Outcome Based Education (OBE) Manual

Department of

Electrical and Electronics Engineering

Regulation : R24

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 consists 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

To produce comprehensively trained, socially responsible, innovative electrical engineers and researchers of high quality who can contribute to the nation and global development.

Mission

- To provide an academic environment with a strong theoretical foundation and practical engineering skills.
- To experience interpersonal communication and teamwork along with emphasis on ethics, professional conduct, and critical thinking.
- The graduates will be trained to have successful engagement in research and development and entrepreneurship.

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: Success in Electrical Engineering:
To provide students with knowledge of Basic Sciences in general and Electrical and electronics Engineering to acquire the necessary skills for analysis and synthesis of problems in generation, transmission and distribution.

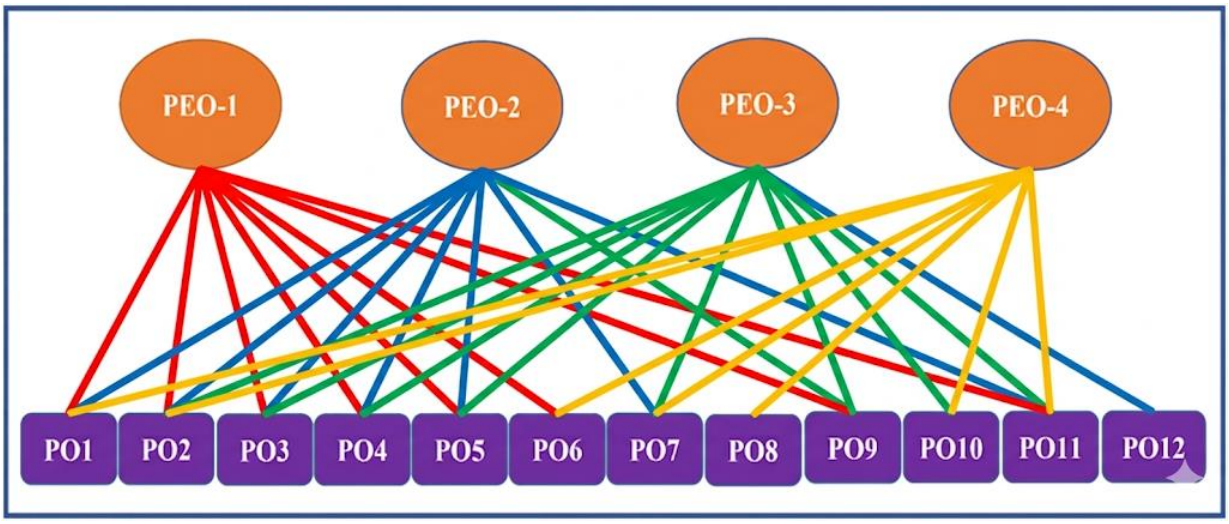
Program Educational Objective - II: Industrial awareness and research:
To provide technical knowledge and skills to identify, comprehend and solve complex tasks in industry and research and inspire the students to become future researchers / scientists with innovative ideas.

Program Educational Objective - III: Successful employment and professional ethics:
To prepare the students for successful employment in various industrial and government organizations, both at the national and international level, with professional competence and ethical administrative acumen to handle critical situations and meet deadlines.

Program Educational Objective - IV: Being a leader professional and societal environment:
To train the students in basic human and technical communication skills so that they may be both good team-members, leaders and responsible citizens.

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

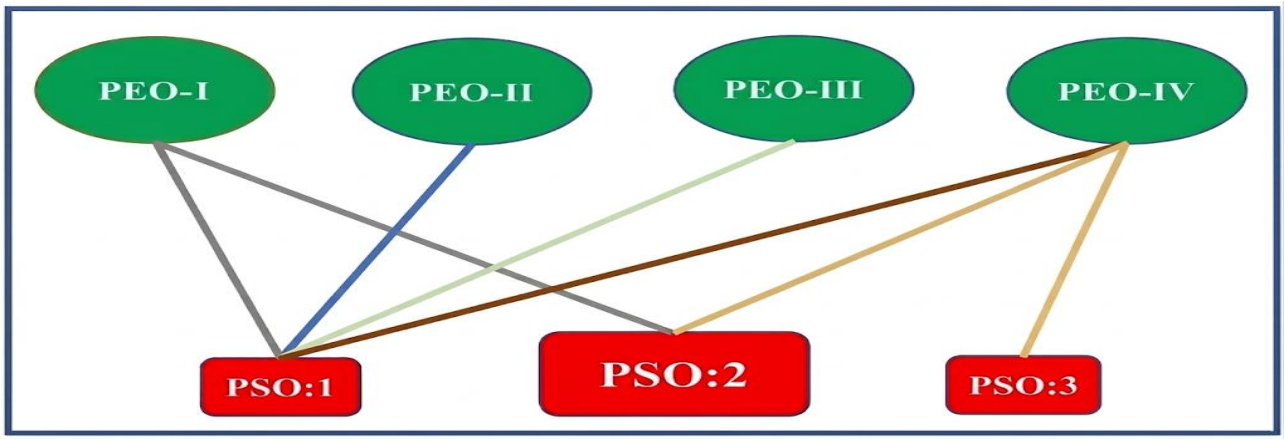
The following Figure1 shows the correlation between the PEOs and the POs



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	**PSO:**1	**PSO:**1,2,3

FIGURE2: Correlation between the PEOs and the PSOs

3. Program Outcomes (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 **12POs**, 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 (EEE) – PROGRAM OUTCOMES (PO's)	
A graduate of the Electrical and Electronics 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 Electrical and Electronics Engineering is given below.

