IARE

INSTITUTE OF AERONAUTICAL ENGINEERING

Outcome Based Education (OBE) Manual (IARE-R16)

Department of Electrical and Electronics Engineering

Contents

Overview

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

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

National Board of Accreditation (NBA) is an authorised body for the accreditation of higher education institutions in India. NBA is also a full member of the Washington Accord. NBA accredited programmes 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 institutions 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 stakeholders 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 Outcomes (POs)
3. Program Specific Outcomes (PSOs)
4. Course Outcomes (COs)

Why OBE?

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

Benefits of OBE

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

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

India, OBE and Accreditation:

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

1.1 Institute Vision, Mission

Vision

To bring forth professionally competent and socially sensible engineers, capable of working across cultures meeting the global standards ethically.

Mission

To provide students with an extensive and exceptional education that prepares them to excel in their profession, guided by dynamic intellectual community and be able to face the technically complex world with creative leadership qualities.

Further, be instrumental in emanating new knowledge through innovative research that emboldens entrepreneurship and economic development for the benefit of wide spread community.

Quality Policy

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

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

Philosophy

The essence of learning lies in pursuing the truth that liberates one from the darkness of ignorance and Institute of Aeronautical Engineering firmly believes that education is for liberation.

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

Core Values

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

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

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

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

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

1.2 Department Vision and Mission

Vision

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

Mission

The mission of Electrical and Electronics Engineering is to provide academic environment with a strong theoretical foundation, practical engineering skills, experience in interpersonal communication and teamwork along with emphasis on ethics, professional conduct and critical thinking. Further, the graduates will be trained to have successful engagement in research and development and entrepreneurship.

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 programme. PEO assessment is not made compulsory by NBA as it is quite difficult to measure in 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 the technical terms as it will be read by prospective students who wants to join the programme. Three to five PEOs are recommended.

Program Educational Objective – I: Success in Electrical Engineering:
To provide students with the knowledge of Basic Sciences in general and Electrical and electronics Engineering in particular so as to acquire the necessary skills for analysis and synthesis of problems in generation, transmission and distribution.

Program Educational Objective – II: Industrial awareness and research:
To provide technical knowledge and skills to identify, comprehend and solve complex tasks in

industry and research and inspire the students to become future researchers / scientists with innovative ideas.

Program Educational Objective – III: Successful employment and professional ethics:
To prepare the students for successful employment in various Industrial and Government organizations, both at the National and International level, with professional competence and ethical administrative acumen so as to handle critical situations and meet deadlines.

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

With a view to challenge ourselves and to nurture diverse capabilities for professional and intellectual growth for our students it is important for the department to define departmental objectives in generalized and broad format. Adherence to these objectives is proposed to be demonstrated through actions or achievements.

The department of Electrical and Electronics Engineering periodically reviews these objectives and as part of this review process, encourages comments from all interested parties including current students, alumni, prospective students, faculty, teaching assistants and members of related professional organizations, and colleagues from other educational institutions.

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

Figure 1 shows the correlation between the PEOs and the POs

PEO 1	PEO 2	PEO 3	PEO 4
PO: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	PO: 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12	PO: 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12	PO: 6, 7, 8, 9, 10, 11, 12

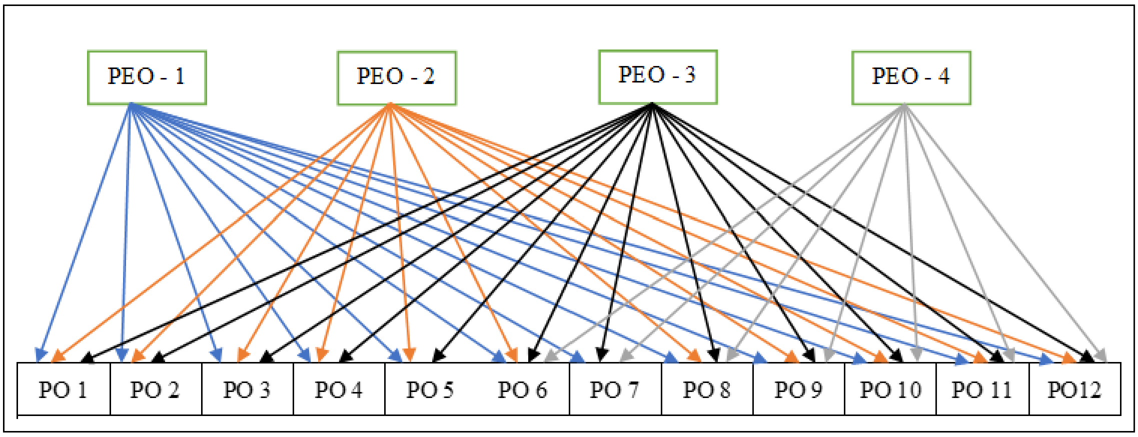


FIGURE 1: Correlation between the PEOs and the POs

Figure 2 shows the correlation between the PEOs and the PSOs

PEO 1	**PEO 2**	**PEO 3**	**PEO 4**
PSO: 1, 2, 3	**PSO:** 1, 2, 3	**PSO:** 1, 2, 3	**PSO:** 1,2,3

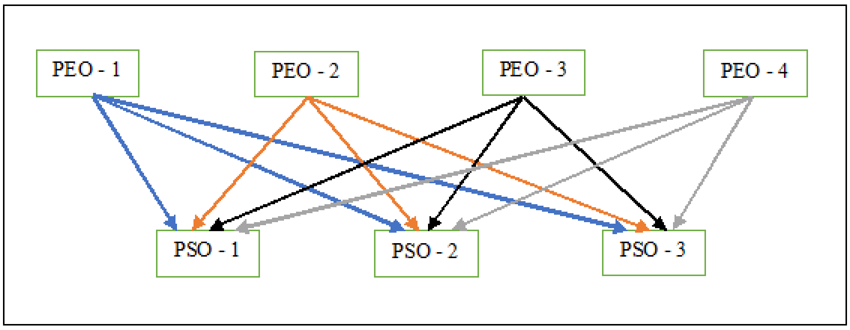


FIGURE 2: Correlation between the PEOs and the PSOs

3 Program Outcomes (POs)

A Program Learning Outcome is broad in scope and be able to do at the end of the programme. POs are to be in line with the graduate attributes as specified in the Washington Accord. POs are to be specific, measurable and achievable. NBA has defined 12 POs and you need not define those POs by yourself and it is common for all the institutions in India. In the syllabus book given to students, there should be clear mention of course objectives and course outcomes along with 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 demonstrate:	
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 analyze 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 the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

4 Program Specific Outcomes (PSOs)

Program Specific Outcomes (PSOs) are statements that describe what the graduates of a specific engineering program should be able to do. A list of PSOs written for the department of Electrical and Electronics Engineering is given below.

B. Tech (EEE) - PROGRAM SPECIFIC OUTCOMES (PSO's)	
A graduate of the Electrical and Electronics Engineering Program will demonstrate:	
PSO1	Design, develop, fabricate and commission the electrical systems involved in 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 in PLC automation, Process controllers, HMI 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 Program Outcomes

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 Fields	(2) Industrial awareness and research	(3) Successful employment and professional ethics	(4) Being a leader in professional and societal environment
PO1	**Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.**	3	3	3	2
PO2	**Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.**	3	3	2	2
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.**	3	3	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.**	3	3	2	2
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.**	3	3	2	2
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.**	2	3	3	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.**	2	2	3	3

PO8	**Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.**	2	2	3	3
PO9	**Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.**	2	3	3	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.**	2	3	3	3
PO11	**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.**	2	3	3	3

PO12	**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.**	2	2	3	3

3 = High; 2 = Medium; 1= Low

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

PEO's→ ↓PSO's		(1) Success in Electrical Engineering Fields	(2) Industrial awareness and research	(3) Successful employment and professional ethics	(4) Being a leader in professional and societal environment
PSO1	Design, develop, fabricate and commission the electrical systems involved in power generation, transmission, distribution and utilization.	2	3	3	2
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	2	3	2

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.	2	2	2	3

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 programme exit questionnaire, alumni survey and employment survey.

