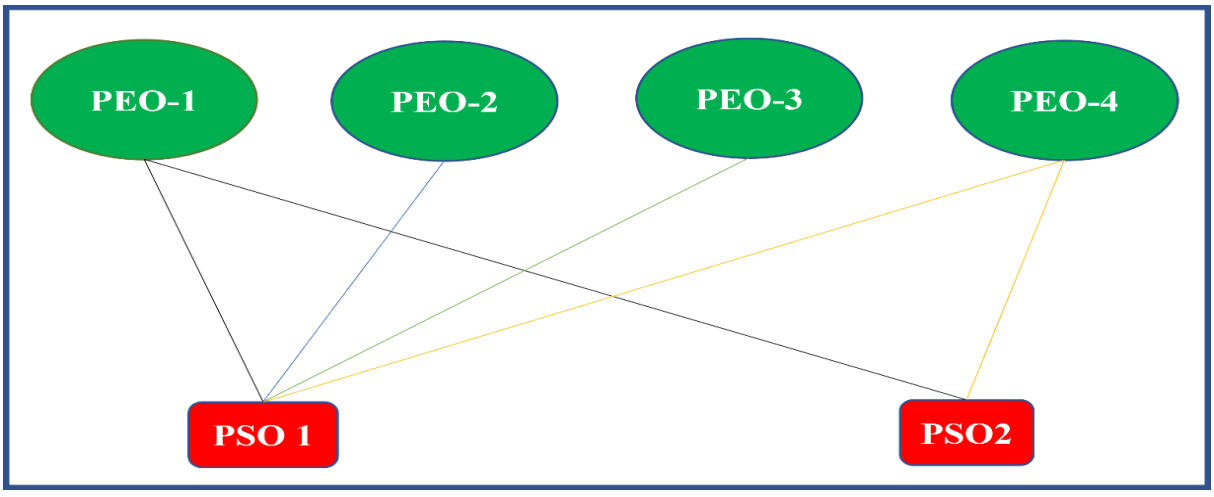
2.1. Mapping of program educational objectives to program outcomes and program specific outcomes:

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,

FIGURE1: 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

FIGURE2: 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. Bloom's 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. Analysing 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 problems 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 • TestforTheme • 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, modeling, 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 the contributions of women in American history.
- Recognize the works of major Re-naissance artists.
- Facilitating a group to achieve agreed – Up on goals.

- Determine 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'smotivationandportraythatcharacterbeforeanaudienc e.
- 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 least 70% 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 outcome	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

<table>
<tr><th>Experiential learning</th><th>Experiential learning</th><th>Experiential learning</th><th>Experiential learning</th><th>Experiential learning</th></tr>
<tr><td rowspan="12">Technical</td><td>PO1</td><td>Apply</td><td>L3</td><td rowspan="12">Bloom’s L1 to L4 for theory courses.
Bloom’sL1toL5forlaboratory courses.
Bloom’sL1toL6for
Project work, experiential learning</td></tr>
<tr><td rowspan="3">PO2</td><td>Identify</td><td>L2</td></tr>
<tr><td>Formulate</td><td>L6</td></tr>
<tr><td>Review</td><td>L2</td></tr>
<tr><td rowspan="2">PO3</td><td>Design</td><td>L6</td></tr>
<tr><td>Develop</td><td>L3, L6</td></tr>
<tr><td rowspan="3">PO4</td><td>Analyze</td><td>L4</td></tr>
<tr><td>Interpret</td><td>L2, L3</td></tr>
<tr><td>Design</td><td>L6</td></tr>
<tr><td rowspan="3">PO5</td><td>Create</td><td>L6</td></tr>
<tr><td>Select</td><td>L1, L2, L6</td></tr>
<tr><td>Apply</td><td>L3</td></tr>
<tr><td rowspan="7">Non-Technical</td><td>PO6</td><td colspan="3" rowspan="7">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 Any of PO6 to PO12, then assign 2.
If Bloom’s L4 to L6 Action Verbs of a CO: Correlates with any of PO6 to PO12, then assign3</td></tr>
<tr><td>PO7</td></tr>
<tr><td>PO8</td></tr>
<tr><td>PO9</td></tr>
<tr><td>PO10</td></tr>
<tr><td>PO11</td></tr>
<tr><td>PO12</td></tr>
</table>

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 ≤ C ≤ 5%	No correlation (0)
5% < C≤ 40%	Low/Slight correlation (1)
40% < C < 60%	Moderate correlation (2)
60% ≤ 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**

PO2	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**

PO3	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 **(Design/Development of Solutions).**	1. **Design:** Investigate and define a problem while identifying constraints, including environmental, sustainability, health, and 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. 10. **Appropriate Considerations:** Be aware of legal frameworks governing engineering activities, including personnel, health, safety, and environmental risks.	**10**

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 (**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 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.	**10**

PO5	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**
PO6	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**

PO7	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**
PO8	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 projects 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, 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.	**10**