B.Tech (EEE) – PROGRAM SPECIFIC OUTCOMES (PSO's)	
A graduate of the Electrical and Electronics Engineering Program will demonstrate:	
PSO1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.
PSO2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development.
PSO3	Gain the hands-on competency skills and other computing tools necessary for entry level position to meet the requirements of the employer.

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 Electrical 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 **(Engineering Knowledge)**.	3	1	1	1
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).**	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 the public health and safety, and the cultural, societal, and Environmental considerations **(Design/Development of Solutions).**	3	1	2	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 **(Conduct Investigations of Complex Problems).**	1	3	1	1
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).**	2	1	2	1
PO6	Apply reasoning informed by the contextual knowledge to assess	1	1	2	3

	societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice **(The Engineer and Society).**				
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	1	1	3
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice **(Ethics).**	1	1	3	2
PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **(Individual and Teamwork).**	1	1	2	3
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	1	2	3
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 multidisciplinary Environments **(Project Management and Finance).**	1	1	3	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 **(Life - Long Learning).**	3	2	1	1

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

PEO's→ ↓PSO's		(1) Success in Electrical Engineering	(2) Industrial awareness and research	(3) Successful employment and professional ethics	(4) Being a leader professional and societal environment
PSO1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	3	2	1	1
PSO2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development.	2			2
PSO3	Gain the hands-on competency skills and other computing tools necessary for entry level position to meet the requirements of the employer.	2			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 Outcomes

Lower Order of Thinking (LOT)				Higher Order of Thinking (HOT)		
Definitions	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Bloom's Definition	Exhibit memory of previously learned material by recalling facts, terms, basic concepts, and answers.	Demonstrate understanding of facts and ideas by organizing, comparing, translating, 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 • Test for Theme • Conclusion • Contrast	• Defend • Determine • Disprove • Estimate • Evaluate • Influence • Interpret • Judge • Justify Mark • Measure • Opinion • Perceive • Prioritize • Prove • Criteria • Criticize • Compare • Conclude	• Create • Design • Develop • Estimate • Formulate • Happen • Imagine • Improve • Makeup • Maximize • Minimize • Modify • Original • Originate • Plan • Predict • Propose • Solution

8. Guide lines 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 guide lines 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

Learningoutcomesformula:

STUDENTSSHOULDBE ABLETO+BEHAVIOR+RESULTINGEVIDENCE

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.
- Are aligned with program goals and objectives.
- Tell how you will know an instructional goal has been achieved.
- Use action words that specify definite, observable behaviors.
- Arrases able through one or more indicators (papers, quizzes, projects, presentations, journals, portfolios, etc.)
- Are realistic and achievable.
- Use simple language.

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 website 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– Upon 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.
- Analyze a character's motivation and portray that character before an audience.
- 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% ac-curacy
2	Immediately following a fifteen-minute discussion on a topic.	The student will be able to summarize in writing the major issues being discussed.	Mentioning at least three of the five major topics.
3	Given an algebraic equation with one unknown.	The student will be able to correctly solve a simple linear equation.	Within a period of five minutes.

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

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

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

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

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

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

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

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

An Introspection- Examine Your Own Course Outcomes

- If you have written statements of broad course goals, take a look at them. If you do not have a written list of course goals, reflect on your course and list the four to six most important student outcomes you want your course to produce.
- Look over your list and check the one most important student outcome. If you could only achieve one outcome, which one would it be?

- Look for your outcome on the list of key competencies or outcomes society is asking us to produce. Is it there? If not, is the reason a compelling one?
- Check each of your other "most important" outcomes against the list of outcomes. How many are on the list of key competencies?
- Take stock. What can you learn from this exercise about what you are trying to accomplish as a teacher? How clear and how important are your statements of outcomes for your use and for your students? Are they very specifically worded to avoid misunderstanding? Are they supporting important needs on the part of the students?

Write Your Course Outcomes!

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

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

8.5 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.

TABLE9: 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’s L1 to L5 for laboratory courses.
Bloom’s L1 to L6 for
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 assign 3.</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 our self 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).

8.6 Tips for Assigning the values while mapping COs to POs.

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, assign2; if the match is low, assign1; 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.

8.7 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. **Inter disciplinary 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 or 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 frame works 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 work shop skills to carryout 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	**10**

		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.	
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**

		4. **Sustainability:** Demonstrate the importance of sustainable development in engineering solutions.	
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 team work and project management to effectively complete assignments and projects. 7. **Peer Evaluation:** Contribute to team dynamics by valuating and reflecting on individual and group performance. 8. **Building Relationships:** Foster team work and lasting relationships, contributing to both academic Success and post-graduation professional networks. 9. **Organizational Integration:** Collaborate with individuals across all level of an organization demonstrating adaptability and interpersonal skills. 10. **Effective Communication:** Develop	**10**

		strong relationships through positive interactions, show casing an ability to get a long with others and work cohesively in teams.	
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 the set 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	**10**

		dynamics. 9. **Stakeholder Management:** Identify and manage stake holders, ensuring their needs and expectations are addressed throughout the project. 10. **Risk Management:** Develop a risk register and apply strategies to identify, assess, and mitigate project risks.	
PO12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (Life-Long Learning).	1. **Professional Certificate:** Pursue professional, Academic, Global certifications. 2. **Advanced Education:** Begin and work towards advanced programs to further deepen knowledge. 3. **Continuous Learning:** Stay updated on industry trends and emerging technologies to remain relevant in the field. 4. **Skill Acquisition:** Learn atleast 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	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control protect electrical power System. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system.	**6**