7 Blooms Taxonomy

Bloom's taxonomy is considered as the global language for education. Bloom's Taxonomy is frequently used by teachers in writing the course outcomes as it provides a readymade structure and 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 a developing new product or point of view. How does this learned information impact your world? How can it be used to impact not just your education but the way you interact with your surroundings? By utilizing Bloom's Taxonomy, students are not going to forget the information as soon as the class ends - rather, they retain and apply the information as they continue to grow as a student and in their careers, staying one step ahead of the competition.

7.1 Incorporating Critical Thinking Skills into Course Outcome Statements

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

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

FIGURE 3: Revised version of Bloom's taxonomy

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

1. **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.

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

3. **Apply** –being able to use previously learned information in different situations or in problem solving.

4. **Analyze** –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.

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

6. **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**	**Analyse**	**Evaluate**	**Create**
Interpreting Illustrating Classifying Summarizing Inferring (concluding) comparing explaining	Recognizing (identifying) Recalling (retrieving)	Executing Implementing	Differentiating Organizing Attributing	Checking (coordinating, detecting, testing, monitoring) Critiquing (judging)	Planning Generating Producing (constructing)

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

Action Verbs for Course Outcomes

	Lower Order of Thinking (LOT)			Higher Order of Thinking (HOT)		
Definitions	**Remember**	**Understand**	**Apply**	**Analyse**	**Evaluate**	**Create**
Bloom's Definition	Exhibit memory of previously learned material by recalling facts, terms, basic concepts, and answers.	Demonstrate understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions, and stating main ideas.	Solve problems to new situations by applying acquired knowledge, facts, techniques and rules in a different way.	Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalizations.	Present and defend opinions by making judgments about information, validity of ideas, or quality of work based on a set of criteria.	Compile information together in a different way by combining elements in a new pattern or proposing alternative solution.
Verbs	• Choose • Define • Find • How • Label • List • Match • Extend	• Classify • Compare • Contrast • Demonstrate • Explain • Illustrate • Infer • Interpret	• Apply • Build • Choose • Construct • Develop • Interview • Make use of • Model	• Analyze • Assume • Categorize • Classify • Compare • Discover • Dissect • Distinguish	• Agree • Appraise • Assess • Award • Choose • Criticize • Decide • Deduct • Importance	• Adapt • Build • Solve • Choose • Combine • Invent • Compile • Compose • Construct

Action Verbs for Course Outcomes

	Lower Order of Thinking (LOT)			Higher Order of Thinking (HOT)		
Definitions	**Remember**	**Understand**	**Apply**	**Analyse**	**Evaluate**	**Create**
Verbs	• Name • Omit • Recall • Relate • Select • Show • Spell • Tell • What • When • Where • Which • Who • Why	• Outline • Relate • Rephrase • Show • Summarize • Translate • Experiment with • Illustrate • Infer • Interpret • Outline • Relate • Rephrase • Show • Summarize • Translate • Experiment with	• Organize • Plan • Select • Solve • Utilize • Identify • Interview • Make use of • Model • Organize • Plan • Select • Solve • Utilize • Identify	• Divide • Examine • Function • Inference • Inspect • List Motive • Simplify • Survey • Take part in • Test for Theme • Conclusion • Contrast	• Defend • Determine • Disprove • Estimate • Evaluate • Influence • Interpret • Judge • Justify Mark • Measure • Opinion • Perceive • Prioritize • Prove • Criteria • Criticize • Compare • Conclude	• Create • Design • Develop • Estimate • Formulate • Happen • Imagine • Improve • Make up • Maximize • Minimize • Modify • Original • Originate • Plan • Predict • Propose • Solution

8 Guidelines for writing Course Outcome Statements:

Well-written course outcomes involve the following parts:

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

8.1 Course Outcomes (COs)

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

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

8.2 Developing Course Outcomes

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

- Limit the course outcomes to 8-12 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
- Focus on 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 (basic e.g., "upon completion of this course students will be able to list the names of the 28 states and 8 union territories" versus "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 missions.
- Include various ways for students to show success (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 are they able to be performed by the students?

Course outcome statements on 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

The Course Outcomes need to link to the Program Outcomes.

Learning outcomes formula:

STUDENTS SHOULD BE ABLE TO + BEHAVIOR + RESULTING EVIDENCE

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 learn in 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 behaviours.

- Are assessable through one or more indicators (papers, quizzes, projects, presentations, journals, portfolios, etc.)
- Are realistic and achievable.
- Use simple language

8.5 Examples of Effective Course Outcomes

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

- Critically review the methodology of a research study published in a scholarly sociology journal.
- Design a Web site using HTML and JavaScript.
- Describe and present the contributions of women to American history.
- Recognize the works of major Renaissance artists.
- Facilitate a group to achieve agreed-upon 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.
- Analyse 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 that objectives have three parts: a condition, an observable behaviour, and a standard. The table below provides three examples.

S No	Condition	Observable Behaviour	Standard
1	Given a list of drugs	the student will be able to classify each item as amphetamine or barbiturate	with at least 70% accuracy
2	Immediately following a fifteen-minute discussion on a topic.	the student will be able to summarize in writing the major issues being discussed.	mentioning at least three of the five major topics.

S No	Condition	Observable Behaviour	Standard
3	Given an algebraic equation with one unknown.	the student will be able to correctly solve a simple linear equation	within a period of five minutes.

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

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

Examples 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?

8.6 CO-PO Course Articulation Matrix (CAM) Mapping

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.

The Table 1 gives information about the action verbs used in the POs and the nature of POs, stating whether the POs are technical or non-technical. You need to understand the intention of each POs and the Bloom's level to which each of these action verbs in the POs correlates to. Once you have understood the POs then you can write the COs for a course and see to what extent each of those CO's correlate with the POs.

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

<table>
<tr><th>Type</th><th>POs</th><th>Action Verb(s) in POs</th><th>Bloom's level(s) for POs</th><th>Bloom's level(s) for COs</th></tr>
<tr><td rowspan="13">Technical</td><td>PO1</td><td>Apply</td><td>L3</td><td rowspan="13">Bloom's L1 to L4 for theory courses.
Bloom's L1 to L5 for laboratory courses.
Bloom's L1 to L6 for project work, experiential learning</td></tr>
<tr><td rowspan="3">PO2</td><td>Identify</td><td>L2</td></tr>
<tr><td>Formulate</td><td>L6</td></tr>
<tr><td>Review</td><td>L2</td></tr>
<tr><td rowspan="2">PO3</td><td>Design</td><td>L6</td></tr>
<tr><td>Develop</td><td>L3, L6</td></tr>
<tr><td rowspan="3">PO4</td><td>Analyse</td><td>L4</td></tr>
<tr><td>Interpret</td><td>L2, L3</td></tr>
<tr><td>Design</td><td>L6</td></tr>
<tr><td rowspan="3">PO5</td><td>Create</td><td>L6</td></tr>
<tr><td>Select</td><td>L1, L2, L6</td></tr>
<tr><td>Apply</td><td>L3</td></tr>
<tr></tr>
<tr><td rowspan="7">Non-Technical</td><td>PO6</td><td colspan="3" rowspan="7">Thumb Rule:
If Bloom's L1 Action Verbs of a CO: Correlates with any of PO6 to PO12, then assign 1.
If Bloom's L2 to L3 Action Verbs of a CO: Correlates with any of PO6 to PO12, then assign 2.
If Bloom's L4 to L6 Action Verbs of a CO: Correlates with any of PO6 to PO12, then assign 3</td></tr>
<tr><td>PO7</td></tr>
<tr><td>PO8</td></tr>
<tr><td>PO9</td></tr>
<tr><td>PO10</td></tr>
<tr><td>PO11</td></tr>
<tr><td>PO12</td></tr>
</table>