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

CODE	SUBJECT	PO												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
IB. Tech – I Semester															
2210001	Matrix Algebra and Calculus	✓	✓	✓	✓								✓	✓	
2210008	Applied Physics	✓	✓	✓			✓							✓	
2210501	Programming for Problem Solving	✓	✓	✓	✓									✓	
2210372	Engineering Workshop	✓	✓	✓	✓									✓	
2210010	English for Skill Enhancement									✓	✓	✓		✓	✓
2210518	Elements of Computer Science and Engineering	✓	✓	✓										✓	✓
2210071	Applied Physics Laboratory	✓	✓	✓	✓									✓	
2210571	Programming for Problem Solving Laboratory	✓	✓	✓	✓	✓								✓	

2210073	English Language and Communication Skills Laboratory	✓	✓	✓	✓	✓									✓
2210021	Environmental Science	✓					✓								
CODE	SUBJECT	PO												PSO	
		1	2	3	4	1	2	7	8	1	2	11	12	1	2
IB. Tech – II Semester															
2220002	Differential Equations and Vector Calculus	✓	✓	✓	✓		✓						✓	✓	✓
2220009	Engineering Chemistry	✓	✓	✓	✓		✓						✓	✓	✓
2220371	Engineering Drawing Practice	✓	✓	✓	✓								✓	✓	
2220321	Engineering Mechanics	✓	✓	✓	✓		✓						✓	✓	✓
2220401	Engineering Materials	✓	✓	✓	✓								✓	✓	✓
2220572	Data Structures Laboratory	✓	✓	✓	✓	✓								✓	
2220072	Engineering Chemistry Laboratory	✓	✓	✓	✓		✓						✓	✓	
2220377	Fuels and lubricants Laboratory	✓	✓	✓										✓	
CODE	SUBJECT	PO												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
II B. Tech – I Semester															
2230323	Mechanics of Solids	✓	✓	✓	✓		✓						✓	✓	✓
2230324	Material Science and Metallurgy	✓	✓	✓	✓								✓	✓	✓
2230325	Thermodynamics	✓	✓										✓	✓	✓
2230326	Fluid Mechanics and Hydraulics Machinery	✓	✓	✓										✓	✓
2230327	Production Technology	✓	✓	✓	✓								✓	✓	✓
2230378	Material Science and Mechanics of Solids Laboratory	✓	✓	✓	✓								✓	✓	✓

2230379	Fluid Mechanics and Hydraulics Machinery Laboratory	✓	✓	✓									✓	✓	✓
2230380	Production Technology Laboratory	✓	✓	✓	✓								✓	✓	✓
2230023	Constitution of India						✓	✓	✓						
2230026	Machine learning	✓	✓	✓	✓	✓								✓	✓
CODE	SUBJECT	PO												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
II B. Tech – II Semester															
2240202	Basic Electrical and Electronic Engineering	✓	✓	✓	✓									✓	
2250328	Metrology and Machine Tools	✓	✓											✓	✓
2240329	Kinematics of Machinery	✓	✓	✓	✓		✓							✓	✓
2240330	Thermal Engineering -I	✓	✓	✓									✓	✓	
2240007	Probability Distributions and Complex Variables	✓	✓	✓	✓								✓	✓	
2240272	Basic Electrical and Electronic Engineering Laboratory	✓	✓	✓										✓	
2240573	Python Programming Laboratory	✓	✓	✓	✓	✓								✓	✓
2240381	Thermal Engineering Laboratory	✓	✓	✓	✓								✓		
2240391	Field based Project	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2240022	Gender Sensitization						✓	✓	✓						
CODE	SUBJECT	PO												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
III B. Tech – I Semester															
2250331	Dynamics of Machinery	✓	✓	✓			✓						✓	✓	✓
2250332	Design of Machine Elements	✓	✓	✓	✓		✓						✓	✓	✓

2250016	Business Economics and Financial Analysis	✓					✓	✓	✓			✓		✓	✓
2250101	Air and Noise Pollution Control	✓	✓	✓	✓									✓	✓
2250351	Renewable Energy Sources	✓	✓	✓	✓									✓	✓
2250382	Kinematics and Dynamics of Machinery Laboratory	✓	✓	✓										✓	✓
2250383	Metrology and Machine Tools Laboratory	✓	✓	✓									✓	✓	✓
2250384	Computer aided Machine Drawing	✓	✓	✓		✓								✓	✓
2250392	Internship	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2250027	Data science with python	✓	✓	✓	✓									✓	
CODE	SUBJECT	PO												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
III B. Tech – II Semester															
2260333	Design of Transmission System	✓	✓	✓	✓		✓						✓	✓	✓
2260334	Thermal engineering - II	✓	✓	✓	✓		✓							✓	✓
2260335	Heat Transfer	✓	✓	✓	✓	✓								✓	✓
2260503	Data Base Management System	✓	✓	✓	✓									✓	✓
2260355	Unconventional Machining Process	✓	✓	✓	✓									✓	✓
2260074	Advanced English communication skills Laboratory									✓	✓		✓		✓
2260385	Heat transfer Laboratory	✓	✓	✓	✓								✓	✓	✓
2260024	Intellectual property rights								✓	✓	✓			✓	
2260093	Industrial Oriented Mini project	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CODE	SUBJECT	PO												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
IV B. Tech – I Semester															