	5. Adopt the engineering professional code and conduct 6. Sustainable and Compliant Design	
PSO2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools 4. Inspect, survey, analyze energy flow, control and manage the power generation and utilization. 5. Familiarize the safety, legal and health norms in electrical system. 6. Adopt the engineering professional code and conduct. 7. Explore autonomous power 8. Evolve into green energy and assess results 9. Realize energy policies and education 10. Potential contribution of clean energy for rural development.	**10**
PSO3	Gain the hands-on competency skills and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving 7. Presentation using software aids. 8. Programming and hands-on skills to meet requirements of global environment.	**8**

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

Courses offered in Electrical and Electronics Engineering Curriculum (MLRS-R24)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	3
I B.Tech–I Semester																
2410001	Matrices and Calculus	✔	✔	✔	✔									✔	✔	
2410008	Applied Physics	✔	✔			✔	✔									
2410501	Problem Solving Using C and C++	✔	✔	✔	✔									✔	✔	✔
2410010	English for Skill Enhancement							✔	✔	✔	✔	✔	✔			
2410372	Engineering Workshop	✔	✔	✔	✔									✔		
2410071	Applied Physics Laboratory				✔	✔										
2410571	Problem Solving Using C and C++ Lab	✔	✔	✔	✔	✔								✔		
2410073	English Language and Communication Skills Lab							✔	✔	✔	✔	✔	✔			
2410596	Web Application Development	✔	✔	✔		✔									✔	
2410FL2	Foreign Language							✔	✔	✔	✔	✔	✔			
CODE	SUBJECT	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
I B.Tech–II Semester																
2420002	Differential Equations and Vector Calculus	✔	✔	✔	✔									✔		
2420009	Engineering Chemistry	✔	✔		✔		✔							✔		
2420221	Electrical Engineering	✔	✔	✔	✔									✔	✔	✔
2420502	Essentials of Problem Solving using Python					✔	✔	✔	✔					✔	✔	✔

2420371	Computer Aided Engineering Graphics	✔	✔	✔	✔	✔								✔		
2420072	Engineering Chemistry Laboratory	✔	✔	✔	✔	✔								✔	✔	✔
2420276	Electrical Engineering Laboratory	✔	✔	✔	✔	✔								✔	✔	✔
2420572	Essentials of Problem Solving using Python Laboratory	✔	✔	✔	✔	✔								✔	✔	✔
2420027	Public speaking skills						✔	✔	✔	✔	✔	✔	✔			
2420026	Yoga & Inner Engineering								✔				✔			
CODE	SUBJECT	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
II B.Tech–I Semester																
2430224	Electro Magnetic Fields	✔	✔	✔	✔									✔		✔
2430222	Network Analysis	✔	✔	✔	✔									✔	✔	
2430460	Analog Electronics	✔	✔	✔	✔										✔	✔
2430223	DC Machines and Transformers	✔	✔	✔										✔	✔	✔
2430507	Data Structures	✔	✔	✔	✔	✔			✔	✔				✔	✔	✔
243EXL1	Design and Innovation	✔	✔	✔	✔	✔	✔							✔	✔	✔
2430277	Network Analysis and Simulation Lab	✔	✔	✔	✔									✔	✔	✔
2430278	DC Machines Lab	✔	✔								✔	✔		✔	✔	✔
2430575	Data Structures Lab Using Python	✔	✔													

2430455	PCB Fabrication	✔	✔	✔	✔									✔	✔	✔
2430291	Internship-1	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
243IKS2	Indian Knowledge System						✔	✔	✔							
CODE	SUBJECT	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
II B.Tech–II Semester																
2440003	Numerical Methods and Complex Variables	✔	✔	✔	✔								✔			
2440225	AC Machines	✔	✔	✔	✔									✔	✔	✔
2440461	Digital Electronics	✔	✔	✔							✔				✔	✔
2440226	Control Systems	✔	✔	✔	✔						✔		✔	✔	✔	✔
2440227	Electrical Power Generation	✔	✔	✔	✔		✔	✔						✔	✔	
244EXL2	Prototype/model Development and Entrepreneurship	✔	✔	✔	✔	✔			✔	✔				✔		✔
2440279	AC Machines Lab	✔	✔			✔				✔				✔	✔	✔
2440280	Control Systems Lab	✔	✔	✔	✔	✔									✔	✔
2440482	Analog and Digital Electronics Lab		✔	✔		✔					✔				✔	✔
2440574	Data Visualization-Power Bi	✔	✔	✔	✔	✔	✔		✔						✔	
2440021	Environmental Science						✔	✔	✔							
CODE	SUBJECT	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
III B.Tech–I Semester																
2450228	Power Electronics	✔	✔	✔	✔	✔							✔	✔	✔	✔

2450428	Micropro cessors and Microcon trollers	✔	✔	✔				✔						✔	✔	
2450229	Electrical Transmission and Distribution	✔	✔	✔	✔									✔		✔
2450236	Wind and Solar Energy Systems	✔	✔	✔	✔									✔	✔	
2450475	Microprocessors and Microcontrollers Lab	✔	✔	✔	✔				✔	✔				✔		
2450281	Power Electronics Lab	✔	✔	✔		✔									✔	
2450592	OOPS through JAVA Lab	✔	✔	✔	✔	✔			✔						✔	✔
2450292	Field Based Project	✔	✔	✔	✔	✔			✔	✔					✔	✔
2450022	Gender Sensitization						✔	✔	✔	✔						
CODE	SUBJECT	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
III B.Tech–II Semester																
2460230	Power Electronics Applications to Renewable Energy Systems	✔	✔	✔	✔									✔	✔	✔
2460231	Power System Analysis	✔	✔	✔	✔									✔	✔	✔
2460232	Electrical Measurements and Instrumentation	✔	✔	✔	✔										✔	✔
2460240	HVDC Transmission	✔	✔	✔	✔									✔	✔	✔
2460102	Remote Sensing &GIS						✔	✔	✔	✔		✔		✔		
2460477	Smart Sensors and Systems Lab	✔	✔	✔	✔	✔	✔			✔					✔	✔
2460282	Simulation of Power Electronics Applications to	✔	✔	✔	✔	✔	✔		✔						✔	✔