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

Observations:

1. The first five POs are purely of technical in nature, while the other POs are non-technical.
2. For the theory courses, while writing the COs, you need to restrict yourself between Blooms Level 1 to Level 4. Again, if it is a programming course, restrict yourself between Blooms Level 1 to Level 3 but for the other courses, you can go up to Blooms Level 4.

3. For the laboratory courses, while composing COs, you need to restrict yourself between Blooms Level 1 to Level 5.
4. Only for Mini-project and Main project, you may extend up to Blooms Level 6 while composing COs.
5. For a given course, the course in-charge has to involve all the other Professors who teach that course and ask them to come up with the CO-PO mapping. The course in-charge has to take the average value of all of these CO-PO mappings and finalize the values or the course in-charge can go with what the majority of the faculty members prefer for. Ensure that none of the Professors who are handling the particular course discuss with each other while marking the CO-PO values.
6. If you want to match your COs with non-technical POs, then correlate the action verbs used in the course COs with the thumb rule given in the table and map the values. (Applies only for mapping COs to non-technical POs).

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

1. Select action verbs for a CO from different Bloom's levels based on the importance of the particular CO for the given course.
2. Stick on to single action verbs while composing COs but you may go for multiple action verbs if the need arises.
3. You need to justify for marking of the values in 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 to 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 then assign 3, if it matches moderately then assign 2 or if the match is low then assign 1 else mark with " - " symbol.
   (b) If an action verb used in a CO is repeated at multiple Bloom's levels, then you need to judge which Bloom's level is the best fit for that action verb.

8.8 Method for Articulation

1. Identify the key competencies of POs/PSOs to each CO and make a corresponding mapping table with assigning ✓mark at the corresponding cell. One observation to be noted is that the first five POs are purely of 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 are matching with 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. Make a table with number of key competencies for CO – PO/PSO mapping with reference to the maximum given Key Attributes for Assessing Program Outcomes.
4. Make a table with percentage of key competencies for CO – PO/PSO mapping with reference to the maximum given Key Attributes for Assessing Program Outcomes.

5. Finally, Course Articulation Matrix (CO - PO / PSO Mapping) is prepared with COs and POs and COs and PSOs on the scale of 0 to 3, 0 being no correlation (marked with " - "), 1 being the low/slight correlation, 2 being medium/moderate correlation and 3 being substantial/high correlation based on the following strategy

$$0\text{–}0 \leqq C \leqq 5\%$$ - No correlation.

$$1 - 5 < C \leqq 40\%$$ - Low / Slight.

$$2 - 40\% < C < 60\%$$ - Moderate

$$3 - 60\% \leqq C < 100\%$$ - Substantial / High

9 Key Competencies for Assessing Program Outcomes:

PO	NBA statement / Vital features	No. of vital features
PO1	**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
PO2	**Identify, formulate, review research literature, and analyse 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

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. 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 issues.	10

PO4	**Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. (Conduct Investigations of Complex Problems)** 1. Knowledge of characteristics of particular materials, equipment, processes, or product 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 analyse 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
PO5	**Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations. (Modern Tool Usage)** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	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. 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. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level 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). Impact of the professional engineering solutions** (Not technical) 1. Socio economic 2. Political and 3. Environmental	3
PO8	**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

PO9	**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 classroom 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's performance, which is then reflected in the final grade. 9. Ability to work with all levels of people in an organization 10. Ability to get along with others 11. Demonstrated ability to work well with a team 12. 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.	12
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). "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 Environ ments (Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	12
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 CSE 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 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	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 involved in power generation, transmission, distribution and utilization.** 1. Operate, control and 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.	5
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 and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development	11

PSO	NBA statement / Vital features	No. of vital features
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. 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 and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	7

11 Program Outcomes and Program Specific Outcomes attained:

Courses offered in Electrical and Electronics Engineering curriculum (IARE-R16) and POs/PSOs attained through curriculum of B.Tech - 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
	B.Tech - I Semester															
AHS002	Linear Algebra and Ordinary Differential Equations	✓	✓													✓
AHS003	Computational Mathematics and Integral Calculus	✓	✓													
AHS006	Engineering Physics	✓	✓		✓										✓	
AHS005	Engineering Chemistry	✓	✓					✓								
ACS001	Computer Programming	✓	✓	✓		✓					✓		✓			
AME103	Computer Aided Engineering Drawing	✓		✓		✓				✓	✓		✓			✓

Code	Subject	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
AHS102	Computational Mathematics Laboratory	✓	✓	✓										✓		
AHS104	Engineering Physics and Chemistry Laboratory	✓	✓		✓									✓	✓	
ACS101	Computer Programming Laboratory	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓			
B.Tech - II Semester																
AHS001	English for Communication										✓					
AHS011	Mathematical Transform Techniques	✓	✓		✓									✓		
AHS009	Environmental Studies	✓			✓			✓								
ACS002	Data Structures	✓	✓	✓	✓	✓					✓	✓				
AEE002	Electrical Circuits	✓	✓	✓							✓		✓	✓		
AHS101	Communication Skills Laboratory									✓	✓					
ACS102	Data Structures Laboratory	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓			
AEE102	Electrical Circuits Laboratory	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓		
ACS112	Engineering Practice Laboratory	✓	✓	✓	✓	✓					✓			✓		✓
B.Tech - III Semester																
AEE003	Power Generation Systems	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓		

Code	Subject	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
AEE004	DC Machines and Transformers	✓	✓	✓	✓					✓	✓			✓	✓	
AEE005	Network Analysis	✓	✓												✓	
AEE006	Electromagnetic Field Theory	✓	✓	✓	✓						✓		✓	✓		
AEC001	Electronic Devices and Circuits	✓	✓	✓							✓					
AEE104	DC Machines Laboratory	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓		✓
AEE105	Electrical Engineering Simulation Laboratory	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
AEC113	Electronic Circuits Laboratory	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
B.Tech - IV Semester																
AEE007	AC Machines	✓	✓	✓	✓					✓	✓		✓	✓		
AEE008	Electrical Measurements and Instrumentation	✓	✓	✓							✓			✓		
AEC019	Digital and Pulse Circuits	✓	✓	✓	✓						✓				✓	
AEE009	Control Systems	✓	✓	✓	✓		✓		✓		✓		✓	✓	✓	✓
AHS004	Complex Analysis and Probability Distributions	✓	✓		✓											
AEE106	AC Machines Laboratory	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓		✓
AEE107	Electrical Measurements and Instrumentation Laboratory	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓		✓