2270336	CAD & AMT	✓	✓	✓		✓						✓	✓	✓
2270337	Instrumentation and Control Systems	✓	✓	✓									✓	
2270338	Finite Element Methods	✓	✓	✓	✓		✓					✓	✓	✓
2270241	Electrical and Hybrid Vehicles	✓	✓	✓	✓								✓	✓
2270359	Refrigeration and air Conditioning	✓	✓	✓	✓								✓	✓
2270386	CAD & AMT Laboratory	✓	✓	✓		✓						✓	✓	✓
2270387	Instrumentation and Control Systems and Production Drawing Laboratory	✓	✓			✓								✓
2270394	Project Stage - I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CODE	SUBJECT	PO												PSO	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2
IV B. Tech – II Semester															
2080364	Robotics	✓	✓	✓	✓									✓	✓
2080369	Non-Destructive Testing	✓	✓	✓	✓									✓	✓
2080373	Automation In Manufacturing	✓	✓	✓	✓									✓	✓
2080395	Technical seminar	✓	✓		✓	✓	✓	✓	✓					✓	✓
2080396	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 end 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)

The framework for Continuous Internal Assessment (CIA) for the Undergraduate (UG) courses includes Continuous Internal Examinations (CIEs), assignments, PPT/poster presentations, case studies, and viva voce. All these are mandatory and designed in a systematic way to assess the understanding of concepts, analytical and problem-solving skills, communication skills, and overall subject competency in accordance with the principles of Outcome-Based Education (OBE).

The assessment performance is formally evaluated to ensure consistency, transparency, and achievement of Course Outcomes (COs) and Program Outcomes (POs). Constructive feedback is given to the students to enable continuous improvement and improve the teaching-learning process, thereby improving overall performance and achievement of outcomes.

12.2. 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 Board (DAB) 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 year, and the collected data is analyzed for continuous improvement.

12.7. Employer Survey

The main purpose of this employer questionnaire is to know employer's 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 a month 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 importance of professional societies like TASK (Telangana Academy of kill and Knowledge), 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 TASK, 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. Student and faculty chapters of the above societies are constituted for a better technical and entrepreneurial environment. These professional societies promote excellence in instruction, research, public service and practice.

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 (CIE, Assignment& PPT/Poster Presentation/Viva-Voce/Case Study)	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, CAT (includes PPT, poster presentation 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.

S. No	Courses	Components	Frequency	Max. Marks	Evidence
1	Core/ Elective	Continuous Internal Assessment	Twice in a semester	30	Answer script
		Assignment	One Assignment per unit.	5	Assignment
		Viva-Voce / PPT/ Poster Presentation/ Case Study etc.	Twice in a semester	5	PPT, Poster Presentation etc
		Semester End Examination	Once in a semester	60	Answer script
2	Laboratory	Day-to-Day Evaluation	Once in a week	10	Work sheets
		Viva-Voce	Once in a week	10	Work sheets
		Certificate/ Open ended experiment	Once in a semester	10	Certificate/ Work sheet
		Internal laboratory assessment	Twice in a semester	10	Answer script
		Semester End Examination	Once in a semester	60	Answer script
3	Project Work	Presentation	Twice in a semester	40	Presentation
		Semester End Examination	Once in a semester	60	Thesis report
4	Technical Seminar	Presentation	Twice in a semester	100	Seminar report

13.2. Indirect Assessment:

Course End Survey-In this survey, questionnaires are prepared based on the level of understanding of the course and the questions are mapped to Course Outcomes. The tools and processes used in indirect assessment are shown in Table.

TABLE 15: Tools used in In-direct 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.

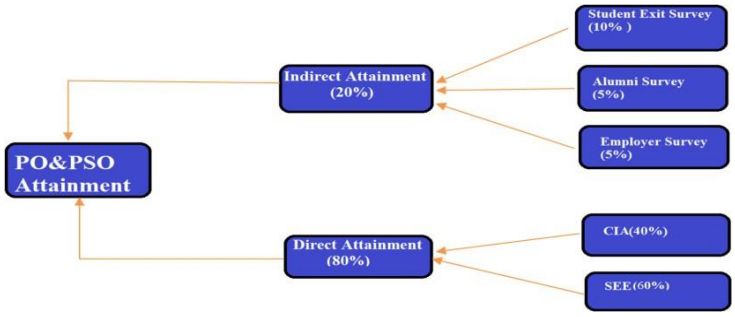


FIGURE 4: Evaluation process of POs / PSOs attainment

15. Course Descriptor:

The "Course Descriptor" 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

15.1 Course Descriptor

MECHANICAL ENGINEERING

1	Department	MECHANICAL ENGINEERING							
2	Course Name	THERMAL ENGINEERING-II							
3	Course Code	2260334							
4	Year/Semester	III/II							
5	Regulation	MLRS-R22							
7	Structure of the course	Theory				Practical			
		Lecture	Tutorials	Practical	Credit	L	T	P	C
		3	0	0	3	0	0	0	0
8	Type of course	BS	HS	ES	PC	PE	OE	PS	MC
		×	×	×	✓	×	×	×	×
9	Course Offered	Odd Semester		×	Even Semester				✓
10	Total lecture, tutorial and practical hours for this course Offered (16 weeks of teaching per semester)								
	Lectures: 48 Hours	Tutorials: 16 hours			Practical: 0 hours				
11	Course Coordinator	Dr.K.VEERA RAGHAVULU							
12	Date Approved by BOS	15/07/2022							
13	Course Webpage	www.mlritm.ac.in/							
14	Prerequisites/ Co-requisites	Level	Course Code	Semester	Prerequisites				
		B.Tech	2230325	II-I	Thermodynamics				