	Renewable Energy Systems Lab															
2460483	Electrical Measurements and Instrumentation Lab	✔	✔	✔	✔	✔								✔	✔	
2460293	Introduction to Computer Aided Electrical Drawing	✔	✔	✔	✔	✔								✔	✔	✔
2460023	Constitution of India						✔	✔	✔	✔						
CODE	SUBJECT	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
IV B.Tech–I Semester																
2470233	Power System Operation and Control	✔	✔	✔	✔									✔	✔	✔
2470234	Power System Protection	✔	✔	✔	✔										✔	✔
2470010	Business Economics and Financial Analysis						✔	✔	✔	✔		✔			✔	✔
2470242	Industrial Electrical Systems	✔	✔	✔	✔										✔	✔
2470462	Basics of Digital Signal Processing	✔	✔	✔										✔	✔	

2470284	Electrical Systems Simulation Lab	✔	✔	✔	✔									✔	✔	✔
2470285	Power Systems Lab	✔	✔	✔	✔									✔	✔	✔
2470294	Project stage-I	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
2470295	Internship-II	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
2470025	Human Values and Professional Ethics						✔	✔	✔							
CODE	SUBJECT	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
IV B.Tech–II Semester																
2480248	Power Quality and Facts	✔	✔	✔	✔									✔	✔	✔
2480252	Electrical Distribution Systems	✔	✔	✔	✔									✔	✔	✔
2480296	Technical Seminar	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
2480297	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. Comprehensive Assessment Tool (CAT)
III. Semester end examination (SEE)
IV. Laboratory and project work
V. Course end survey
VI. Programme exit survey
VII. Alumni survey
VIII. Employer survey
IX. Course expert committee
X. Department Advisory Board
XI. Faculty meetings
XII. 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), quiz and CAT (includes PPT, poster presentation etc). 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 Comprehensive Assessment Tool (CAT)

The Comprehensive Assessment Tool (CAT) is a flexible, outcome-driven evaluation mechanism that enhances faculty autonomy by enabling the design of innovative and diverse pedagogical practices beyond conventional examinations. It encompasses a broad range of activities including certifications from open coding platforms, Tech Talks, term papers, MOOCs, open-ended experiments, concept videos, hackathons, and language proficiency tests. Through the CAT, the classroom is transformed into an effective learning centre where assessment is continuous, comprehensive, and aligned with defined Course Outcomes (COs) and Program Outcomes (POs). This tool fosters holistic student development by integrating technical proficiency, critical thinking, and professional communication into a unified and measurable assessment framework.

12.3 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.

12.4 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 bythe 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.

12.5 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.

12.6 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.

12.7 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.

12.8 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.

12.9 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. In form 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.

12.10 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

12.11 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 ina month for ensuring the implementation of PAQIC's suggestions and guide lines. All these proceedings are recorded and kept for the availability of all faculties.

12.12 Professional Societies

The importance of professional societies like CSI (Computer Society of India), ACM (Association for Computing Machinery), TASK (Telangana Academy of kill and Knowledge)search for knowledge. Student and faculty chapters of the above societies are constituted for a better technical and entrepreneurial environment. These professional societies promote excellence in instruction, research, public service and practice.

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) where as 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, Quiz & CAT)	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
		Quiz	Twice in a semester	05	Worksheets
		CAT(Tech-talk, Concept video, NPTEL certificate etc)	Twice in a semester	05	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	Worksheets
		Viva-Voce	Once in a week	10	Worksheets
		Certificate/ Open ended experiment	Once in a semester	10	Certificate/ Worksheet
		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

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.

TABLE16: 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.