Code	Subject	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
AEE115	Control Systems and Simulation Laboratory	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
B.Tech - V Semester																
AEC008	Integrated Circuits Applications	✓	✓	✓	✓						✓				✓	
AEE010	Power Electronics	✓	✓	✓	✓		✓			✓	✓		✓	✓	✓	
AHS012	Optimization Techniques	✓	✓	✓										✓		
AEE011	Transmission and Distribution Systems	✓	✓	✓	✓		✓			✓	✓		✓	✓		
AHS015	Business Economics and Financial Analysis	✓	✓						✓	✓		✓				
AHS106	Research and Content Development Laboratory	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
AEE108	Power Electronics and Simulation Laboratory	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
AEC106	Integrated Circuits Applications Laboratory	✓	✓			✓	✓	✓		✓	✓	✓			✓	✓
B.Tech - VI Semester																
AEE012	Power System Analysis	✓	✓	✓	✓					✓	✓		✓	✓		✓
AEE013	Solid State Electric Motor Drives	✓	✓	✓	✓		✓		✓				✓		✓	
AEC022	Microcontrollers and Digital Signal Processing	✓	✓	✓			✓				✓			✓		

Code	Subject	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
AEE2011	Ideation and Product Development	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
AEE109	Solid State Electric Motor Drives Laboratory	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
AEE110	PLC and Automation Laboratory	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
AEC114	Microcontrollers and Digital Signal Processing Laboratory		✓	✓		✓	✓		✓	✓	✓			✓		✓
B.Tech - VII Semester																
AEE014	Power System Protection	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓		
AEE015	High Voltage Engineering	✓	✓	✓			✓		✓		✓		✓	✓	✓	
AEE016	Power System Operation and Control	✓	✓	✓	✓		✓	✓		✓	✓		✓	✓	✓	
AEE111	High Voltage Engineering and Solar Laboratory	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
AEE112	Power System Protection Laboratory	✓	✓	✓	✓		✓		✓	✓	✓		✓	✓		✓
AEE113	Power System Computer Aided Design Laboratory	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
AEE301	Project Work (Phase - I)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
B.Tech - VIII Semester																

Code	Subject	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
AEC024	Embedded Systems Design and Programming	✓	✓	✓	✓										✓	
AEE019	Hybrid Electric Vehicles	✓	✓	✓		✓		✓					✓	✓	✓	✓
AEE401	Comprehensive Examination	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
AEE302	Project Work (Phase - II)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Professional Elective Courses																
Group – I: Power Systems Engineering																
AEE501	Real Time Control of Power Systems	✓	✓	✓											✓	
AEE502	Power System Transients	✓	✓	✓										✓	✓	
AEE503	Energy Audit and Management	✓	✓	✓	✓		✓		✓		✓		✓	✓	✓	
AEE504	Extra High Voltage AC Transmission	✓	✓				✓							✓		
AEE505	Advanced Power System Protection	✓	✓				✓							✓	✓	
Group – II: Power Electronics																
AEE506	Power Electronics for Renewable Energy Systems	✓	✓	✓			✓	✓	✓					✓	✓	
AEE507	Power Electronic Applications in Power Systems	✓	✓	✓			✓	✓	✓					✓	✓	
AEE508	Power Electronics and Distributed Generation	✓	✓	✓										✓	✓	
AEE509	Power Quality	✓	✓	✓										✓	✓	

Code	Subject	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
AEE510	Micro/Nano Processing Technology	✓	✓		✓									✓		
Group – III: Power Systems Control																
AEE511	Industrial Automation and Control	✓	✓	✓	✓		✓			✓	✓		✓		✓	✓
AEE512	Motion Control	✓	✓	✓											✓	✓
AEE513	Power Systems Stability	✓	✓	✓		✓								✓	✓	
AEE514	Solid State Relays	✓	✓	✓			✓							✓	✓	
AEE515	Smart Grid Technology	✓	✓	✓	✓	✓	✓						✓	✓	✓	
AEE522	Energy Management Systems and SCADA	✓	✓	✓	✓	✓	✓						✓	✓	✓	✓
Group – IV: Control Systems and Industrial Electronics																
AEE516	Power Plant Control and Instrumentation	✓	✓	✓	✓	✓	✓				✓		✓	✓		
AEE517	Distributed Control and Communication Networks	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	
AEE518	Industrial Electronics	✓	✓	✓										✓	✓	
AEE519	Digital Image Processing	✓	✓	✓										✓		
AEE520	Modern Control Theory	✓	✓	✓	✓	✓								✓		
Group – V: Advanced Power Systems																

Code	Subject	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
AEE521	Electrical Insulation in Power Apparatus and Systems	✓	✓	✓	✓									✓		
AEE522	Energy Management Systems and SCADA	✓	✓	✓											✓	✓
AEE523	Illumination Engineering	✓	✓	✓										✓		
AEE524	Flexible Alternating Current Transmission Systems	✓	✓	✓	✓		✓			✓	✓		✓	✓	✓	
AEE525	HVDC Transmission	✓	✓	✓										✓	✓	
Group – VI: Advanced Electrical Engineering																
AEE526	Special Electrical Machines	✓	✓											✓	✓	
AEE527	Advanced Control Systems	✓	✓	✓	✓									✓	✓	
AEE528	Modeling and Analysis of Electrical Machines	✓	✓		✓	✓	✓							✓	✓	
AEE529	Electromagnetic and Applications	✓	✓	✓										✓		
AEE530	Digital Control Systems	✓	✓	✓										✓		
Open Elective - I																
AME551	Elements of Mechanical Engineering	✓	✓													

Code	Subject	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
ACE551	Disaster Management	✓					✓	✓		✓						
ACE552	Geospatial Techniques	✓	✓													
ACS551	Principles of Operating System	✓	✓	✓		✓					✓	✓				✓
ACS552	JAVA Programming	✓	✓	✓	✓	✓					✓	✓				✓
AEC551	Embedded System Design	✓	✓	✓										✓	✓	
AME552	Introduction to Automobile Engineering	✓	✓	✓												
AME553	Introduction to Robotics	✓	✓	✓											✓	
AAE551	Aerospace Propulsion and Combustion	✓	✓	✓												
Open Elective - II																
AEC552	Fundamentals of Image Processing	✓	✓	✓												
ACS553	Fundamentals of Database Management Systems	✓	✓	✓	✓	✓					✓		✓			✓
AIT551	Basics of Information Security and Cryptography	✓	✓													
AHS551	Modeling And Simulation	✓	✓	✓		✓					✓			✓	✓	✓
AHS552	Research Methodologies	✓	✓				✓		✓		✓					

Code	Subject	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
AEE551	Energy From Waste	✓	✓				✓	✓	✓			✓	✓			
AAE552	Finite Element Analysis	✓	✓	✓										✓		
AME554	Basic Refrigeration and Air-Conditioning	✓	✓	✓												
AAE553	Launch Vehicles and Controls	✓	✓	✓	✓									✓		
Audit Courses																
AHS601	Intellectual Property Rights	✓					✓	✓	✓	✓	✓	✓	✓			
AHS602	Total Quality Management	✓										✓				
AHS603	Professional Ethics and Human Values	✓					✓	✓	✓	✓	✓	✓		✓		
AHS604	Legal Sciences	✓									✓					
AHS605	Clinical Psychology	✓									✓					
AHS606	English for Special Purposes	✓									✓					
AHS607	Entrepreneurship	✓									✓					
AHS608	Any Foreign Language	✓									✓					
AHS609	Design History	✓									✓					
AHS017	Gender Sensitivity	✓							✓		✓					
Value Added Courses – I																
AEE801	Embedded Programming Using Aurdino / Raspberry PI	✓	✓	✓	✓										✓	✓
AEE802	Course on Solar Energy	✓	✓	✓										✓	✓	

