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MARRI LAXMAN REDDY INSTITUTE OF TECHNOLOGY AND MANAGEMENT

Outcome Based Education (OBE) Manual

Department of
Electrical and Electronics Engineering

Regulation: UGR22

Contents Page No

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 out comes using statements "able to do" in favor of students. OBE provides clear standards for observable and measurable outcomes.

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

Higher Education Institutions are classified into two categories by NBA

Tier-1: Institutions consists of all IITs, NITs, Central Universities, State Universities and Autonomous Institutions. Tier-1 institution can also claim the benefits as per the Washington Accord.
Tier-2: Institutions 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 stake holders.
5. Enabling graduates to excel in their profession and accomplish reater heights in their careers.
6. Preparing graduates for the leadership positions and challenging them and making them aware of the opportunities in the technology development.

Benefits of OBE

Clarity: The focus on outcome creates a clear expectation of what needs to be accomplished by the end of the course.

Flexibility: With a clear sense of what needs to be accomplished, instructors will be able to structure their lessons around the students' needs.

Comparison: OBE can be compared across the individual, class, batch, program and institute levels.

Involvement: Students are expected to do their own learning. Increased student's involvement allows them to feel responsible for their own learning, and they should learn more through this individual learning.

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

India, OBE and Accreditation:

From 13 June 2014, India has become the permanent signatory member of the Washington Ac-cord Implementation of OBE in higher technical educational o 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 there in 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 inter actions 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, TRUST WORTHINESS, 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 Head of the Department in consultation with the faculty members. 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 Behaviour. 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.

PEO 1 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.

PEO 2 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.

PEO 3 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

PEO 4 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.

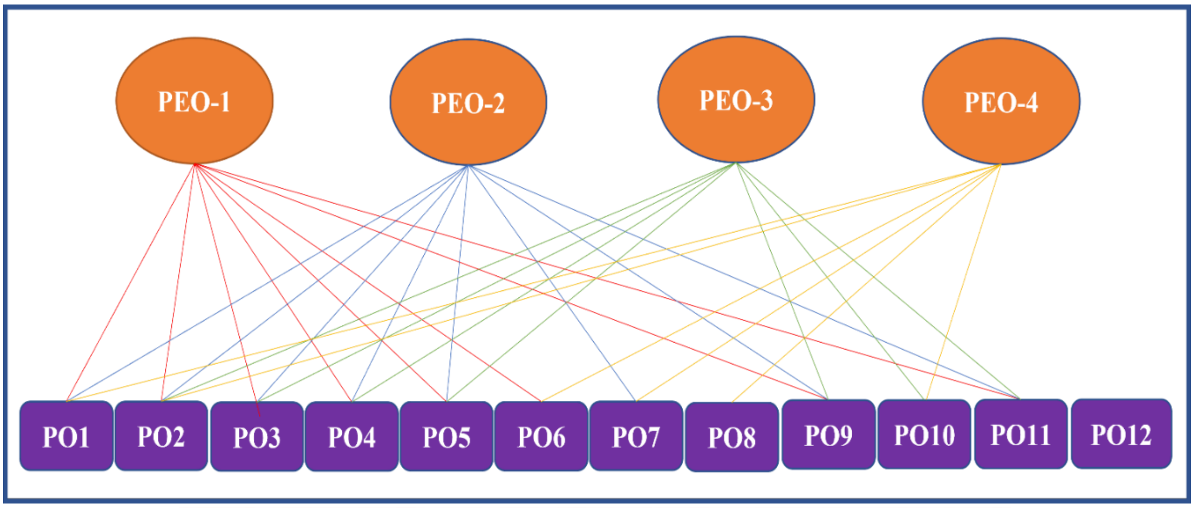
2.1. Mapping of program educational objectives to program outcomes and program specific outcomes:

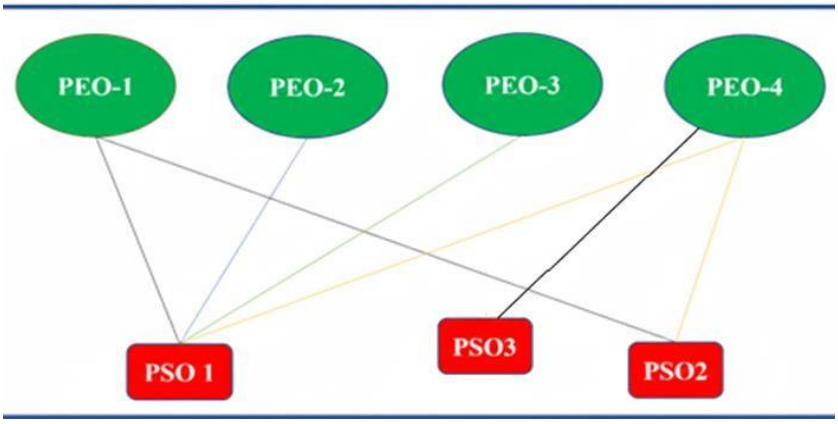
The following Figure1 shows the correlation between the PEOs and the POs

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) – PROGRAMSPECIFICOUTCOMES (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 societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice **(The Engineer and Society).**	1	1	2	3

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. Blooms Taxonomy

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

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

Questioning information is a vital part of learning, and both analysis and evaluation do just this. 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 outcomes 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 Figure3.

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**	**Meta cognitive**
• 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 • Knowledgeaboutcognitivetask,includingappropriatecontextualandconditional 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 to get her 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	• Organize • Plan • Select • Solve • Utilize • Identify • Interview • Make use of • Model • Organize • Plan	• 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	• Create • Design • Develop • Estimate • Formulate • Happen • Imagine • Improve • Makeup • Maximize • Minimize • Modify • Original • Originate

		• Show • Summarize • Translate • Experiment with	• Select • Solve • Utilize • Identify		• Criteria • Criticize • Compare • Conclude	• Plan • Predict • Propose • Solution

8. Guidelines for writing Course Outcome Statements:

Well-written course outcomes involve the following parts:

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

8.1. Course Outcomes (COs)

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

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

8.2. Developing Course Outcomes

When creating course outcomes consider the following 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, modelling, depicting, etc.) rather than using a single statement such as "At the end of the course, students will know" as the stem for each expected outcome statement.

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

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

Course outcome statements at the course level describe:

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

Course outcomes have three major characteristics:

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

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

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

8.3. Relationship of Course Outcome to Program Outcome

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

The Course Outcomes need to link to the Program Outcomes.