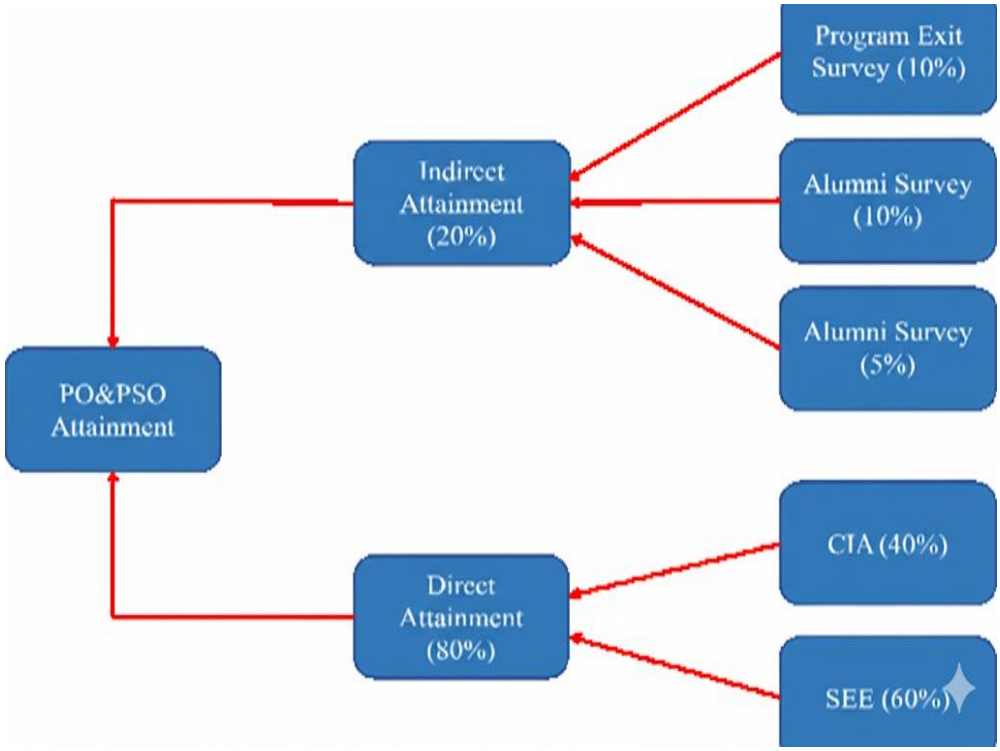


FIGURE 4: Evaluation process of POs/PSOs attainment

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

ELECTRICAL POWER GENERATION SYSTEMS

1	Department	ELECTRICAL &ELECTRONICS ENGINEERING							
2	Course Name	ELECTRICAL POWER GENERATION SYSTEMS							
3	Course Code	2440279							
4	Year/Semester	II/II							
5	Regulation	MLRS-R24							
7	Structure of the course	Theory				Practical			
		Lecture	Tutorials	Practical	Credit	L	T	P	C
		2	0	0	2	0	0	0	0
8	Type of course	PCC	HS	ES	PC	PE	OE	CC	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: 0 hours	Practical: 0 hours						
11	Course Coordinator	Mrs.A.KALPANA							
12	Date Approved by BOS								
13	Course Webpage	www.mlritm.ac.in/							
14	Prerequisites/ Co-requisites	Level	Course Code	Semester	Prerequisites				
		UG	2430224	III	Electromagnetic Fields				

15. Course Overview:

A course on Electrical Power Generation Systems is usually an introductory class in electrical engineering focusing on the generation, transmission, and distribution of electrical power. It also gives the idea of Design, operation, and characteristics of transmission lines and Economic considerations in power generation, transmission and distribution.

16. Course Objectives:

The students will be able to:

- Understand the fundamental concepts of power generation and gain knowledge about different renewable and non-renewable energy sources.
- Study the detailed theory on the construction and working principles of thermal, hydro-electric, nuclear, and gas power plants.
- Analyze the key aspects of solar and wind power energy systems and their environmental impacts in the present-day scenario to achieve clean energy.

- Examine the various factors affecting the cost of generation and explore different tariff methods for electrical energy consumption to attain optimum utilization of generated electrical energy.
- Develop the ability to apply knowledge of electrical power generation in minor and major projects, and to pursue research work in the future.

17. Course Outcomes:

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

CO1	Explain the operating principles of thermal and nuclear power stations to evaluate their significance.
CO2	Describe the working principles and layout of hydroelectric power stations (HPS) along with their multipurpose utilities.
CO3	Summarize the process of solar power generation using the photovoltaic effect and its applications.
CO4	Explain the working principles of wind energy systems (WES), the different types of turbines, and the importance of WES.
CO5	Analyze the impact of tariffs on the cost of power generation.

18. Course Learning Outcome (CLOs):

Sno	Topic Name	CLO No	Course Learning Outcome	COs	Blooms Level
1	Thermal Power Stations: Evaluation of power systems, present day scenario	CLO 1	**Recall** the basic structure, major components, and functional role of thermal power stations in conventional electricity generation. **Explain** the present-day status of thermal power generation with respect to energy demand contribution, efficiency improvements, and environmental impacts.	CO1	Understand
2	Line diagram of thermal power station (TPS) showing paths of coal, steam, water, air, ash and flue gasses	CLO 2	*Draw and label* a neat line diagram of a thermal power station clearly indicating the paths of coal, steam, water, air, ash, and flue gases.	CO1	Apply
3	Brief description of TPS components: Economizers, boilers, super heaters, turbines, condensers, chimney and cooling towers.	CLO 3	*Explain* the working principles and roles of TPS components in the efficient generation of electrical power.	CO1	Understand
4	Gas power stations:	CLO	*Identify* the major components of a	CO1	Remember

	Principle of operation and components (Block diagram approach only).	4	gas power station using a block diagram.		
5	Hydroelectric Power Stations: Elements of hydroelectric power station, types	CLO 5	*Explain* the function of each element of a hydroelectric power station and the operating principles of various types of hydro plants.	CO2	Understand
6	Concept of pumped storage plants, estimation of power developed from a given catchment area, heads and efficiencies;	CLO 6	*Analyze* the performance of pumped storage plants under varying heads and efficiencies for load management and grid support.	CO2	Analyze
7	Hydraulic turbines: Classification of turbines, impulse and reaction turbines	CLO 7	*Select* an appropriate type of turbine (impulse or reaction) for given head and discharge conditions.	CO2	Apply
8	Pelton wheel, Francis turbine and Kaplan turbine hydraulic design, draft tube theory, functions and efficiency.	CLO 8	*Explain* the hydraulic design principles, working mechanisms, and draft tube theory of Pelton, Francis, and Kaplan turbines.	CO2	Understand
9	Solar radiation: Environmental impact of solar power, physics of the sun, solar constant, extraterrestrial and terrestrial solar radiation	CLO 9	*Analyze* the effects of atmospheric conditions on terrestrial solar radiation and their implications for solar power system performance.	CO3	Analyze
10	Photovoltaic systems: Photovoltaic effect, semiconducting materials, electrostatic	CLO 10	*Illustrate* the photovoltaic effect in a p–n junction semiconductor and relate material properties to solar cell output	CO3	Apply