15. Course Overview:

Thermal Engineering applies the principles of thermodynamics to practical applications. This course aims to provide mechanical engineering students with a comprehensive understanding of the Rankine cycle, including methods to enhance its performance, such as reheating and regeneration. It also covers gas turbines, rocket engines, and their performance evaluation. A strong foundation in thermal engineering is essential for improving and designing various machine components. The course is structured to enable students to analyze and optimize turbine efficiencies through the calculation of key empirical values

16. Course Objectives:

The students will try to learn:

- Developing a fundamental understanding of the Rankine cycle.
- Providing comprehensive knowledge of boilers and chimneys.
- Enhancing students' understanding of steam nozzles and steam turbines.
- Building a strong foundation in the steam formation process.
- Equipping students with essential knowledge of gas turbine plants.

17. Course Outcomes:

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

CO1	**Describe** the operation of steam power plants and boilers, covering the Rankine cycle, efficiency, and performance enhancement techniques. (L2)
CO2	**Analyze** the thermodynamic behaviour of steam nozzles, including flow characteristics, velocity calculations, critical pressure ratio, and the effects of supersaturation. (L4)
CO3	**Apply** basic thermodynamic principles to study the performance of steam turbines. (L3)
CO4	**Explain** the working and performance of steam condensers and gas turbines (L2)
CO5	**Examine** the performance of jet propulsion and rocket engines by evaluating thrust, propulsion efficiency, thermodynamic cycles, and thrust augmentation methods. (L4)

18. Course Learning Outcome (CLOs):

Sno	Topic Name	CLO No	Course Learning Outcome	Course Outcome	Blooms Level
1	**Rankine Cycle**	CLO 1	Understand the schematic layout, thermodynamic analysis, and methods to improve efficiency using regeneration and reheating.	CO1	Analyze
2	Boiler	CLO 2	Classify boilers, describe their working principles, mountings, accessories, and evaluate performance parameters like efficiency and heat balance.	CO1	Evaluate
3	Draught	CLO 3	Classify draught systems, calculate chimney height and efficiency, and determine conditions for maximum discharge.	CO1	Understand
4	Function and	CLO	Steam nozzles play a crucial role in steam	CO2	Understand

	Applications of Steam Nozzle	4	power plants, turbines, injectors, and ejectors by converting thermal energy into kinetic energy. Understanding different types of nozzles, such as convergent, divergent, and convergent-divergent, helps in selecting the appropriate design based on flow conditions and applications.		
5	Thermodynamics of Flow through Nozzles	CLO 5	The thermodynamic analysis of steam flow through nozzles involves assumptions related to isentropic expansion and negligible heat losses. Key parameters such as stagnation properties, velocity at exit, velocity coefficient, and critical pressure ratio are evaluated to determine nozzle efficiency and conditions for maximum mass flow rate.	CO2	Analyze
6	Super Saturated Flow and Nozzle	CLO 6	Super saturated flow occurs when steam expands rapidly without sufficient time for condensation, leading to a degree of undercooling. Understanding the effects of super saturation, Wilson line, and deviations from ideal expansion helps in improving nozzle performance and predicting real-world inefficiencies.	CO2	Evaluate
7	Working Principles of Steam Turbin	CLO 7	Steam turbines are classified into impulse and reaction types based on their energy conversion mechanisms. Understanding their working principles, mechanical details, and flow characteristics helps in selecting the appropriate turbine for different applications.	CO3	Understand
8	Performance and Efficiency of Impulse and	CLO 8	The study of velocity diagrams, friction effects, and efficiency conditions is essential for evaluating turbine	CO3	Analyze

	Reaction Turbines		performance. Examining compounding methods, velocity and pressure variations, and thermodynamic analysis helps optimize power output and efficiency.		
9	Operation of Steam Turbines	CLO 9	Assessing mechanical aspects such as axial thrust, blade efficiency, and rotor speed reduction techniques ensures stable operation. Understanding the degree of reaction, Parson's reaction turbine, and efficiency conditions aids in improving turbine design and functionality.	CO3	Evaluate
10	Function and Types of Steam Condensers	CLO 10	Steam condensers are essential for improving steam power plant efficiency by maintaining low back pressure. Understanding their classification, working principles, and efficiency parameters helps in selecting suitable condenser types.	CO4	Understand
11	Effects in Condensers	CLO 11	Vacuum and condenser efficiency are key performance indicators, influenced by cooling water requirements and air leakage. Identifying air leakage sources, its effects, and the role of air pumps helps in optimizing condenser operation.	CO4	Analyze
12	Gas Turbine Cycles and Performance evalution	CLO 12	Gas turbines operate on simple and modified cycles incorporating regeneration, intercooling, and reheating. Comparing closed and semi-closed cycles, combustion chambers, and turbine performance helps in improving efficiency and reliability.	CO4	Evaluate
13	Principles and Classification of Jet Propulsion	CLO 13	Jet propulsion operates on Newton's third law, converting high-velocity exhaust into thrust. Understanding the classification and working principles of jet engines with	CO5	Understand