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

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

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 are search study published in a scholarly sociology journal.
- Design a web site using HTML and Java Script.
- Describe and present the contributions of women to American history.
- Recognize the works of major Re-naissance artists.
- Facilitating a group to achieve agreed – Up on goals.
- Determine and apply the appropriate statistical procedures to analyze the results of simple experiments.
- Develop an individual learning plan for a child with a learning disability.
- Produce a strategic plan for a small manufacturing business.
- 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 that are TOO general and VERY HARD to measure...

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

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

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

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

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

An Introspection - Examine Your Own Course Outcomes

- If you have written statements of broad course goals, 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

Experiential learning	Experiential learning	Experiential learning	Experiential learning	Experiential learning
Technical	PO1	Apply	L3	Bloom'sL1 to L4 for theory courses. Bloom'sL1 to L5 for laboratory courses. Bloom's L1 to L6 for Project work, experiential learning
	PO2	Identify	L2	
		Formulate	L6	
		Review	L2	
	PO3	Design	L6	
		Develop	L3, L6	
	PO4	Analyze	L4	
		Interpret	L2, L3	
		Design	L6	
	PO5	Create	L6	
		Select	L1, L2, L6	
		Apply	L3	
Non-Technical	PO6	**Thumb Rule:** If Bloom's L1 Action Verbs of a CO: Correlates with any of PO6 to PO12, then assign 1. If Bloom's L2 to L3 Action Verbs of a CO: Correlates with 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		
	PO7			
	PO8			
	PO9			
	PO10			
	PO11			
	PO12			

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

Observations:

1. The first five Program Outcomes (POs) are purely technical in nature, while the other POs are non-technical.
2. For theory courses, while writing the Course Outcomes (COs), you need to restrict yourself between Bloom's Level 1 to Level 4. However, if it is a programming

course, restrict yourself between Bloom's Level 1 to Level 3, but for other courses, you can go up to Bloom's Level 4.

3. For laboratory courses, while composing COs, you need to restrict yourself between Bloom's Level 1 to Level 5.

4. Only for mini-projects and main projects, you may extend up to Bloom's Level 6 while composing COs.

5. For a given course, the course in-charge must involve all other professors who teach that course and ask them to come up with the CO-PO mapping. The course in-charge must take the average value of all these CO-PO mappings and finalize the values. Alternatively, the course in-charge can proceed with what the majority of faculty members prefer. Ensure that none of the professors handling the course discuss with each other while marking the CO-PO values.

6. If you want to match your COs with non-technical POs, correlate the action verbs used in the COs with the thumb rule given in the table and map the values. (This applies only for mapping COs to non-technical POs).

8.6. 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 POs. If the CO matches strongly with a particular PO criterion, assign 3; if it matches moderately, assign 2; if the match is low, assign 1; otherwise, mark with a "-" symbol.

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

8.7. 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**
$0 \leq C \leq 5\%$	No correlation (0)
$5\% < C \leq 40\%$	Low/Slight correlation (1)
$40\% < C < 60\%$	Moderate correlation (2)
$60\% \leq C < 100\%$	Substantial/High correlation (3)

9. Key Competencies for assessing Program Outcomes:

PO No.	NBA Statement/ Vital Features	Key Components	No. of Key Components
PO1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems **(Engineering Knowledge).**	1. **Scientific Principles:** Application of scientific principles and methodologies. 2. **Mathematical Principles:** Utilization of mathematical concepts in problem-solving. 3. **Interdisciplinary Integration:** Integration of knowledge from various engineering disciplines. 4. **Engineering Specialization:** Application of specialized engineering knowledge in complex engineering problems.	4

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	**10**

		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:** Beaware of legal frame works governing engineering activities, including personnel, health, safety, and environmental risks.	
PO4.	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).**	1. **Research-Based Knowledge:** Gain a deep understanding of materials, equipment, processes, and products through research to address engineering problems effectively. 2. **Research Methods:** Develop essential laboratory and workshop skills to carry out experimental investigations and gather reliable data. 3. **Design of Experiments:** Address complex problems in various engineering contexts, including operations, management, and technology development. 4. **Analysis:** Leverage technical literature and reliable information sources. 5. **Interpretation of Data:** Follow appropriate codes of practice and industry standards when analyzing and interpreting experimental data. 6. **Synthesis:** Ensure high-quality results by integrating various data sources and considering quality control during engineering investigations. 7. **Valid Conclusions:** Draw valid conclusions by addressing technical uncertainties through sound reasoning	**10**

		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:** Up hold high standards of professional and ethical conduct in engineering.	**5**

PO7.	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development **(Environment and Sustainability).**	1. **Socio-Economic Impact:** Understand the socio-economic effects of engineering solutions on society. 2. **Political Impact:** Recognize the political implications and responsibilities of engineering solutions. 3. **Environmental Impact:** Assess the environmental consequences of engineering practices and solutions. 4. **Sustainability:** Demonstrate the importance of sustainable development in engineering solutions.	**4**
PO8.	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice **(Ethics).**	1. **Ethical Judgement:** Make informed decisions based on ethical principles, using professional codes of ethics to guide actions and evaluate the ethical aspects of practice. 2. **Integrity:** Demonstrate a strong sense of trust and integrity, standing firm in one's values while acting responsibly and ethically. 3. **Fairness and Equity:** Ensure fair treatment and equity in all professional activities, valuing diversity and respecting others' perspectives. 4. **Professional Responsibility:** Adhere to the norms of engineering practice by committing to high ethical standards and demonstrating ethical behavior in all professional engagements.	**4**
PO9	Function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings **(Individual and Teamwork).**	1. **Independence:** Work effectively as an individual, taking ownership of tasks and driving progress independently. 2. **Maturity:** Demonstrate maturity by focusing on goal achievement, requiring minimal external motivation. 3. **Self-Direction:** Approach vaguely defined problems with systematic problem-solving skills to find solutions. 4. **Team Collaboration:** Engage in team work during various activities, including hands-on labs and multidisciplinary projects.	**10**