	field across the depletion layer				
11	Wind energy: Sources and potential, power from wind, Betz criterion, components of wind energy conversion system, types of turbines	CLO 11	*Analyze* the performance and suitability of different wind turbine types based on wind conditions and site characteristics.	CO4	Analyze
12	Types of generating systems for wind energy	CLO 12	*Select* an appropriate wind energy generating system based on wind conditions, grid requirements, and power control needs.	CO4	Apply
13	Economic Aspects of Power Generation Terms commonly used in system operation		*Explain* the significance of economic aspects like fixed cost, running cost, depreciation, and tariffs in power system operation.	CO5	Understand
14	Various factors affecting cost of generations; load curves, connected load, maximum demand, peak load, base load and peak load power plants		*Explain* the various factors affecting the cost of power generation and the significance of load curves in power system operation.	CO5	Understand
15	load factors, plant capacity factor, plant use factor, demand factors, diversity factor, cost of power plant, tariffs.		*Analyze* the impact of demand, diversity, and operational factors on the cost of generation and tariff setting.		

19. Employability Skills:

Example: Ability to design and analyze power generation, transmission, and distribution systems, including understanding system components like transformers, circuit breakers, and transmission lines.

Skills in planning and organizing projects related to power system design and implementation, including time management and resource allocation.

20. Content Delivery / Instructional Methodologies:

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

21. Evaluation Methodology:

The course is evaluated for a total of 100 marks, consisting of 40 marks for Continuous Internal Assessment (CIA) and 60 marks for the Semester End Examination (SEE). The CIA includes 20 marks from Continuous Internal Examinations (CIE-I and CIE-II), 10 marks from objective tests, quizzes, or short answer assessments, and 10 marks from Continuous Assessment Tests (CAT) such as presentations or assignments. Each CIE is conducted for 1 hour 30 minutes and evaluated for 30 marks, which are scaled downto10 marks.

The SEE is conducted for60 marks with a duration of three hours. The syllabus is divided into five modules with equal weightage. The question paper includes two questions from each module, generally with an internal choice, and each question carries 12 marks with possible sub-parts. Students are required to answer questions covering all modules.

Table 1: Outline for Continuous Internal Assessment (CIA-I and CIA-2) and SEE

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

22. Course content - Number of modules: Five:

MODULE 1	Thermal Power Stations: Evaluation of power systems, present day scenario, Line diagram of thermal power station (TPS) showing paths of coal, steam, water, air, ash and flue gasses; Brief description of TPS components: Economizers, boilers, super heaters, turbines, condensers, chimney and cooling towers. Gas power stations: Principle of operation and components (Block diagram approach only)..	No. of Lectures: 8
MODULE 2	Hydroelectric Power Stations: Elements of hydroelectric power station, types, concept of pumped storage plants, estimation of power developed from a given catchment area, heads and efficiencies; Hydraulic turbines: Classification of turbines, impulse and reaction turbines, Pelton wheel, Francis turbine and Kaplan turbine hydraulic design, draft tube theory, functions and efficiency	No. of Lectures:10
MODULE 3	Solar radiation: Environmental impact of solar power, physics of the sun, solar constant, extraterrestrial and terrestrial solar radiation, solar concentrators, collectors, thermal applications, design of standalone solar systems, simple problems. Photovoltaic systems: Photovoltaic effect, semiconducting materials, electrostatic field across the depletion layer, voltage developed, I-V characteristics, module structure and fabrication, output power and efficiency, fill factor, maximum power point tracking (MPPT), solar grid connected inverters, simple problems.	No. of Lectures: 10
MODULE 4	Wind energy: Sources and potential, power from wind, Betz criterion, components of wind energy conversion system, types of turbines, horizontal and vertical axis wind turbines, aerodynamics, momentum theory (actuator disk concept), operational characteristics, blade element theory, types of generating systems for wind energy, permanent magnet generators, DC generators, induction generators, doubly fed induction generators, applications of wind energy, safety and environmental aspects, simple problems.	No. of Lectures: 12
MODULE 5	Terms commonly used in system operation, various factors affecting cost of generations; load curves, connected load, maximum demand, peak load, base load and peak load power plants, load factors, plant capacity factor, plant use factor, demand factors, diversity factor, cost of power plant, tariffs	No. of Lectures: 8

TEXTBOOKS:

1. C L Wadhwa, “Generation, Distribution and Utilization of Electrical Energy”, New Age International Limited, New Delhi, 3rd Edition, 2005.
2. G D Rai, “Non-Conventional Energy Sources”, Khanna Publishers, 1st Edition, 2011.

3. G N Tiwari, M K Ghosal, “Fundamentals of Renewable Energy Sources”, Narosa Publications, New Delhi, 1 st Edition, 2007.
4. Chetan Singh Solanki, “Solar Photovoltaics”, PHI Publications, 2nd Edition, 2011.
5. M L Soni, P V Gupta, U S Bhatnagar and A Chakraborti, “A text book on Power system engineering”, Dhanpat Rai and Co. Pvt. Ltd, 1999.

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1. J B Gupta, “A Course in Electrical Power”, S K Kataria and Sons, New Delhi, 15th Edition, 2013.
2. M V Deshpande, “Elements of Power Station design”, Prentice Hall India Learning Private Limited, New Delhi, 1st Edition, 1992.
3. Mukund R Patel, “Wind and Solar Power Systems”, CRC Press, 1st Edition, 1999.
4. V K Mehta and Rohit Mehta, “Principle of Power Systems”, S Chand & Company, Ltd, New Delhi, 3rd Edition, 2005.