			schematic and T-S diagrams helps in analyzing their operation.		
14	Thrust, Propulsion Efficiency, and Performance of Turbojet Engines	CLO 14	Turbojet engines meet specific needs through efficient thrust generation and augmentation methods. Evaluating thermodynamic cycles, propulsion efficiency, and thrust power helps in optimizing performance.	CO5	Analyze
15	Working and Efficiency of Rocket Propulsion Systems	CLO 15	Rockets are classified based on propellant type, with solid and liquid engines serving different applications. Assessing thrust, specific impulse, and propulsion efficiency aids in improving rocket design and performance.	CO5	Evaluate

19. Employability Skills:

➢ Problem-Solving and Analytical Skills ➢Technical Knowledge and Practical Application ➢ Effective Communication and Team Collaboration
Problem-solving and analytical skills enhance employability by enabling individuals to tackle complex challenges and find effective solutions, which are highly valued by employers. Technical knowledge and practical application ensure that employees can confidently apply their expertise to real-world tasks, increasing their value in the workplace. Additionally, effective communication and teamwork are critical for collaborating with colleagues, sharing ideas clearly, and contributing to a positive, productive work environment all of which are essential for career success..

20. Content Delivery / Instructional Methodologies:

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

21. Evaluation Methodology:

The performance of a student in a course will be evaluated for 100 marks each, with 40 marks allotted for CIE (Continuous Internal Evaluation) and 60 marks for SEE (Semester End-Examination). In CIE, for theory subjects, during a semester, there shall be two mid-term examinations. Each Mid-Term examination consists of two parts i) **Part – A** for 10 marks, ii) **Part – B** for 20 marks with a total duration of 2 hours as follows:

Mid Term Examination for 30 marks:

a. Part - A: Objective / quiz / short answer type paper for 10 marks.
b. Part - B: Descriptive paper for 20 marks.

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

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

a. Part-A is a compulsory question which consists of ten sub-questions from all units carrying equal marks.
b. Part-B consists of five questions (numbered from 2 to 6) carrying 10 marks each. Each of these questions is from each unit and may contain sub-questions. For each question there will be an "either" "or" choice, which means that there will be two questions from each unit and the student should answer either of the two questions.
c. The duration of Semester End Examination is 3 hours.

Table 1: Outline for Continues Internal Evaluation (CIE-I and CIE-II) and SEE

Activities	CIE-I	CIE-II	Average of CIE	SEE	Total Marks
Continues Internal Evaluation (CIE)	20 Marks	20 Marks			Average of CIE + SEE
Objective / quiz / short answer Questions	10 Marks	10 Marks			
Assignment	5 Marks	5 Marks			
Viva-Voce / PPT / Poster Presentation / Case Study	5 Marks	5 Marks			
Total Marks	**40 Marks**	**40 Marks**	**40 Marks**	**60 Marks**	**100 Marks**

22. Course content - Number of modules: Five:

MODULE 1	Steam Power Plant: Rankine cycle - Schematic layout, Thermodynamic Analysis, Concept of Mean Temperature of Heat addition, Methods to improve cycle performance – Regeneration & reheating. Boilers: Classification – Working principles with sketches including H.P.Boilers – Mountings and Accessories – Working principles- Boiler horse power,	No. of Lectures: 10

	Equivalent Evaporation, Efficiency and Heat balance – Draught- Classification – Height of chimney for given draught and discharge- Condition for maximum discharge- Efficiency of chimney	
MODULE 2	Steam Nozzles: Stagnation Properties- Function of nozzle – Applications and Types- Flow through nozzlesThermodynamic analysis – Assumptions -Velocity of nozzle at exit-Ideal and actual expansion in nozzle- Velocity coefficient- Condition for maximum discharge- Critical pressure ratio- Criteria to decide nozzle shape- Super saturated flow, its effects, Degree of super saturation and Degree of under cooling - Wilson line	No. of Lectures:8
MODULE 3	Steam Turbines: Classification – Impulse turbine; Mechanical details – Velocity diagram – Effect of friction – Power developed, Axial thrust, Blade or diagram efficiency – Condition for maximum efficiency. De-Laval Turbine - its featuresMethods to reduce rotor speed-Velocity compounding and Pressure compounding- Velocity and Pressure variation along the flow – Combined velocity diagram for a velocity compounded impulse turbine. Reaction Turbines: Mechanical details – Principle of operation, Thermodynamic analysis of a stage, Degree of reaction – Velocity diagram – Parson's reaction turbine – Condition for maximum efficiency.	No. of Lectures: 10
MODULE 4	Steam Condensers: Requirements of steam condensing plant – Classification of condensers – Working principle of different types – Vacuum efficiency and Condenser efficiency – Air leakage, sources and its affects, Air pump- Cooling water requirement. Gas Turbines: Simple gas turbine plant – Ideal cycle, essential components – Parameters of performance – Actual cycle – Regeneration, Inter cooling and Reheating – Closed and Semi-closed cycles – Merits and Demerits- Combustion chambers and turbines of Gas Turbine Plant- Brief Concepts	No. of Lectures: 10
MODULE 5	Jet Propulsion: Principle of Operation –Classification of jet propulsive engines – Working Principles with schematic diagrams and representation on T-S diagram - Thrust, Thrust Power and Propulsion Efficiency – Turbo jet engines – Needs and Demands met by Turbo jet – Schematic Diagram, Thermodynamic Cycle, Performance Evaluation Thrust Augmentation – Methods. Rockets: Application – Working Principle – Classification – Propellant Type – Thrust, Propulsive Efficiency – Specific Impulse – Solid and Liquid propellant Rocket Engines.	No. of Lectures:10