		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 inter personal skills. 10. **Effective Communication:** Develop strong relationships through positive interactions, show casing an ability to get along with other sand 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,	**5**

		clearly communicating complex ideas during oral discussions and presentations.	
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 pre defined objectives and quality standards. 4. **Work Breakdown Structure:** Develop and organize a structured break down of tasks and activities to achieve project goals. 5. **Scheduling:** Create and manage schedules to ensure tasks are completed on time and milestones are met. 6. **Budget Management:** Develop and manage project budgets, ensuring that resources are used efficiently and within financial constraints. 7. **Quality Assurance**: Apply quality control measures to ensure that project deliverables meet the required standards. 8. **Human Resources Planning:** Plan and allocate human resources effectively, ensuring the right skills and team dynamics. 9. **Stakeholder Management:** Identify and manage stakeholders, ensuring their needs and expectations are addressed throughout the project. 10. **Risk Management:** Develop a risk register and apply strategies to identify, assess, and mitigate project risks.	**10**
PO12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological	1. **Professional Certificate:** Pursue professional, Academic, Global certifications. 2. **Advanced Education:** Begin and work towards advanced programs to further deepen knowledge.	

	change **(Life-Long Learning).**	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. 5. Adopt the engineering professional code and conduct 6. Sustainable and Compliant Design	6

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-R22) and POs / PSOs attained through course modules for I, II, III, IV, V, VI, VII and VIII semesters.

Code	Subject	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	I B.Tech I Semester															
EE111	Matrix algebra and calculus (2210001)	✓	✓	✓	✓								✓	✓		✓
EE112	Engineering Chemistry (2210009)	✓	✓				✓	✓						✓	✓	✓
EE113	Programming for Problem Solving (2210501)	✓	✓	✓	✓	✓								✓	✓	
EE114	Electrical circuits analysis-I (2210221)	✓	✓	✓	✓									✓	✓	
EE115	Engineering drawing Practice (2210371)	✓	✓			✓			✓	✓			✓			
EE116	Elements of electrical and electronics and engineering (2210276)	✓	✓	✓	✓	✓							✓	✓	✓	✓
EE117	Engineering Chemistry lab (2210009)	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
EE118	Programming for Problem Solving lab (2210571)	✓	✓	✓	✓	✓								✓	✓	
	I B.Tech II Semester															
EE121	Differential equations and vector calculus (2220002)	✓	✓	✓	✓								✓	✓	✓	✓
EE122	Applied Physics (2220008)	✓	✓		✓		✓	✓	✓					✓	✓	✓
EE123	Engineering Workshop (2220372)	✓	✓	✓		✓	✓	✓	✓	✓						
EE124	English for skill enhancement						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

	(2210010)															
EE125	Electrical circuits analysis-II (2220222)	✓	✓	✓	✓									✓	✓	
EE126	Data structures lab (2220572)	✓	✓	✓	✓	✓							✓			✓
EE127	Applied Physics Lab (2220071)	✓	✓	✓	✓	✓	✓							✓	✓	✓
EE128	English language and communication skills Lab (2220073)		✓	✓	✓		✓		✓	✓	✓			✓	✓	✓
EE129	Electrical circuits analysis lab (2220277)	✓	✓	✓	✓									✓	✓	✓
EE1210	Environmental Science (2220021)			✓			✓	✓	✓		✓	✓				
	II B.Tech I Semester															
EE211	Power System-I (2230223)	✓	✓			✓								✓		✓
EE212	Solid Mechanics & Hydraulic Machines (2230301)	✓	✓	✓	✓	✓							✓	✓	✓	✓
EE213	Analog Electronics (2230402)	✓	✓	✓	✓										✓	✓
EE214	Electrical Machines-I (2230224)	✓	✓	✓										✓	✓	✓
EE215	Electro Magnetic Fields (2230225)	✓	✓	✓	✓									✓		✓
EE216	Electrical Machines-I Lab (2230278)	✓	✓							✓	✓			✓	✓	✓
EE217	Analog Electronics Lab (2230471)	✓	✓			✓									✓	✓

EE218	Electrical Simulation Tools Lab (2230279)	✓	✓	✓	✓	✓							✓	✓	✓	
EE219	Applied Python Programming Lab (2230586)	✓	✓	✓	✓	✓							✓			✓
EE2110	Gender Sensitization (2230022)						✓	✓	✓			✓				
II B.Tech II Semester																
EE221	NUMERICAL METHODS AND COMPLEX VARIABLES (2240003)	✓	✓	✓	✓								✓			
EE222	MEASUREMENTS & INSTRUMENTATION (2240226)	✓	✓	✓	✓	✓							✓	✓	✓	✓
EE223	Electrical Machines-II (2240227)	✓	✓	✓	✓									✓	✓	✓
EE224	Digital Electronics & IC Applications Lab (2240403)	✓	✓	✓							✓				✓	✓
EE225	POWER SYSTEMS-II (2240228)	✓	✓	✓	✓									✓		✓
EE226	Electrical Machines Lab-II (2240280)	✓	✓			✓				✓				✓	✓	✓
EE227	Digital Electronics & IC Applications Lab (2240472)		✓	✓		✓					✓				✓	✓
EE228	MEASUREMENTS & INSTRUMENTATION LAB (2240281)	✓	✓	✓	✓	✓				✓					✓	✓
EE229	CONSTITUTION OF INDIA (2240023)	✓	✓		✓		✓		✓	✓	✓					✓
III B.Tech I Semester																
EE311	POWER ELECTRONICS (2250229)	✓	✓	✓	✓								✓	✓	✓	✓
EE312	CONTROL SYSTEMS (2250230)	✓	✓	✓	✓						✓		✓	✓	✓	✓

EE313	MICROPROCESSORS AND MICROCONTROLLERS (2250404)	✓	✓	✓			✓								✓	✓
EE314	(OE-I) OOPS Through Java Programming (2250525)	✓	✓	✓	✓	✓				✓		✓				✓
EE315	BUSINESS ECONOMICS AND FINANCIAL ANALYSIS (2250016)		✓		✓		✓					✓	✓			
EE316	POWER ELECTRONICS LAB (2250282)	✓	✓	✓	✓	✓				✓					✓	✓
EE317	ADVANCED ENGLISH COMMUNICATION SKILLS LAB (2250074)								✓		✓	✓	✓			
EE318	MICROPROCESSORS AND MICROCONTROLLERS LAB (2250473)	✓	✓	✓	✓					✓				✓	✓	
EE319	Java Programming Lab (2250570)	✓	✓	✓	✓	✓										✓
III B.Tech II Semester																
EE321	OE-II (Remote Sensing & GIS) (2260102)	✓	✓		✓	✓	✓					✓				
EE322	PE-I (HIGH VOLTAGE ENGINEERING) (2260235)	✓	✓	✓	✓									✓		
EE323	BASICS OF DIGITAL SIGNAL PROCESSING (2260405)	✓	✓	✓	✓								✓	✓	✓	
EE324	POWER SYSTEM PROTECTION (2260231)	✓	✓	✓	✓									✓		✓
EE325	POWER SYSTEMS OPERATION AND CONTROL (2260032)	✓	✓	✓	✓									✓	✓	✓
EE326	POWER SYSTEM LABORATORY (2260284)					✓	✓			✓			✓	✓		✓
EE327	BASICS OF DIGITAL SIGNAL PROCESSING LABORATORY	✓	✓	✓	✓	✓							✓	✓	✓	