Code	Subject	PO												PSO		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
AEE803	IoT and Applications	✓	✓	✓										✓	✓	✓
AEE804	Artificial Intelligence	✓	✓	✓										✓	✓	✓
Value Added Courses – II																
AEE805	Distributed Generation and Microgrid	✓	✓	✓	✓									✓	✓	
AEE806	Nano Technology	✓	✓	✓	✓									✓	✓	
AEE807	Optimization In Electrical Engineering	✓	✓											✓		
AEE808	Electrical Safety Engineering	✓	✓	✓			✓							✓		

12 Methods for measuring Learning Outcomes and Value Addition:

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

i) Continuous Internal Assessment (CIA)
ii) Alternate Assessment Tools (AAT)
iii) Semester end examination (SEE)
iv) Laboratory and project work
v) Course exit survey
vi) Program exit survey
vii) Alumni survey
viii) Employer survey
ix) Course expert committee
x) Program Assessment and Quality Improvement Committee (PAQIC)
xi) Department Advisory Board (DAB)
xii) Faculty meetings
xiii) Professional societies

The above assessment indicators are detailed below.

12.1 Continuous Internal Assessment (CIA)

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

12.2 Alternate Assessment Tools (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table.

12.3 Semester End Examination (SEE)

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

12.4 Laboratory and Project Works

The laboratory work is continuously monitored and assessed to suit the present demands of the industry. Students are advised and guided to do project works giving solutions to research / industrial problems to the extent possible 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.

12.5 Course Exit Surveys

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

12.6 Programme Exit Survey

The programme exist questionnaire form is to be filled by all the students leaving the institution. The questionnaire is designed in such a way to gather information from the students regarding the program educational objectives, solicit about program experiences, carrier choices, as well as any suggestions and comments for the improvement of the program. The opinions expressed in exit interview forms are reviewed by the DAC for implementation purposes.

12.7 Alumni Survey

The survey asks former students of the department about the status of their employment and further education, perceptions of institutional emphasis, estimated gains in knowledge and skills, involvement a sunder graduate student, and continuing involvement with Institute of Aeronautical

Engineering. This survey is administered every three years. The data obtained will be analyzed and used in continuous improvement.

12.8 Employer Survey

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

12.9 Course Expert Committee

The course expert team is responsible in exercising the central domain of expertise in developing and renewing the curriculum and assessing its quality and effectiveness to the highest of professional standards. 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.

12.10 Programme Assessment and Quality Improvement Committee (PAQIC)

PAC Monitors the achievements of Program Outcomes (POs), Program Specific Outcomes (PSOs) and Program Educational Objectives (PEOs). It will evaluate the program effectiveness and proposes the necessary changes. It also prepares the periodic reports on program activities, progress, status or other special reports for management. It also motives the faculty and students towards attending workshops, developing projects, working models, paper publications and engaging in research activities.

12.11 Department Advisory Board (DAB)

Departmental Advisory Board plays an important role in the development of the department. Department level Advisory Board will be established for providing guidance and direction for qualitative growth of the department. The Board interacts and maintains liaison with key stakeholders. DAB will Monitor the progress of the program and develop or recommend the new or revised goals and objectives for the program. Also, the DAB will review and analyze the gaps between curriculum and Industry requirement and gives necessary feedback or advices to be taken to improve the curriculum.

12.12 Faculty Meetings

The DAC 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 DAC's suggestions and guidelines. All these proceedings are recorded and kept for the availability of all faculties.

12.13 Professional Societies

The importance of professional societies like IEEE, IETE, ISTE, IE (I) 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) whereas the indirect assessment methods are based on the course end survey and program exit survey provided by the students, Alumni and Employer. The weightage in CO attainment of Direct and Indirect assessments are illustrated in Table.

Assessment Method	Assessment Tool	Weightage in CO attainment
Direct Assessment	Continuous Internal Assessment (CIE & AAT)	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 the various assessments and examinations. These assessment methods provide evidence that a student has command over a specific course, content, or skill, or that the students work demonstrates a specific quality such as creativity, analysis, or synthesis.

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

- Continuous internal examination, semester end examinations, AAT (includes assignment, 5 minutes videos, seminars etc.) are used for CO calculation.
- The attainment values are calculated for individual courses and are formulated and summed for assessing the POs.
- Performance in AAT 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	25	Answer script
		Alternative Assessment Tools (AAT)	Twice in a semester	5	Video / Quiz / assignment
		Semester End Examination	Once in a semester	70	Answer script
2	Laboratory	Conduction of experiment	Once in a week	4	Work sheets
		Observation	Once in a week	4	Work sheets
		Result	Once in a week	4	Work sheets
		Record	Once in a week	4	Work sheets
		Viva	Once in a week	4	Work sheets
		Internal laboratory assessment	Once in a semester	10	Answer script
		Semester End Examination	Once in a semester	70	Answer script
3	Project Work	Presentation	Twice in a semester	30	Presentation
		Semester End Examination	Once in a semester	70	Thesis report
4	Comprehensive Examination	Written examination (objective type)	Once in a semester	50	Online assessment
		Oral examination	Once in a Semester	50	Viva

13.2 Indirect Assessment:

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

TABLE 15: Tools used in 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 attainment of POs/PSOs.

1. Direct method
2. Indirect method

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

TABLE 16: Attainment of PO/PSOs

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

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

14.1 PO Direct attainment is calculated using the following rubric:

PO Direct Attainment = (Strength of CO-PO)*CO attainment / Sum of CO-PO strength.

The below figure represents the evaluation process of POs/PSOs attainment through course outcome attainment.

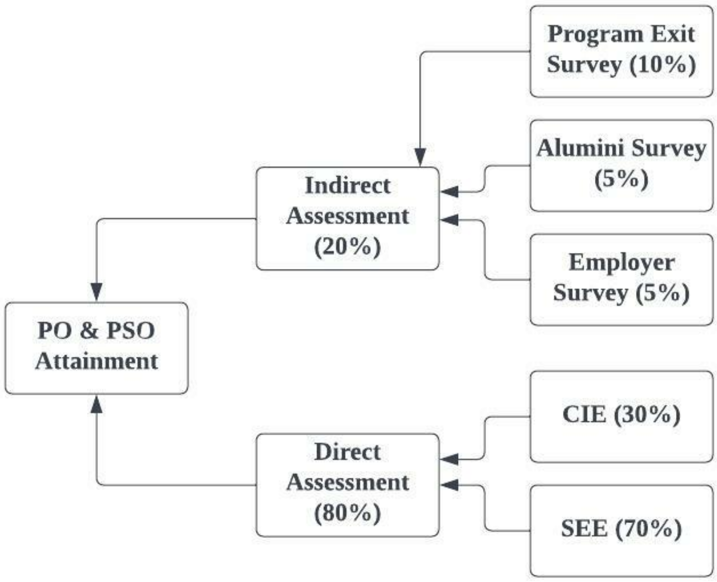


FIGURE 4: Evaluation process of POs/PSOs attainment

15 Course Description:

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

The "Course Description" contains the following contents:

- Course Overview
- Prerequisite(s)
- Marks Distribution
- Content delivery / Instructional methodologies
- Evaluation Methodology
- Course Objectives
- Course Outcomes
- Program Outcomes
- 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
- Syllabus
- List of Text Books / References / Websites
- Course Plan