TEXTBOOKS:

1. Thermal Engineering / Mahesh M Rathore/ Mc Graw Hill/5th Edition
2. Thermal Engineering/ Rajput/ Lakshmi Publications/ 10th Edition

REFERENCE BOOKS:

1. Gas Turbine Theory/ Saravanamuttoo, Cohen, Rogers/ Pearson/6th Edition
2. Fundamentals of Engineering Thermodynamics / Rathakrishnan/ PHI /2nd Edition
3. Gas Turbines – V. Ganesan /Mc Graw Hill/3rd Edition

ELECTRONIC RESOURCES:

1. https://www.youtube.com/watch?v=sO2OKC5j2II
2. https://archive.nptel.ac.in/courses/112/103/112103316/
3. https://onlinecourses.nptel.ac.in/noc23_me31/preview
4. https://nptel.ac.in/courses/112103262

23. COURSE PLAN:

S. No.	Topics to be covered	Cos	Reference
1.	Basic Concepts, Rankine cycle- schematic layout, Thermodynamic analysis	CO1	T1:2.2
2.	Concept of mean temperature of heat addition	CO1	T2:2.3
3.	Methods to improve cycle performance (vedio ecture)	CO1	R1:2.6
4.	Reheating and regeneration	CO1	T1:2.6
5.	Intercooling	CO1	T2:2.7 R1:2.18
6.	Classification of boilers	CO1	T2:2.22
7.	Mountings Working principles	CO1	T2:2.25
8.	Draught, Classification, Height of chimney for given Draught & discharge	CO1	T2:2.26 R1:2.55
9.	Problems	CO1	T2:2.16 R1:2.61
10.	Problems	CO1	T2:2.30 R1:2.58
11.	Nozzles	CO2	R1:4.36
12.	Types of nozzles	CO2	T2:3.18 R1:4.64
13.	Function of nozzle	CO2	T2:3.22
14.	Application	CO2	T2:4.2
15.	Flow through nozzles	CO2	T1:4.12 R2:5.75
16.	Thermodynamic analysis,	CO2	T1:4.8 R1:5.72
17.	Velocity of nozzle at exit- ideal & actual expansion in nozzle	CO2	T1:5.8 R1:5.73
18.	Velocity coefficient, condition for maximum discharge (Vedio lecture)	CO2	T1:5.14 R1:6.78
19.	Classification, impulse turbine- mechanical details, Velocity diagram, effect of friction	CO3	T1:8.8 R1:8.73
20.	Power developed, axial thrust, Blade or diagram	CO3	T1:12.4 R2:13.68

	efficiency- condition for maximum efficiency		
21.	Mechanical details- principle of operation, Thermodynamic analysis of a stage,	CO3	T2:13.7 R1:14.74
22.	Problems	CO3	T2:13.7 R1:14.74
23.	Problems	CO3	T2:13.7 R1:14.74
24.	Degree of reaction – velocity diagram, parison reaction turbine	CO3	T1:5.8 R1:5.73
25.	Condition for maximum efficiency	CO3	T1:5.14 R1:6.78
26.	Requirements of steam condensing plant	CO3	T2:5.19 R1:6.81
27.	Classification of condensers	CO4	T1:6.4
28.	Problems	CO4	T2:7.7 R1:7.74
29.	Requirement of steam condensing plant,	CO4	T1:5.8 R1:5.73
30.	Classifications of condensers and working principles.	CO4	T1:5.14 R1:6.78
31.	Vacuum efficiency and condenser efficiency, leakages,	CO4	T2:5.19 R1:6.81
32.	Air pump, cooling water requirements.	CO4	T1:6.4
33.	Simple gas turbine plat, ideal cycle and its components. Parameters and performance.	CO4	T2:7.7 R1:7.74
34.	Methods: Reheating.	CO4	T1:7.12 R2:8.75
35.	Regeneration.	CO4	T1:8.8 R1:8.73
36.	Combustion chambers.	CO4	T1:12.4 R2:13.68
37.	Problems	CO4	T2:13.7 R1:14.74
38.	Problems	CO4	T1:5.8 R1:5.73
39.	Principle of operation- classification of jet propulsive engines	CO5	T2:5.19 R1:6.81
40.	Working principles with schematic diagrams, and representation on T-S diagram	CO5	T1:6.4
41.	thrust, thrust power and efficiency	CO5	T2:7.7 R1:7.74
42.	Turbo jet engines- needs and demands met by turbo jet- schematic diagram	CO5	T1:7.12 R2:8.75
43.	Thermodynamic cycle, performance evaluation thrust augmentation- methods	CO5	T1:7.8 R1:8.72
44.	Rockets- applications(ppt), working principle-	CO5	T1:8.8 R1:8.73
45.	classification(video lecture), Solid propellant rocket engines(video lecture)	CO5	T1:5.8 R1:5.73
46.	Problems	CO5	T1:5.14 R1:6.78
47.	Problems	CO5	T1:5.14 R1:6.78
48.	Problems	CO5	T1:5.14 R1:6.78