	(2260474)															
EE328	CONTROL SYSTEMS LABORATORY (2260283)	✓	✓	✓	✓	✓									✓	✓
EE329	INDUSTRY ORIENTED MINI PROJECT (2260293)	✓	✓	✓	✓	✓		✓		✓	✓	✓		✓	✓	✓
EE3210	INTELLECTUAL PROPERTY RIGHTS (2250024)	✓	✓		✓		✓		✓	✓	✓				✓	
IV B.Tech I Semester																
EE411	Power Electronic Applications to Renewable Energy Systems (2270233)	✓	✓	✓	✓									✓	✓	
EE412	OE-III (ELEMENTS OF ELECTRIC AND HYBRID VEHICLES) (2270303)	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	
EE413	PE-II (Power Semiconductor Drives) (2270238)	✓	✓	✓	✓									✓	✓	✓
EE414	PE-III (Industrial Electrical Systems) (2270240)	✓	✓	✓	✓											
EE415	Fundamentals of Management for Engineers (2270017)	✓	✓	✓	✓	✓									✓	
EE416	Simulation of Renewable Energy Systems Laboratory (2270285)	✓	✓	✓	✓	✓				✓					✓	✓
EE417	Project Stage - I (2270294)					✓	✓			✓			✓	✓		✓
IV B.Tech II Semester																
EE421	PE-IV (Utilization of Electrical Energy) (2280243)	✓	✓	✓	✓											
EE422	PE-V (Power Quality & FACTS) (2280245)	✓	✓	✓	✓	✓								✓	✓	
EE423	PE-VI (Electrical Distribution Systems) (2280249)	✓	✓	✓	✓											

EE424	Technical Seminar (2280295)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
EE425	Project Stage - II (2280296)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

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 frameworks to interpret the results.

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

The above assessment indicators are detailed below.

12.1. Continuous Internal Assessment (CIA)

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

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

12.2. Semester End Examination (SEE)

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

12.3. Laboratory and Project Works

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

12.4. Course Exit Surveys

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

12.5. Programme / Student Exit Survey

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

12.6. Alumni Survey

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

12.7. Employer Survey

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

12.8. Course Expert Committee

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

12.9. Department Advisory Board

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

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

12.10. Faculty Meetings

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

12.11. Professional Societies

The importance of professional societies like Society of Institute of Electrical and Electronics Engineers (IEEE), Institute of Electronics and Telecommunication Engineers (IETE) etc. are explained to the students and they are encouraged to become members of the above to carry out their continuous 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 & Assignment)	80%
	Semester End Examination	
Indirect Assessment	Course End Survey	20%

13.1. Direct Assessment:

Direct assessment methods are based on the student's knowledge and performance in various assessments and examinations. These assessment methods provide evidence that a student has command over a specific course, content, or skill. Additionally, they demonstrate that the student's work exhibits specific qualities such as creativity, analysis, or synthesis.

The various direct assessment tools used to assess the impact of the delivery of course content is listed in the table.

- Continuous internal examination, semester end examinations, Assignment, 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 POs.
- Performance in Assignment is indicative of the student's communication skills.

S.No	Courses	Components	Frequency	Max. Marks	Evidence
1	Core/ Elective	Continuous Internal Examination	Twice in a semester	30	Answer script
		Assignment	One Assignment per unit.	5	Assignment
		Viva-Voce / PPT/ Poster Presentation/ Case Study etc.	Twice in a semester	5	PPT, Poster Presentation etc
		Semester End Examination	Once in a semester	60	Answer script
		Day-to-Day Evaluation	Once in a week	10	Work sheets

2	Laboratory	Viva-Voce	Once in a week	10	Work sheets
		Certificate/ Open ended experiment	Once in a semester	10	Certificate/ Work sheet
		Internal laboratory assessment	Twice in a semester	10	Answer script
		Semester End Examination	Once in a semester	60	Answer script
3	Project Work	Presentation	Twice in a semester	40	Presentation
		Semester End Examination	Once in a semester	60	Thesis report
4	Technical Seminar	Presentation	Once in a semester	100	Seminar report

13.2. Indirect Assessment:

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

TABLE15: Tools used in Indirect assessment

Tools	Process	Frequency
Course end survey	• Taken for every course at the end of the semester • Gives an overall view that helps to assess the extent of coverage / compliance of COs • Helps the faculty to improve upon the various teaching methodologies	Once in a semester

Direct Tools: (Measurable in terms of marks and w.r.t. CO) Assessment done by faculty at department level.

Indirect Tools: (Non measurable (surveys) in terms of marks and w.r.t.CO) Assessment done at institute level.

14. PO/PSO-Assessment tools and Processes

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

1. Direct method
2. Indirect method

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

TABLE16: Attainment of PO / PSOs

<table>
<tr><td rowspan="5">POs / PSOs Attainment</td><th>Assessment</th><th>Tools</th><th>Weight</th></tr>
<tr><td>Direct Assessment</td><td>CO attainment of courses</td><td>80%</td></tr>
<tr><td rowspan="3">Indirect Assessment</td><td>Student exit survey</td><td rowspan="3">20%</td></tr>
<tr><td>Alumni survey</td></tr>
<tr><td>Employer survey</td></tr>
</table>

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.