15.1 Course Description (Annexure - I)

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Transmission and Distribution Systems**				
Course Code	AEE011				
Program	B. Tech				
Semester	V				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. P Mabuhussain, Assistant Professor, EEE				

I COURSE OVERVIEW:

This course deals with the modeling, analysis and design of electrical power transmission lines. It gives an emphasis on overhead line insulators, underground cables, corona phenomena,sag and tension calculation, AC and DC distribution systems, substation design and equipment, voltage drop calculations in AC and DC distributors fed at one end or both ends. Also a brief overview is presented about Indian grid scenario and the Indian Electricity rules.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE005	III	Network Analysis
B.Tech	AEE003	IV	Power Generation Systems

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Transmission and Distribution Systems	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
50 %	Understand
40%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
50%	50%	-

VI COURSE OBJECTIVES:

The students will try to learn:

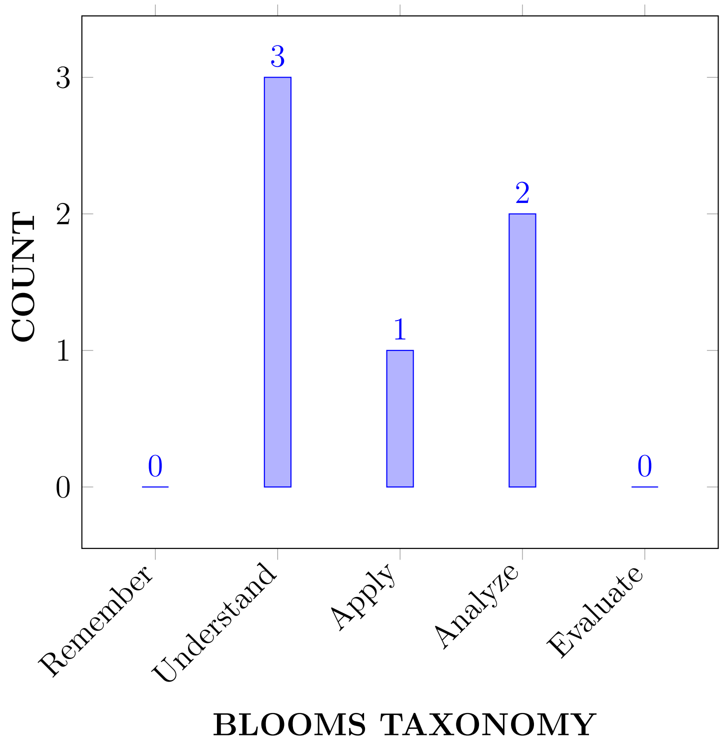
I	The mathematical solutions for transmission line parameters of a single phase and three phase system.
II	The mathematical modeling of short, medium and long transmission linesalong with the transient behavior.
III	The mechanical design of overhead transmission lines, the use of insulators and underground cables in electrical power transmission system.
IV	The requirements of distribution system, substaion equipment and voltage drop caculations in AC and DC distributors.

VII COURSE OUTCOMES:

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

CO 1	**Compute** the line parameters and corona loss for electrical desing of a tranmission line system.	Analyze
CO 2	**Model** the short, medium and long transmission lines using ABCD constants for evalutating the performance of tranmission system under no load and surge impedance loading conditions.	Apply
CO 3	**Examine** the different types of insulators and the methods for improving string effciciency in the design of ovehead transmission system.	Understand
CO 4	**Calculate** the insulation resistance, capacitance and dielectric stress in underground cable transmission system to increase the efficiency and quality operation of cables.	Understand
CO 5	**Analyze** the sag and tension for designing the overhead tranmsission line under various loading and weather conditions.	Analyze
CO 6	**Determine** the voltage drop in AC and DC distgribution feeders and select the appropriate substation equipment for efficient distribution of electrical power to consumers.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

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IX PROGRAM SPECIFIC OUTCOMES:

Program Specific Outcomes	
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.
PSO 3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.

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X HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/AAT/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	CIE/AAT/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/AAT/SEE

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/AAT/SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	CIE/AAT/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	CIE/AAT/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

XI HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	3	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	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
CO 1	✓	✓	✓	✓	-	-	-	-	-	✓	-	-	✓	-	-
CO 2	✓	✓	✓	-	-	-	-	-	✓	✓	-	-	✓	-	-
CO 3	✓	✓	-	-	-	-	-	-	✓	✓	-	✓	✓	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	✓	-		✓	-	-
CO 5	✓	✓	-	✓	-	-	-	-	-	✓	-	-	-	-	-
CO 6	✓	✓	✓	-	-	-	-	-	-	✓	-	-	✓	-	-

XIII 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 matched.
CO 1	PO 1	**Recall** the knowledge of **mathematics,science and electrical engineering fundamentals** and apply them to calculate the resistance, inductance and capacitance of transmission lines.	3
	PO 2	**Identify** the type of tranmsiision line, Formulate the equations to calculate the transmission line parameters using the **first principles of mathematics, science and engineering.**	6
	PO 3	**Develop** the solutions for complex netwroks involving double ciruit lines, neighbouring communicaton system by effectively **designing** the tranmission system.	5
	PO 4	**Design** the ovehead tranmission line such that it will have no effect of neighbouring communicaton system	5
	PO 10	**Discuss** the concepts of inductance and capacitance of different types of transmission lines and prepare a PPT and present it.	3
	PSO 1	**Analyze** the types of overhead transmission line systems and **develop** the equations for transmission line inductance and capacitance using the concepts of GMR and GMD.	3
CO 2	PO 1	**Classify** the types of transmission lines based on the distance and define the performance parameters of lines using the **knowledge of science, engineering fundamentals.**	3
	PO 2	**Analyze** the performance parameters (efficiency and regulation) of lines using the ABCD constants using the first **principles of mathematics, and engineering sciences.**	6
	PO 3	**Develop** the mathematical **solutions** by mathematical **modeling** of transmission lines and solve **the complex engineering problems** related to these lines.	5
	PO 9	**Model** the transmission line system involving multiple lines with a team of members or individually.	4
	PO 10	**Discuss** the concepts tranmsission line modelling and performance of lines and prepare a PPT and present it.	3
	PSO 1	**Analyze** the performance of short, medium and long transmission lines using the ABCD constants and observe the Ferranti effect in transmission line system.	3
CO 3	PO 1	**Classify** the types of overhead insulators and calcualte the string efficiency by applying the **knowledge of science, engineering fundamentals.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	**Develop** the equations for determining the string efficiency in ovehead lines using the **principles of mathematics, science and engineering fundamentals.**	5
	PO 9	**Find** the string efficiecy of an insulator string with 3 or more discs by involvinh with a team of members or individually.	4
	PO 10	**Discuss**the concept string effficiency and methods for improving it and prepare a PPT and present it.	3
	PO 12	**Recognize** the need of caclcuating string efficiency and adapt it in real time for improving the votlage distribution in a string of insulators	3
	PSO 1	**Investigate** the methods available to increase the string efficiency or voltage distribution across a string of insulators and to increse the flexibility of tranmission system.	3
CO 4	PO 1	Know the insulation resistance, capacitance and dielectric stress of cables and from the basic **knowledge of science and engineering fundamentals.**	3
	PO 2	**Analyze** the dielectric stress in cables using the **principles of mathematics and engineering sciences.**	5
	PO 10	**Discuss**the concept of resistance, capacitance and dielectric stree of cables and prepare a PPT and present it.	3
	PSO 1	**Analyze** the underground cable operating parameters such as insulation resistance, capacitance and dielectric stress **suggest** the methods to get uniform dielectric stress in cable and to improve the power tranmission system.	2
CO 5	PO 1	**Define** the skin effect, proximity effect, Ferranti effect, corona effect, sag and tension from the **knowledge of science, engineering fundamentals.**	3
	PO 2	**Analyze** the surge impedance and surge impedance loading of lines, sag and tension under different weather conditions and also **identify the solutions** to minimize the skin effect, proximity effect, Ferranti effect and corona effect using the first **principles of mathematics, natural sciences, and engineering sciences.**	4
	PO 4	**Investigate** for voltage profile of the line at different loading conditions and suggest the methods to be adopted for improving the voltage profile	5
	PO 10	**Discuss**the the concepts of sag and tension in overhead lines and prepare a PPT and present it.	3
	PSO 1	**Design** a syttem for determing the ferrenti effect, surge impedance and surge impedance loading of the transmission line	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO 1	Understand the Indian electri grid scenario and the Indian Electricity rules by **using the knowledge of principles of science, mathematics and electrical engineering fundamentals.**	3
	PO 2	**Determine** the Voltage drop in AC and DC distributors using **the first principles of mathematics, science and engineering**	5
	PO 3	**Analyze** the indian electricity rules to design the distruibution system equipment in cost effective way and according the needs of utility companies	4
	PO 10	**Discuss**the the concepts of AC and DC distribution feeders, substations and voltage drop caluculations and prepare a PPT and present it.	3
	PSO 1	**Develop** the solutions for economic electric power distribution using the kelvins laws and examine the indian grid scenario.	2