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engg. specialization to the solution of complex engineering problems.
PO2: Problem analysis: Identify, formulate, research literature, and analyze engineering problems to arrive at substantiated conclusions using first principles of mathematics, natural, and engineering sciences.
PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components, processes to meet the specifications with consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4: Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
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.
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.
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.
PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.
PO10: Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions.
PO 11: 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. Manage projects in multidisciplinary environments.
PO 12: 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.
Program Specific Outcomes
PS01: Students acquire necessary technical skills in mechanical engineering that make them employable graduate.
PS02: An ability to impart technological inputs towards development of society by becoming an entrepreneur.

25. HOW PROGRAM OUTCOMES ARE ASSESSED:

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/ Viva-Voce
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/ Viva-Voce
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/ Viva-Voce
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.	1	CIE/ PPT/ Objective / quiz /SEE/ Assignments/ Viva-Voce
PO 6	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	Assignments/ SEE /CIE, AAT, QUIZ

26. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Outcomes	Strength	Proficiency Assessed by

PSO1	Students acquire necessary technical skills in mechanical engineering that make them employable graduate. **Technical and Engineering Skills & Adaptability and Lifelong Learning**	3	CIE/ PPT/ SEE/ Objective / quiz / Assignments/ Viva-Voce
PSO2	An ability to impart technological inputs towards development of society by becoming an entrepreneur. **Innovation and Problem-Solving & Entrepreneurial and Leadership Skills**	2	CIE/ PPT/ SEE/ Objective / quiz / Assignments/ Viva-Voce

3 = High; 2 = Medium; 1 = Low

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

CO / TKC	PROGRAM OUTCOMES												PSOs	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
	4	10	10	10	4	5	4	4	10	5	10	8	4	4
CO1	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
CO2	✓-	-	✓	-	-	✓	-	-	-	-	-	-	✓	✓
CO3	✓	✓	-	✓	-	-	-	-	-	-	-	-	✓	-
CO4	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
CO5	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	✓

28. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

Course Outcomes	PO'S/ PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO1	PO1	1. Application of scientific principles and methodologies. 2. Utilization of mathematical concepts in problem-solving. 3. Integration of knowledge from various engineering disciplines	3
	PO2	1. Structuring and abstracting the problem for systematic analysis. 2. Examining research literature 3. Investigating problems using data collection and relevant methodologies. 4. Applying mathematical, natural, and engineering sciences in problem-solving	4

CO2	PO1	1. Application of scientific principles and methodologies. 2. Utilization of mathematical concepts in problem-solving. 3. Integration of knowledge from various engineering disciplines	3
	PO3	1. Understand customer and user needs while considering factors such as aesthetics. 2. Identify and manage cost drivers in engineering solutions. 3. Use creativity to develop innovative engineering solutions. 4. Ensure fitness for purpose across production, operation, maintenance, and disposal.	4
	PO6	1. Understand the commercial and economic context of engineering processes. 2. Apply management strategies in engineering objectives within this context. 3. Promote sustainable development through engineering activities.	3
	PSO1	1. Fundamental engineering knowledge 2. Thermal engineering concepts	2
	PSO2	1. Product development 2. Identification of industrial challenges 3. Design and modeling tools 4. Computational and simulation tools	4
CO3	PO1	1. Application of scientific principles and methodologies. 2. Utilization of mathematical concepts in problem-solving. 3. Integration of knowledge from various engineering disciplines	3
	PO2	1. Investigating problems using data collection and relevant methodologies. 2. Applying mathematical, natural, and engineering sciences in problem-solving.	2
	PO4	1. Develop essential laboratory and workshop skills to carry out experimental investigations and gather reliable data. 2. Address complex problems in various engineering contexts, including operations, management, and technology development	2
	PSO1	1. Fundamental engineering knowledge 2. Thermal engineering concepts	3