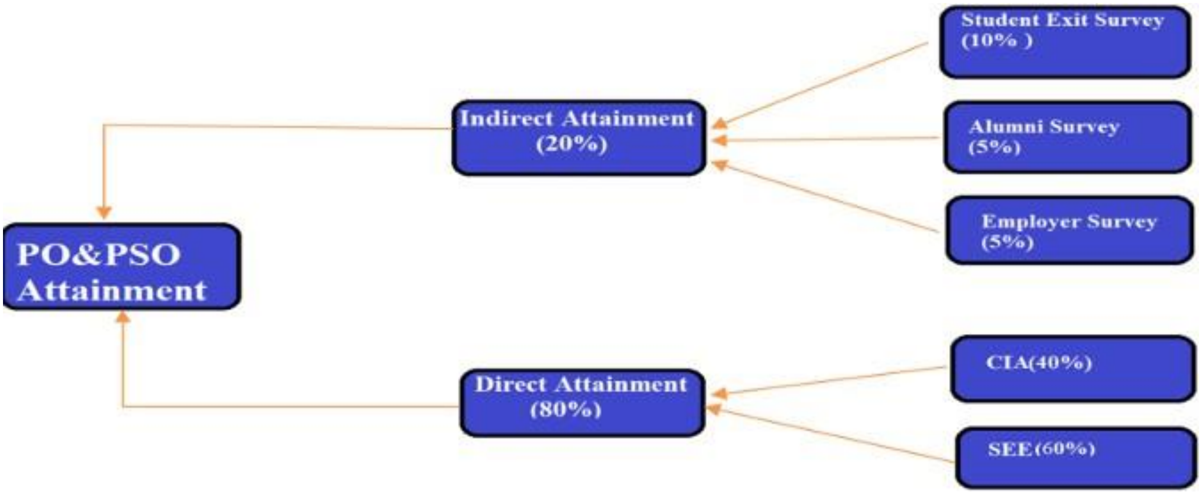


FIGURE4: Evaluation process of POs/PSOs attainment

15. Course Description:

The "Course Description" provides general information regarding the topics and content addressed in the course. A sample course description is given in Annexure – A for reference. The "Course Description" contains the following contents:

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

15.1 Course Description:

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

POWER SEMI CONDUCTOR DRIVES

1	Department	ELECTRICAL & ELECTRONICS ENGINEERING							
2	Course Name	POWER SEMI CONDUCTOR DRIVES							
3	Course Code	2270238							
4	Year/Semester	IV/I							
5	Regulation	MLRS-R22							
7	Structure of the course	Theory				Practical			
		Lecture	Tutorials	Practical	Credit	L	T	P	C
		3	0	0	3	0	0	0	0
8	Type of course	PCC	HS	ES	PCC	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	A.KALPANA							
12	Date Approved by BOS								
13	Course Webpage	www.mlritm.ac.in/							
14	Prerequisites/ Co-requisites	Level	Course Code	Semester	Prerequisites				
		UG	2060212, 2230224, 2240227	VI,III,IV	POWER ELECTRONICS, Electrical Machines – I, Electrical Machines – II				

15. Course Overview:

A course on Power Semiconductor Drives generally focuses on the principles and applications of power semiconductors in controlling electric drives. These drives are crucial for various industrial applications, from manufacturing to transportation. This course would be suitable for students or professionals aiming to deepen their knowledge in power electronics and drive systems, with a mix of theoretical knowledge and practical skills.

16. Course Objectives:

The students will try to:

- Introduce the drive system and operating modes of drive and its characteristics
- Understand Speed – Torque characteristics of different motor drives by various power converter topologies
- Appreciate the motoring and braking operations of drive
- Differentiate DC and AC drives.
- Cover the control mechanisms for synchronous motors, including both separate and self-control methods, operation with VSI, CSI, and cyclo-converters, and analyze their speed-torque characteristics and applications

17. Course Outcomes:

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

CO1	**Identify** the drawbacks of speed control of motor by conventional methods.	Apply
CO2	**Differentiat**e Phase controlled and chopper-controlled DC drives speed-torque characteristics merits and demerits	Analyze
CO3	Understand Ac motor drive speed–torque characteristics using different control strategies its merits and demerits	Understand
CO4	**Analyze** and evaluate the performance of various rotor-side control techniques of induction motors	Analyze
CO5	**Analyze** control strategies for synchronous motors, including separate and self-control methods, operation with various converters, and closed-loop control systems, understanding their speed-torque characteristics and practical applications.	Analyze

18. Course Learning Outcome (CLOs):

Sno	Topic Name	CLO No	Course Learning Outcome	Course Outcome	Blooms Level
1	Introduction to Thyristor controlled Drives	CLO1	Understand thyristor controlled drives	CO1	Understand
2	Continuous current operation, output voltage and current waveforms Speed and Torque expressions.	CLO2	Understand speed torque characteristics.	CO1	
3	Three phase semi and fully controlled converters connected to D.C separately excited and D.C series motors	CLO3	Undertand three phase controlled converters fed dc motor drive.	CO1	

4	Four Quadrant Operation of DC Drives	CLO4	Learn various control strategies used for four-quadrant DC drives.	CO2	Analyse
5	Four quadrant operation of D.C motors by single phase and three phase dual converters – Closed loop operation of DC motor	CLO5	Apply the principles of four-quadrant operation to DC motors.	CO2	
6	Control of DC Motors by Choppers	CLO6	Analyze and solve problems involving single-phase and three-phase dual converters	CO2	
7	Variable voltage characteristics, Control of Induction Motor by Ac Voltage Controllers	CLO7	Solve problems related to motor control.	CO3	
8	Variable frequency characteristics-Variable frequency control of induction motor.	CLO8	Apply AC voltage controller techniques to control induction motors	CO3	
9	Closed loop operation of induction motor drives.	CLO9	Implement and analyze variable frequency control methods for induction.	CO3	
10	Rotor Side Control of Induction Motor	CLO10	Identify common issues and faults in rotor side control systems.	CO4	
11	Static rotor resistance control – Slip power recovery	CLO11	Apply static rotor resistance control techniques to induction motors.	CO4	Apply
12	Static Scherbius drive – Static Kramer Drive – their performance and speed torque characteristics	CLO12	Design and assess drive systems utilizing Static Scherbius and Static Kramer drives.	CO4	
13	Control of Synchronous Motors	CLO13	Analyze the torque-speed characteristics of synchronous motors	CO5	
14	Load commutated CSI fed Synchronous Motor	CLO14	Interpret and solve problems related to the operation of synchronous motors.	Co5	

15	Variable frequency control - Cyclo converter, PWM based VSI & CSI.	CLO15	Design and evaluate closed-loop control systems for synchronous motor drives	CO5	

19. Employability Skills:

Example: Power Electronics Engineer, Electrical Design Engineer, Control Systems Engineer, Automation Specialist, Application Engineer, Field Service Engineer, R&D Engineer
These roles are critical in industries such as automotive, aerospace, manufacturing, energy, and consumer electronics, where power semiconductor drives play a crucial role in system performance and efficiency.