XIV TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	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
CO 1	3	6	5	5	-	-	-	-	-	3	-	-	3	-	-
CO 2	3	6	5	-	-	-	-	-	4	3	-	-	3	-	-
CO 3	3	5	-	-	-	-	-	-	4	3	-	3	3	-	-
CO 4	3	5	-	-	-	-	-	-	-	3	-	-	2	-	-
CO 5	3	4	-	5	-	-	-	-	-	3	-	-	3	-	-
CO 6	3	5	4	-	-	-	-	-	-	3	-	-	2	-	-

XV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	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
CO 1	100	60	50	45.5	-	-	-	-	-	60	-	-	60	-	-
CO 2	100	60	50	-	-	-	-	-	33.3	60	-	-	60	-	-
CO 3	100	50	-	-	-	-	-	-	33.3	60	-	37.5	60	-	-
CO 4	100	50	-	-	-	-	-	-	-	60	-	-	40	-	-
CO 5	100	40	-	45.5		-	-	-	-	60	-	-	60	-	-
CO 6	100	50	40	-	-	-	-	-	-	60	-	-	40	-	-

XVI COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and 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 - $0 \leq C \leq 5\%$ – No correlation
1 -$5 < C \leq 40\%$ – Low/ Slight
2 - $40\ \% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	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
CO 1	3	3	2	2	-	-	-	-	-	2	-		3	-	-
CO 2	3	3	2	-	-	-	-	-	1	2	-	-	2	-	-
CO 3	3	2	-	-	-	-	-	-	1	2	-	1	1	-	-
CO 4	3	2	-	-	-	-	-	-	-	2	-	-	2	-	-
CO 5	3	1	-	2	-	-	-	-	-	2	-		3		-
CO 6	3	2	1	-	-	-	-	-	-	2	-	-	2	-	-
TOTAL	18	13	5	4	-	-	-	-	2	12	-	1	11	-	-
AVERAGE	3.0	2.16	1.67	2.0	-	-	-	-	1.0	2.0	-	1.0	2.2	-	-

XVII ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	-				

XVIII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
✓	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XIX SYLLABUS:

UNIT I	TRANSMISSION LINE PARAMETERS
	Transmission line parameters: Types of conductors, simple diagrams of typical towers and conductors for 400, 220 and 132 kV operations, calculation of resistance for solid conductors, calculation of inductance for single phase and three phase, single and double circuit lines, concept of GMR and GMD, symmetrical and asymmetrical conductor configuration with and without transposition, numerical problems, capacitance calculations for symmetrical and asymmetrical single and three phase lines, single and double circuit lines, effect of ground on capacitance, numerical problems; Corona: Types, critical disruptive voltages, factors affecting corona, methods for reducing corona power loss, charge voltage diagram, audible noise, radio interference.

UNIT II	**MODELING AND PERFORMANCE OF TRANSMISSION LINES**
	Classification of transmission lines: Short, medium and long line and their model representations, nominal T, nominal /pi and A, B, C, D constants for symmetrical and asymmetrical networks, numerical problems, mathematical solutions to estimate regulation and efficiency of all types of lines, numerical problems; Long transmission line: Rigorous solution, evaluation of A, B, C, D constants, interpretation of the long line equations, methods of voltage control, Ferranti effect, incident, reflected and refracted waves, surge impedance and surge impedance loading of long lines, wave length and velocity of propagation of waves, representation of long lines, equivalent T and equivalent /pi network model, numerical problems.
UNIT III	**OVERHEAD INSULATORS AND UNDERGROUND CABLES**
	Overhead insulators: Types of insulators, voltage distribution, string efficiency and methods for improvement, capacitance grading and static shielding, numerical problems. Underground cables: Types of cables, construction, types of insulating materials, calculations of insulation resistance and stress in insulation, capacitance of single and three core belted cables, grading of cables, capacitance grading, description of inter sheath grading, numerical problems.
UNIT IV	**MECHANICAL DESIGN OF TRANSMISSION LINES**
	Sag and tension calculations: Sag and tension calculations with equal and unequal heights of towers, effect of wind and ice on weight of conductor, stringing chart and sag template and its applications, numerical problems.
UNIT V	**DISTRIBUTION SYSTEMS**
	Distribution systems: Classification, comparison of DC vs AC and underground vs overhead, radial and ring main system, requirements and design features, Substation: Substation design, equipments, types of substations, bus bar arrangement layout, bus schemes, location, Kelvin's law for the design of feeders and its limitations; voltage drop calculations in DC distributors: Radial DC distributor fed at one end and at both the ends (equal / unequal voltages) and ring main distributor, voltage drop calculations in AC distributors, power factors referred to receiving end voltage and with respect to respective load voltages, numerical problems; Basic concept of interconnected systems: Indian electricity rules, various voltage levels of transmission and distribution systems, Indian grid scenario.

TEXTBOOKS

1. D P Kothari and I J Nagrath, "Power System Engineering", McGraw-Hill Education, 2nd Edition, 2007.
2. V K Mehta and Rohit Mehta, "Principles of Power System", S Chand, 3rd revised Edition, 2015.
3. D Das, "Electrical Power systems", New age international publishers, 2nd edition, 2006.
4. K R Padiyar, "HVDC transmission Systems", New age international publishers, 2nd edition, 2005.
5. B R Guptha, "Power system analysis and Design" S. Chand Publishing, 2nd edition, 1998.

REFERENCE BOOKS:

1. C L Wadhwa, "Electric Power Systems", New age publications, New Delhi, 9th Edition, 2007.
2. Turan Gonen, "Electrical Power Distribution System Engineering", CRC Press, 3rd Edition, 2014.
3. V Kamaraju, "Electrical Power Distribution Systems", TMH, Publication, Edition 2009.
4. Singh S N, "Electric Power Generation, Transmission and Distribution", Prentice Hall of India Pvt. Ltd., New Delhi, 2nd Edition, 2002.