		3. Design and development skills	
	PSO2	1. Product development 2. Identification of industrial challenges 3. Design and modeling tools 4. Computational and simulation tools	3
CO4	PO1	1. Application of scientific principles and methodologies. 2. Utilization of mathematical concepts in problem-solving. 3. Integration of knowledge from various engineering disciplines	3
	PO2	1. Investigating problems using data collection and relevant methodologies. 2. Applying mathematical, natural, and engineering sciences in problem-solving.	2
CO5	PO1	1. Application of scientific principles and methodologies. 2. Utilization of mathematical concepts in problem-solving. 3. Integration of knowledge from various engineering disciplines	3
	PO2	1. Investigating problems using data collection and relevant methodologies. 2. Applying mathematical, natural, and engineering sciences in problem-solving.	2
	PO3	1. Identify and manage cost drivers in engineering solutions. 2. Use creativity to develop innovative engineering solutions. 3. Ensure fitness for purpose across production, operation, maintenance, and disposal.	3
	PSO1	1. Fundamental engineering knowledge 2. Thermal engineering concepts 3. Design and development skills	3
	PSO2	1. Product development 2. Identification of industrial challenges 3. Computational and simulation tools	3

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

Course Outcomes	PROGRAM OUTCOMES												PSOs	
	PO 1 4	PO 2 10	PO 3 10	PO 4 10	PO 5 4	PO 6 5	PO 7 4	PO 8 4	PO 9 10	PO 10 5	PO 11 10	PO 12 8	PSO 1 4	PSO 2 4
CO1	3	4	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	-	4	-	-	3	-	-	-	-	-	-	2	4
CO3	3	2	-	2	-	-	-	-	-	-	-	-	3	3
CO4	3	2	-	-	-	-	-	-	-	-	-	-		
CO5	3	2	3	-	-	-	-	-	-	-	-	-	3	3

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

Course Outcomes	PROGRAM OUTCOMES												PSOs	
	PO 1 4	PO 2 10	PO 3 10	PO 4 10	PO 5 4	PO 6 5	PO 7 4	PO 8 4	PO 9 10	PO 10 5	PO 11 10	PO 12 8	PSO 1 4	PSO 2 4
CO1	75	40	-	-	-	-	-	-	-	-	-	-	-	-
CO2	75	-	40	-	-	60	-	-	-	-	-	-	50	100
CO3	75	20	-	20	-	-	-	-	-	-	-	-	75	75
CO4	75	20	-	-	-	-	-	-	-	-	-	-	-	-
CO5	75	20	40	-	-	-	-	-	-	-	-	-	75	75

31. 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,
2 - 40 % <C < 60% –Moderate
1-5 <C≤ 40% – Low/ Slight
3 - 60% ≤ C < 100% – Substantial /High

Course Outcomes	PROGRAM OUTCOMES												PSOs	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	-	2	-	-	3	-	-	-	-	-	-	2	3
CO3	3	1	-	-	-	-	-	-	-	-	-	-	3	3
CO4	3	1	-	-	-	-	-	-	-	-	-	-	-	-
CO5	3	1	2	-	-	-	-	-	-	-	-	-	3	3
Total	15	5	4	-	-	3	-	-	-	-	-	-	8	9

Average	3	1.25	2	-	-	3	-	-	-	-	-	-	2.7	3

31. ASSESSMENT METHODOLOGY DIRECT:

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

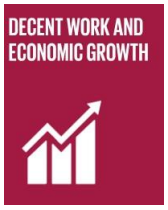
32. ASSESSMENT METHODOLOGY INDIRECT:

✓	Course End Survey (CES)

33. RELEVANCE TO SUSTAINABILITY GOALS:

Thermal Engineering, as a versatile and powerful programming language, can play a significant role in advancing various SDGs.

x	1		NA
✓	2		NA
✓	3		NA
✓	4		**Quality Education:** Quality education in thermal engineering provides a strong foundation in understanding energy, heat, and work, essential for solving real-world challenges. It emphasizes both theory and practical skills, preparing students to work with energy systems like power plants and refrigeration. This knowledge enhances employability in industries focused on energy and thermal processes.
x	5		NA
x	6		NA

✓	7		**NA**
x	8		**Decent work and economic growth** : thermal engineering plays a key role in promoting decent work and economic growth by optimizing energy efficiency and reducing waste in industries. This leads to more sustainable practices, lower costs, and the creation of energy-focused jobs. Advancements in thermodynamics also drive innovation in sectors like manufacturing and power generation, boosting economic development.
✓	9		**Industry innovation and infrastructure:** Thermal engineering is vital for industry innovation and infrastructure, as it drives advancements in energy-efficient technologies and sustainable engineering solutions. These innovations improve industrial processes and contribute to building more resilient and eco-friendly infrastructures.
x	10		NA
x	11		NA
x	12		**Responsible consumption and production:** optimizing energy use and minimizing waste in industrial processes. By improving efficiency, it supports sustainable practices that reduce environmental impact and conserve resources.
✓	13		**Climate Action**: Thermal engineering is essential to climate action by enabling the development of energy-efficient technologies that reduce greenhouse gas emissions. It supports the transition to renewable energy sources and sustainable systems, helping mitigate the effects of climate change.
x	14		NA

x	15		NA
x	16		NA
x	17		**Partnerships for the Goals:** This syllabus promotes collaboration among students from diverse fields in multidisciplinary teams, fostering partnerships for the development of innovative and sustainable engineering solutions that align with global sustainability goals.

Signature of Course Coordinator **HOD**
Name & Designation