20. Content Delivery / Instructional Methodologies:

✓	PowerPointPresentation	✓	Chalk&Talk	✓	Assignments	✓	MOOC
✓	ALP	✓	Seminars	x	MiniProject	x	Videos

21. Evaluation Methodology:

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

Mid Term Examination for 30 marks:

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

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

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

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

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

Activities	CIA-I	CIA-II	Average of CIA	SEE	Total Marks
Continues Internal Evaluation (CIE)	30 Marks	30 Marks			Average of CIA + SEE
Assignment	5 Marks	5 Marks			
Viva-Voce/PPT/Poster Presentation/Case Study	5 Marks	5 Marks			
Total Marks	**40 Marks**	**40 Marks**	**40 Marks**	**60 Marks**	**100 Marks**

22. Course content - Number of modules: Five:

MODULE 1	**SINGLE PHASE** Introduction to Thyristor controlled Drives, Single Phase semi and fully controlled converters connected to D.C separately excited and D.C series motors – continuous current operation – output voltage and current waveforms – Speed and Torque expressions – Speed – Torque Characteristics- Problems on Converter fed D.C motors. **THREE PHASE** Three phase semi and fully controlled converters connected to D.C separately excited and D.C series motors – output voltage and current waveforms – Speed and Torque expressions – Speed – Torque characteristics – Problems.	No. of Lectures: 11
MODULE 2	**FOUR QUADRANT OPERATION** Introduction to Four quadrant operation – Motoring operations, Electric Braking – Plugging, Dynamic, and Regenerative Braking operations. Four quadrant operation of D.C motors by single phase and three phase dual converters – Closed loop operation of DC motor (Block Diagram Only) **CHOPPER CONTROL OF DC MOTOR** Control of DC Motors by Choppers: Single quadrant, two quadrant and four quadrant chopper fed dc separately excited and series motors – Continuous current operation – Output voltage and current wave forms – Speed and torque expressions – speed-torque characteristics – Problems on Chopper fed D.C Motors – Closed Loop operation (Block Diagram Only).	No. of Lectures:11
MODULE 3	**CONTROL OF AC MOTOR** Variable voltage characteristics-Control of Induction Motor by Ac Voltage Controllers – Waveforms – speed torque characteristics. Variable frequency characteristics- **VARIABLE FREQUENCY CONTROL**	No. of Lectures: 8

	Variable frequency control of induction motor by Voltage source and current source inverter and cyclo converters- PWM control – Comparison of VSI and CSI operations – Speed torque characteristics – numerical problems on induction motor drives – Closed loop operation of induction motor drives (Block Diagram Only).	
MODULE 4	**ROTOR SIDE CONTROL OF INDUCTION MOTOR** Static rotor resistance control – Slip power recovery – Static Scherbius drive – Static Kramer Drive – their performance and speed torque characteristics – advantages, applications, problems.	No. of Lectures: 7
MODULE 5	**CONTROL OF SYNCHRONOUS MOTORS** Separate control and self-control of synchronous motors – Operation of self-controlled synchronous motors by VSI, CSI and cyclo converters. Load commutated CSI fed Synchronous Motor – Operation – Waveforms – speed torque characteristics – Applications – Advantages and Numerical Problems – **CLOSED LOOP CONTROL** Closed Loop control operation of synchronous motor drives (Block Diagram Only), variable frequency control - Cyclo converter, PWM based VSI & CSI.	No. of Lectures: 11

TEXTBOOKS:

1. "G K Dubey", Fundamentals of Electric Drives, CRC Press, 2002.
2. "Vedam Subramanyam", Thyristor Control of Electric drives, Tata McGraw Hill Publications, 1987.

REFERENCE BOOKS:

1. "S K Pillai", A First course on Electrical Drives, New Age International (P) Ltd. 2nd Edition. 1989
2. "P. C. Sen", Thyristor DC Drives, Wiley-Blackwell, 1981
3. "B. K. Bose", Modern Power Electronics, and AC Drives, Pearson 2015.
4. "R. Krishnan", Electric motor drives - modeling, Analysis and control, Prentice Hall PTR, 2001.

ELECTRONIC RESOURCES:

1. https://www.phindia.com/Books/BookDetail/9788120336582/power-semiconductor-drives-sivanagaraju-prasad-reddy
2. https://archive.nptel.ac.in/courses/108/104/108104140/
3. https://nptel.ac.in/courses/108108077
4. https://archive.nptel.ac.in/courses/108/102/108102145/
5. https://archive.nptel.ac.in/courses/108/102/108102145/

6. http://www.digimat.in/nptel/courses/video/108108077/L01.html

23. COURSE PLAN:

S.No.	Topics to be covered	Cos	Reference
1	Discussion on Outcome Based Education, CO, POs and PSOs	-	-
2	Introduction to Thyristor controlled Drives	CO1	T1,5, 5.1
3	Single Phase semi and fully controlled converters connected to D.C separately excited motor	CO1	T1, 5.10, 5.10
4	Single Phase semi and fully controlled converters connected to D.C series motors	CO1	T1, 5.15
5	continuous current operation – output voltage and current waveforms – Speed and Torque expressions – Speed – Torque Characteristics	CO1	T1.5.15
6	Problems on Converter fed D.C motors	CO1	T1, EXAMPLE 5.13
7	Three phase semi and fully controlled converters connected to D.C separately excited motors	CO1	T1, 5.12
8	Three phase semi and fully controlled converters connected to D.C series motor	CO1	T1, 5.12.1
9	output voltage and current waveforms – Speed and Torque expressions – Speed – Torque characteristics	CO1	T1, 5.12
10	Problems.	CO1	T1, EX-5.17
11	Introduction to Four quadrant operation	CO2	T1, 5.14
12	Motoring operations, Electric Braking – Plugging, Dynamic, and Regenerative Braking operations	CO2	T1, 5.14
13	Four quadrant operation of D.C motors by single phase dual converters	CO2	T1,5.14.2
14	Four quadrant operation of D.C motors by three phase dual converters	CO2	T1, 5.14.2
15	Closed loop operation of DC motor (Block Diagram Only)	CO2	T1,5.22
16	Control of DC Motors by Choppers: Single quadrant, two quadrant and four quadrant chopper fed dc separately excited and series motors	CO2	T1, 5.18
17	Continuous current operation – Output voltage and current wave forms – Speed and torque expressions – speed-torque characteristics	CO2	T1,5.19
18	Problems on Chopper fed D.C Motors – Closed Loop operation (Block Diagram Only).	CO2	T1,5.22