ELECTRONIC RESOURCES:

1. https://www.youtube.com/watch?v=uy9lZCdkQIM&list=PLD4ED2FAF3C155625
2. https://www.youtube.com/watch?v=dHgXGVOkVok
3. https://www.youtube.com/watch?v=NEXWcOgqZOI

23. COURSE PLAN:

S. No.	Topics to be covered	Co’s	Reference
	Discussion on Outcome Based Education, CO, POs and PSOs		
1	Introduction to Conventional Sources and Non-Conventional sources	CO1	T1:1.1
2	Thermal Power Stations: Evaluation of power systems	CO1	T1:2.1
3	present day scenario	CO1	T1:2.2
4	Line diagram of thermal power station	CO1	T1: 2.3
5	Brief description of TPS components	CO1	T1:2.6
6	Gas power stations	CO1	T1:2.9
7	Hydroelectric Power Stations: Elements of hydroelectric power station	CO21	T1: 2.2
8	types	CO2	T1:2.4
9	concept of pumped storage plants	CO2	T1: 1.5
10	Estimation of power developed from a given catchment area	CO2	T1: 1.3
11	Heads and efficiencies	CO2	T1: 1.7
12	Hydraulic turbines: Classification of turbines	CO2	T1: 1.2
13	Impulse and reaction turbines	CO2	T1: 1.6

14	Pelton wheel, Francis turbine	CO2	T1: 2.4, 2.5
15	Kaplan turbine hydraulic design	CO2	T1: 2.7
16	Draft tube theory, functions and efficiency	CO2	T1: 2.8
17	Solar radiation: Environmental impact of solar power	CO3	T1: 3.8
18	Extraterrestrial and terrestrial solar radiation	CO3	T1: 3.2
19	Solar concentrators	CO3	T1: 3.6
20	Collectors, Design of standalone solar systems	CO3	T1: 4.8
21	Photovoltaic systems: Photovoltaic effect	CO3	T1: 4.2
22	semiconducting materials	CO3	T1: 6.1
23	electrostatic field across the depletion layer	CO3	T1: 4.5
24	voltage developed, I-V characteristics	CO3	T1: 4.1
25	module structure and fabrication, output power and efficiency	CO3	T1: 6.3
26	maximum power point tracking (MPPT)	CO3	T1: 6.8
27	Solar grid connected inverters,	CO3	T1: 4.9
28	Wind energy: Sources and potential	CO4	T1:6.4
29	Betz criterion	CO4	T1: 7.3
30	Components of wind energy conversion system	CO4	T1: 7.8
31	Types of turbines	CO4	T1: 7.5
32	Horizontal and vertical axis wind turbines	CO4	T1: 4.7
33	Aerodynamics	CO4	T1: 6.4
34	Blade element theory	CO4	T1: 6.5
35	Operational characteristics	CO4	T1: 7.2
36	Momentum theory	CO4	T1: 7.9
37	Aypes of generating systems for wind energy	CO4	T1:6.6
38	Permanent magnet generators,	CO4	T1: 7.7
39	DC generators	CO4	T1: 7.4
40	Induction generators	CO4	T1: 7.6
41	Doubly fed induction generators	CO4	T1: 6.9
42	Applications of wind energy	CO4	T1: 5.9
43	safety and environmental aspects	CO4	T1: 5.8
44	various factors affecting cost of generations	CO5	T1:4.2
45	Load curves, connected load, maximum demand, peak load, base load and peak load power plants	CO5	T1: 5.2, 5.7,3.4, 5.4
46	Load factors, plant capacity factor, plant use factor,	CO5	T1: 5.6, 3.4
47	Demand factors, diversity factor, cost of power plant,	CO5	T1:3.4

48	Tariffs	CO5	T1: 5.1

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engineering. Specialization to the solution of complex engineering problems.
PO 2: 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.
PO 4: 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.
PO 5: 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.
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.
PO 7: 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.
PO 10: 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
PSO 1: Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.
PSO 2: Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.
PSO 3: Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.

25. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engg. specialization to the solution of complex engineering problems.	3	CIE/PPT/ Objective / quiz /SEE/ Assignments/ Viva-Voce/
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.	3	CIE/PPT/ Objective / quiz /SEE/ Assignments/ Viva-Voce/
PO3	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.	1	CIE/PPT/ Objective / quiz /SEE/ Assignments/ Viva-Voce/
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.	3	CIE/PPT/ Objective / quiz /SEE/ Assignments/ Viva-Voce/

26. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PSO1	Design, Develop, Fabricate and Commission	3	CIE/PPT/

	the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.		Objective / quiz /SEE/ Assignments/ Viva-Voce/
PSO2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	3	CIE/PPT/ Objective / quiz /SEE/ Assignments/ Viva-Voce/
PSO3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	1	CIE/PPT/ Objective / quiz /SEE/ Assignments/ Viva-Voce/

3 = High; 2 = Medium; 1 = Low

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

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	PSO3
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. Scientific principles and methodology 2. Mathematical principles 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
	PO2	1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Experimental design 7. Solution development or experimentation /Implementation 8. Interpretation of results	8
	PO3	1. Use creativity to establish innovative solutions. 2. Knowledge of management techniques which may be used to achieve engineering	3

		objectives within that context. 3. Understanding of the requirement for engineering activities to promote sustainable development;	
	PO4	1. Knowledge of characteristics of particular materials, equipment, processes, or products; 2. Workshop and laboratory skills; 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.); 4. Understanding of appropriate codes of practice and industry standards; 5. Ability to work with technical uncertainty. 6. Understanding of engineering principles and the ability to apply them to analyses key engineering processes. 7. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems; 8. Understanding of and ability to apply a systems approach to engineering problems.	8
	PO6	1. Understanding of the requirement for engineering activities to promote sustainable development 2. Awareness of the frame work of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	2
	PO7	Environmental	1
	PSO1	1. Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	1
	PSO2	1. Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	1
CO2	PO1	1. Scientific principles and methodology 2. Mathematical principles 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
	PO2	1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Experimental design 7. Solution development or experimentation /Implementation	8