XX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	-
CONTENT DELIVERY (THEORY)			
2	Introduction, Types of conductors	CO 1	T1: 2.1-2.5, R1:2.2- 2.8
3	Calculation of resistance for solid conductors, description and effect of resistance on solid conductors, skin effect and proximity effect	CO 1	T1: 2.11, R1:2.13
4	Calculation of inductance for single phase line	CO 1	T1: 2.3, R1:2.1-2.3
5	Calculation of inductance for three phase line	CO 1	T1: 2.4, R1:2.4
6	Single and double circuit lines, concept of GMR, GMD	CO 1	T1: 2.6, R1:2.5
7	Inductance of bundled conductors and double circuit transmission line	CO 1	T1: 2.7, R1: 2.11
8	Capacitance for 3 wire line symmetrical and asymmetrical line	CO 1	T1: 2.8, R1: 2.6-2.7
9	Capacitance for bundled conductor line and double circuit line.	CO 1	T1: 2.8, R1: 2.6-2.7
10	Effect of ground on capacitance	CO 1	T1: 2.9, R1: 2.10
11	Corona, description of the phenomenon, factors affecting corona, critical voltages and power loss	CO 2	T2:14.1-14.9, R1: 6.1 & 6.2
12	Radio interference, Electrostatic and electromagnetic interference with communication lines	CO 2	T3: 14.10, R1: 6.5 & 6.6
13	Classification of transmission lines, modeling, equivalent representation and performance of short lines	CO 5	T1: 5.1-5.2, R1: 4.1-4.2
14	Modeling of nominal –T and Nominal –Pie representation of medium lines.	CO 3	T1:5.3, R1: 4.3

15	Modeling and performance of long transmission line using rigorous solution	CO 3	T1:5.4, R1:4.4
16	Evaluation of ABCD constants of long lines, Equivalent-T and equivalent-Pie representation of long lines	CO 5	T1: 5.4, R1:4.5
17	Ferranti effect, charging current, effect on regulation of the transmission line	CO 4	T1:5.6, R1: 4.6
18	Surge impedance and SIL of long lines, wave length and velocity of propagation of waves.	CO 4	T1:5.5, R1:4.4
19	Overhead line insulators: properties, materials used and types of insulators	CO 5	T2: 8.4-8.5, R1: 81
20	String efficiency and methods for improvement	CO 6	T2: 8.6, R1: 8.2
21	Testing of insulators	CO 5	T2: 8.4-8.5, R1: 81
22	Underground cables: Construction, types of insulating materials	CO 5	T2: 11.1 -11.5, R1: 9.1&9.9
23	Types of cables	CO 2	T2: 11.1 -11.5, R1: 9.1&9.9
24	Calculation of insulation resistance and capacitance in insulation of a single core cable	CO 7	T2:11.7-11.10, R1: 9.4 & 9.5
25	Calculation of Dielectric stress on single core cables	CO 7	T2:11.7-11.10, R1: 9.4 & 9.5
26	Capacitance of 3-core belted cables	CO 7	T2:11.7-11.10, R1: 9.4 & 9.5
27	Grading of cables: description of capacitance grading and inter-sheath grading	CO 7	T2:11.11-11.13
28	Sag and tension calculations with equal and unequal heights of towers, Effect of wind and ICE on weight of conductor	CO 8	T2: 8.15& 8.16
29-30	Stringing chart, sag template and its applications, Mechanical design of typical towers and conductors for 400KV, 220KV and 132KV operations	CO 8	T2: 8.16, R1: 7.4&7.5
31	Distribution systems: Classification, comparison of DC vs AC and underground vs overhead	CO 9	T5:12.5-12.8, R1: 12.4
32	Radial and ring main system, requirements and design features	CO 9	T5:12.9-12.10, R1: 12.4
33	Substation: Substation design, equipments, types of substations, bus bar arrangement layout, bus schemes, location	CO 9	T5:12.12, R1: 12.4
34	Kelvin's law for the design of feeders and its limitations	CO 9	T5:12.15, R1: 12.5

35-37	Voltage drop calculations in DC distributors: Radial DC distributor fed at one end and at both the ends (equal / unequal voltages) and ring main distributor	CO 9	T5:12.13, R1: 12.4
38-39	oltage drop calculations in AC distributors, power factors referred to receiving end voltage and with respect to respective load voltages,	CO 9	T5:12.14, R1: 12.4
40	Basic concept of interconnected systems: Indian electricity rules	CO 10	R1:1.1 1-1.12
41	Various voltage levels of transmission and distribution systems, Indian grid scenario.	CO 10	R1:1.1 1-1.12
PROBLEM SOLVING/ CASE STUDIES			
42	Numerical Problems to calculate inductance of single phase and three phase line	CO 1	T1: 3.4, R1: 3.4
43	Numerical Problems to calculate inductance of bundled conductor line and double circuit line	CO 1	T1: 3.5, R1: 3.5
44	Numerical Problems to calculate capacitance of single phase and three phase line	CO 1	T1: 3.9, R1: 3.6
45	Numerical Problems to calculate capacitance of bundled conductor line	CO 1	T1: 3.7, R1: 3.7
46	Numerical Problems to calculate capacitance of double circuit line	CO 1	T1: 3.1-3.7, R1: 3.1-3.7
47	Numerical Problems on corona	CO 2	T2: 14.1-14.10, R1: 6.1-6.6
48	Numerical problems to evaluate performance of short and medium transmission lines	CO 3	T1:5.1-5.3, R1:4.1-4.3
49	Numerical problems to evaluate performance of long lines	CO 3	T1:5.1-5.3, R1:4.1-4.3
50	Problems on Ferranti effect, surge impedance and SIL of long lines	CO 4	T1: 5.4 -5.10, R1:4.4-4.6
51	Numerical problems to calculate string efficiency	CO 6	T2: 8.7, R1: 8.2
52	Numerical problems on resistance, capacitance of cables	CO 7	T2: 11.7-11.10, R1: 9.1-9.5
53	Numerical problems on dielectric stress of cables	CO 7	T2: 11.7-11.10, R1: 9.1-9.5
54	Numerical problems on grading of cables	CO 7	T2:11.11-11.13
55	Numerical problems to calculate sag and tension claulation for supports at equal levels	CO 8	T2: 8.4-8.7, R1: 8.1-8.2
56	Voltage drop calculations in AC and DC distribution feeders	CO 9	T2: 8.4-8.7, R1: 8.1-8.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Skin effect, Proximity effect, inductive reactance spacing factor, transposition of lines	CO 4	T1: 2.1-2.10

58	Propagation constant, characteristic impedance, surge impedance and surge impedance loading, wave length, velocity of propagation of waves	CO 4	T1: 5.1-5.7
59	String efficiency, safety factor of insulators, sag and tension on lines, sag template, stringing chart	CO 6	T2: 8.4-8.7
60	Insulation resistance, dielectric stress, capacitance grading, inter sheath grading	CO 7	T2:11.1-11.13
61	Distributio system classification, substation equipment, indian grid scenario	CO 10	T5:12.1-12.14
DISCUSSION OF QUESTION BANK			
62	UNIT I: Transmission line parameters	CO 1	T1: 2.1-2.10
63	UNIT II:Modeling and performance of transmission lines	CO 3	T1: 5.1-5.7
64	UNIT III: Overhead Insulators and underground Cables	CO 5	T2: 8.4-8.7
65	UNIT IV: Mechnaical design of tranmsision lines	CO 8	T5:12.1-12.14
66	UNIT V: Distribution Systems	CO 9	T2:11.1-11.13

Signature of Course Coordinator **HOD,EEE**

Mr. P Mabuhussain, Assistant Professor