19	Variable voltage characteristics-Control of Induction Motor by Ac Voltage Controllers – Waveforms – speed torque characteristics.	CO3	T1, 6.11
20	Variable frequency characteristics- Variable frequency control of induction motor by Voltage source inverter	CO3	T1, 6.12.1, 6.13
21	Variable frequency control of induction motor by current source inverter and -	CO3	T1, 6.17,6.17.1, 6.17.2
22	– cyclo converters	CO3	T1, 6.14
23	PWM control – Comparison of VSI and CSI operations	CO3	T1, 6.17.3
24	Speed torque characteristics	CO3	T1, 6.17.4
25	numerical problems on induction motor drives –	CO3	T1,6.27
26	Closed loop operation of induction motor drives (Block Diagram Only).	CO3	T1,6.15
27	Static rotor resistance control –	CO4	T1,6.20.2
28	Slip power recovery –	CO4	T1,6.21
29	Static Scherbius drive –	CO4	T1,6.21.1
30	Static Kramer Drive – their performance and	CO4	T1,6.21.2
31	Speed Torque characteristics – advantages, applications.	CO4	T1,6.21.1, T1,6.21.2
32	Separate control of synchronous motors –	CO5	T1,7.1
34	self-control of synchronous motors –	CO5	T1,7.7
35	Operation of self-controlled synchronous motors by VSI, CSI and	CO5	T1,7.7
36	Cyclo converters.	CO5	T1,7.7
37	Load commutated CSI fed Synchronous Motor – Operation – Waveforms	CO5	T1,7.5
38	speed torque characteristics – Applications –	CO5	T1,7.5
39	Advantages and Numerical Problems –	CO5	T1 7.5
40	Closed loop control	CO5	
41	Closed Loop control operation of synchronous motor drives (Block Diagram Only)	CO5	T1, 7.4
42	Variable frequency control - Cyclo converter,.	CO5	T1,7.4
43	PWM based VSI & CSI	CO5	T1,7.4.1

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

PO No.	NBA Statement / Vital Features	No. of Vital Features
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge)**. Knowledge, understanding and application of 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**
PO 2.	Identify, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences **(Problem Analysis).** 1. 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**
PO 3.	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. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues; 2. Understand customer and user needs and the importance of considerations such as aesthetics; 3. Identify and manage cost drivers; 4. Use creativity to establish innovative solutions; 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal; 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes; 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context; 9. Understanding of the requirement for engineering activities to promote sustainable development; 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues;	**10**
PO 4.	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the	

	information to provide valid conclusions **(Conduct Investigations of Complex Problems).** 1. 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 nature of intellectual property and contractual issues; 5. Understanding of appropriate codes of practice and industry standards; 6. Awareness of quality issues; 7. Ability to work with technical uncertainty. 8. Understanding of engineering principles and the ability to apply them to analyze key engineering processes; 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques; 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems; 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5.	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computersoftware/simulationpackages/diagnosticequipment/technicallibraryresources/ literature search tools.	**1**
PO 6.	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice **(The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes; 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context; 3. Understanding of the requirement for engineering activities to promote sustainable development; 4. Awarenessoftheframeworkofrelevantlegalrequirementsgoverningengineeringactivities, including personnel, health, safety, and risk (including environmental risk) issues; 5. Understandingoftheneedforahighlevelofprofessionalandethicalconductinengineering.	**5**
PO 7.	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development **(Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic, 2. Political and 3. Environmental	**3**

PO 8.	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice **(Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9.	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **(Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the class room periods, in the hands –on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen - week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference. 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other' performance, which is the reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extend into the Junior years, and for some of those students, the friendships continue into the workplace after graduation. 10. Ability to work with all levels of people in an organization. 11. Ability to get along with others. 12. Demonstrated ability to work well with a team.	**12**
PO 10	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).** "Students should demonstrate the ability to communicate effectively in writing / Orally." 1. Clarity(Writing) 2. Grammar/Punctuation(Writing) 3. References(Writing) 4. Speaking Style(Oral) 5. Subject Matter(Oral)	**5**
PO11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments **(Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Break down Structure	**12**

	5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	
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. Project management professional certification /MBA 2. Begin work on advanced degree 3. Keeping current in EEE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2or 3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

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.

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	1	CIE/PPT/ Objective / quiz /SEE/

	meet the specifications with consideration for the public health and safety, and the cultural, societal, and environmental considerations.		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 the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	3	CIE/PPT/ 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 objectives within that context. 3. Understanding of the requirement for engineering activities to promote sustainable development;	3
	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 analyse 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
	PSO1	1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems.	3
	PSO2	1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various	3

		components and control topologies. Synthesis, systematic procedure to examine electrical components/machines using software tools 3. Control and manage the power generation and utilization.	
	PSO3	1. Explicit software and programming tools for electrical systems. 2. Model, program for operation and control of electrical systems. 3. Constitute the systems employed for motion control. 4. Interface automation tools. 5. Research, analysis, problem solving and presentation using software aids.	5
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. Interpretation of results	8
	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
	PSO 1	1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems.	3
	PSO2	1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various	5

		components and control topologies. Synthesis, systematic procedure to examine electrical components/machines using software tools 3. Inspect, survey and analyze energy flow. 4. Control and manage the power generation and utilization. 5. Familiarize the safety, legal and health norms in electrical system.	
	PSO 3	1. Explicit software and programming tools for electrical systems. 2. Model, program for operation and control of electrical systems. 3. Constitute the systems employed for motion control. 4. Interface automation tools. 5. Research, analysis, problem solving and presentation using software aids.	5
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	1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems.	3
	PSO2	1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. Synthesis, systematic procedure to examine electrical components/machines using software tools 3. Inspect, survey and analyze energy flow. 4. Control and manage the power generation and utilization.	4
	PSO3	1. Model, program for operation and control of electrical systems. 2. Constitute the systems employed for motion control. 3. Interface automation tools. 4. Research, analysis, problem solving and	4

		presentation using software aids.	
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 6. Solution development or experimentation /Implementation 7. Interpretation of results 8. Documentation	8
	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	4. Operate, control and protect electrical power system. 5. Validate the interconnected power system. 6. Ensure reliable, efficient and compliant operation of electrical systems.	3
	PSO2	1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. Synthesis, systematic procedure to examine electrical components/machines using software tools 3. Inspect, survey and analyze energy flow. 4. Control and manage the power generation and utilization. 5. Familiarize the safety, legal and health norms in electrical system.	5
	PSO 3	6. Explicit software and programming tools for electrical systems.	5