		8. Interpretation of results	
	PO4	1. Workshop and laboratory skills; 2. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.); 3. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques; 4. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems; 5. Understanding of and ability to apply a systems approach to engineering problems.	3
	PSO1	1. Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	1
	PSO2	1. Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	1
CO3	PO1	1. Scientific principles and methodology 2. Mathematical principles 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
	PO2	1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Experimental design 6. Solution development or experimentation /Implementation 7. Interpretation of results.	7
	PSO1	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	1
	PSO2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	1
CO4	PO1	1. Scientific principles and methodology 2. Mathematical principles 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
	PO2	1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Experimental design	8

		6. Solution development or experimentation /Implementation 7. Interpretation of results 8. Documentation	
	PO4	1. Workshop and laboratory skills; 2. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.); 3. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues; 4. Understanding of engineering principles and the ability to apply them to analyze key engineering processes; 5. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems; 6. Understanding of and ability to apply a systems approach to engineering problems.	6
	PSO 1	1. Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	1
	PSO2	1. Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	1
CO5	PO1	1. Scientific principles and methodology 2. Mathematical principles 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
	PO2	1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation /Implementation 9. Interpretation of results 10. Documentation	10
	PO4	1. Knowledge of characteristics of particular materials, equipment, processes, or products; 2. Workshop and laboratory skills; 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.); 4. Understanding use of technical literature and other information sources Awareness of	7

		nature of intellectual property and contractual issues; 5. Understanding of engineering principles and the ability to apply them to analyze key engineering processes; 6. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems; 7. Understanding of and ability to apply a systems approach to engineering problems.	
	PSO1	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	1
	PSO2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	1

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

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	PO12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	1	1	1
CO1	3	8	3	8	-	2	3	-	-	-	-	-	1	1	-
CO2	3	8	-	-	-	-	-	-	-	-	-	-	1	1	-
CO3	3	7	-	-	-	-	-	-	-	-	-	-	1	1	-
CO4	3	8	-	6	-	-	-	-	-	-	-	-	1	1	-
CO5	3	10	-	7	-	-	-	-	-	-	-	-	1	1	-

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

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	PSO 3
CO1	100	80	30	72.7	-	40	100	-	-	-	-	-	100	100	100
CO2	100	80	-	-	-	-	-	-	-	-	-	-	100	100	-
CO3	100	70	-	-	-	-	-	-	-	-	-	-	100	100	-
CO4	100	80	-	54.5	-	-	-	-	-	-	-	-	100	100	-

CO5	100	100	-	63.6	-	-	-	-	-	-	-	-	100	100	-

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	PSO 3
CO1	3	3	1	3	-	2	3	-	-	-	-	-	3	3	3
CO2	3	3	-	-	-	-	-	-	-	-	-	-	3	3	-
CO3	3	3	-	-	-	-	-	-	-	-	-	-	3	3	-
CO4	3	3	-	2	-	-	-	-	-	-	-	-	3	3	-
CO5	3	3	-	3	-	-	-	-	-	-	-	-	3	3	-
Total	15	15	1	8	-	2	3	-	-	-	-	-	15	15	-
Average	3	3	1	2.66	-	2	3	-	-	-	-	-	3	3	-

32. ASSESSMENT METHODOLOGY DIRECT:

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

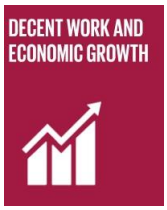
33. ASSESSMENT METHODOLOGY INDIRECT:

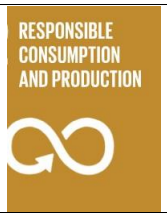
✓	Course End Survey (CES)

34. RELEVANCE TO SUSTAINABILITY GOALS:

The Electrical Power Generation course contributes to sustainability goals by enabling students to design efficient, reliable, and eco-friendly power generation systems that support sustainable energy production and responsible resource utilization. The relevance to SDGs includes:

x	1		
x	2		
x	3		

x	4		
x	5		
x	6		
✓	7		**Affordable and clean Energy:** Achieving affordable and clean energy involves a mix of technologies, policies, and strategies to balance cost, environmental impact, and energy needs. Here's a broad look at some key approaches: **Renewable Energy Sources** 1. Solar Power 2. Wind Power 3. Hydropower and Tidal.
✓	8		The economic growth stemming from innovations in power generation, transmission, and distribution is multifaceted, supporting job creation, increased productivity, technological leadership, and sustainable development. As nations embrace cleaner and more efficient energy systems, they stand to reap the rewards of enhanced energy security, environmental sustainability, and economic competitiveness.
✓	9		The innovations in power generation, transmission, and distribution systems reflect significant advancements in technology, efficiency, and sustainability. New materials, smarter systems, and the integration of renewable energy are reshaping the industry. At the same time, infrastructure development is essential to support these innovations, ensuring reliable energy delivery, resilience against outages, and integration of new technologies like electric vehicles and renewable energy sources.
x	10		
x	11		

x	12		
✓	13		**Climate Action**: Addressing climate change through power plants involves a multi-faceted approach aimed at reducing greenhouse gas emissions, increasing energy efficiency, and transitioning to cleaner energy sources. Here's how power plants can contribute to climate action.
x	14		
x	15		
x	16		
x	17		

Signature of Course Coordinator **HOD**
Name & Designation: A.KALPANA
Asst. Professor
EEE Dept.