		7. Model, program for operation and control of electrical systems. 8. Constitute the systems employed for motion control. 9. Interface automation tools. 10. Research, analysis, problem solving and presentation using software aids.	
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 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.	7
	PSO1	1. Operate, control and protect electrical power system. 2. Validate the interconnected power system.	2
	PSO2	1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. Synthesis, systematic procedure to examine electrical components/machines	5

		using software tools 3. Inspect, survey and analyze energy flow. 4. Control and manage the power generation and utilization. 5. Familiarize the safety, legal and health norms in electrical system.	
	PSO 3	1. Explicit software and programming tools for electrical systems. 2. Model, program for operation and control of electrical systems. 3. Constitute the systems employed for motion control. 4. Interface automation tools. 5. Research, analysis, problem solving and presentation using software aids.	5

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
No. of POs	3	10	10	11	1	5	3	3	12	5	12	8	6	11	7
CO1	3	8	3	8	-	-	-	-	-	-	-	-	3	3	5
CO2	3	8	-	-	-	-	-	-	-	-	-	-	3	5	5
CO3	3	7	-	-	-	-	-	-	-	-	-	-	3	4	4
CO4	3	8	-	6	-	-	-	-	-	-	-	-	3	5	5
CO5	3	10	-	7	-	-	-	-	-	-	-	-	2	5	5

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	-	-	-	-	-	-	-	-	50	27.2	71.4
CO2	100	80	-	-	-	-	-	-	-	-	-	-	50	45.4	71.4
CO3	100	70	-	-	-	-	-	-	-	-	-	-	50	36.3	57.1
CO4	100	80	-	54.5	-	-	-	-	-	-	-	-	50	45.4	71.4

CO5	100	100	-	63.6	-	-	-	-	-	-	-	-	33.3	45.4	71.4

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	1	3
CO2	3	3	-	-	-	-	-	-	-	-	-	-	2	2	3
CO3	3	3	-	-	-	-	-	-	-	-	-	-	2	1	2
CO4	3	3	-	2	-	-	-	-	-	-	-	-	2	2	3
CO5	3	3	-	3	-	-	-	-	-	-	-	-	2	2	3
Total	15	15	1	8	-	-	-	-	-	-	-	-	10	8	14
Average	3	3	1	2.66	-	-	-	-	-	-	-	-	2	1.6	2.8

32. ASSESSMENT METHODOLOGY DIRECT:

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

33. ASSESSMENT METHODOLOGY INDIRECT:

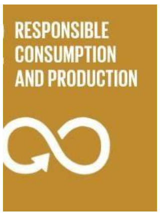
✓	Course End Survey (CES)

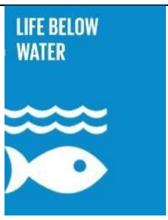
34. RELEVANCE TO SUSTAINABILITY GOALS:

The study of motor drives and their efficient control directly contributes to global sustainability efforts by improving energy efficiency, reducing waste and emissions, and fostering technological innovation. Industries that implement advanced motor control techniques benefit not only in terms of cost savings but also in their environmental and social contributions.

x	1		
x	2		

x	3	GOOD HEALTH AND WELL-BEING	:
✓	4	QUALITY EDUCATION	**Quality Education:** As industries adopt new and more energy-efficient technologies, there is a growing need for skilled professionals who understand advanced motor control techniques, such as those covered in this syllabus. Knowledge of sustainable motor control contributes to the training and development of engineers, helping to promote sustainability through technological innovation.
x	5	GENDER EQUALITY	
x	6	CLEAN WATER AND SANITATION	
✓	7	AFFORDABLE AND CLEAN ENERGY	**Affordable and clean Energy:** Advanced motor control techniques such as thyristor-controlled drives, chopper-fed DC motors, voltage-controlled and frequency-controlled induction motors, and synchronous motors enable more efficient use of electrical power. This directly reduces energy consumption, leading to more efficient industrial processes and lowering electricity costs. Induction motors and synchronous motors, when controlled efficiently (using voltage source inverters, cyclo-converters, or PWM control), can be integrated into renewable energy systems such as wind turbines and solar power generation.
✓	8	DECENT WORK AND ECONOMIC GROWTH	The growing demand for efficient motor systems, particularly in the renewable energy and electric mobility sectors, supports the creation of green jobs. Training in modern motor control technologies and drives is critical for building the workforce necessary to support these industries. By improving energy efficiency and reducing operational costs, industries can become more competitive. The ability to precisely control motor performance (through systems like chopper-fed DC drives and closed-loop operation) enables higher productivity with lower operational expenses, fostering economic growth.

✓	9		The control of DC motors, AC motors, and synchronous motors using advanced techniques like four-quadrant operation, closed-loop control, and speed-torque regulation contributes to enhanced automation, precision, and efficiency in manufacturing processes. This leads to reduced energy use, fewer emissions, and overall operational efficiency in industries like automotive manufacturing, robotics, and materials processing. **Renewable Energy Systems:** The motor control techniques learned in the syllabus can also be applied to the motors in renewable energy generation and distribution systems, contributing to the development of cleaner and more reliable infrastructure.
x	10		
x	11		
✓	12		The use of motor drives in manufacturing and industrial settings helps optimize the performance of machines and processes, leading to less energy waste and more efficient use of materials. Advanced motor control strategies also allow for the recycling of materials and more efficient use of resources. Variable frequency drives (VFDs), chopper controls, and high-efficiency motor technologies reduce the environmental impact of industrial operations by ensuring that motors operate at their optimal efficiency points, which minimizes energy consumption, operational costs, and carbon footprints.
✓	13		By controlling the speed and torque of motors efficiently, industrial facilities can significantly reduce the energy required for manufacturing processes, thereby reducing greenhouse gas emissions associated with fossil fuel consumption. For instance, the adoption of efficient AC drives in industries like cement, steel, and paper mills contributes to overall reductions in CO_2 emissions. The integration of energy-efficient motors, particularly those powered by inverters or controlled via sophisticated motor controllers, in heating, ventilation, and air conditioning (HVAC) systems can reduce overall energy consumption in commercial buildings and residential homes.

x	14		
x	15		
x	16		
x	17		

Signature of Course Coordinator **HOD**

Name & Designation

Mrs.A.Kalpana

Assistant Professor