



IARE
INSTITUTE OF
AERONAUTICAL ENGINEERING

Outcome Based Education (OBE) Manual
IARE – MT23



(M.Tech – Electrical Power Systems)

Department of
Electrical and Electronics Engineering

Contents

1	Vision, Mission, Quality Policy, Philosophy & Core Values	1
1.1	Vision and Mission of the Institution	1
1.2	Vision and Mission of the Department	2
2	Program Educational Objectives (PEOs)	2
2.1	Mapping of program educational objectives to program outcomes :	3
3	Program Outcomes (POs)	3
4	Relation between the Program Educational Objectives and the POs	4
5	Blooms Taxonomy	5
5.1	Incorporating Critical Thinking Skills into Course Outcome Statements	6
5.2	Definitions of the different levels of thinking skills in Bloom’s taxonomy:	6
5.3	List of Action Words Related to Critical Thinking Skills	7
6	Guidelines for writing Course Outcome Statements:.....	10
6.1	Course Outcomes (COs)	10
6.2	Developing Course Outcomes	10
6.3	Relationship of Course Outcome to Program Outcome	11
6.4	Characteristics of Effective Course Outcomes.....	11
6.5	Examples of Effective Course Outcomes.....	11
6.6	CO-PO Course Articulation Matrix (CAM) Mapping	14
6.7	Tips for Assigning the values while mapping COs to POs.....	15
6.8	Method for Articulation	15
7	Key Competencies for Assessing Program Outcomes	16
8	Program Outcomes Attained through course modules.....	18
9	Methods for measuring Learning Outcomes and Value Addition.....	19
9.1	Continuous Internal Assessment (CIA).....	20
9.2	Alternate Assessment Tools (AAT)	20
9.3	Semester End Examination (SEE)	20
9.4	Laboratory and Project Works	20
9.5	Course Exit Surveys.....	20
9.6	Programme Exit Survey	20
9.7	Alumni Survey	20
9.8	Employer Survey	21
9.9	Course Expert Committee.....	21
9.10	Programme Assessment and Quality Improvement Committee (PAQIC).....	21
9.11	Department Advisory Board (DAB)	21
9.12	Faculty Meetings.....	22
9.13	Professional Societies	22
10	CO - Assessment processes and tools:.....	22
10.1	Direct Assessment.....	22

10.2	Indirect Assessment	23
11	PO- Assessment tools and Processes	24
11.1	PO Direct Attainment is calculated using the following rubric	24
12	Course Description	25
A	Sample Course Description	26

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 favors of students. OBE provides clear standards for observable and measurable outcomes.

National Board of Accreditation (NBA) is an authorized body for the accreditation of higher education institutions in India. NBA is also a full member of the Washington Accord. NBA accredited 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. 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, Philosophy & Core Values

1.1 Vision and Mission of the Institution

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 Vision and Mission of the Department

Vision of the Department

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

Mission of the Department

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 Behavior. 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.

The PEOs are defined with input from all program constituents and describe the expected accomplishments of graduates during the first several years following graduation:

PEO 1: Success in Electrical Power Systems

Impart engineering knowledge in specific and re-equip with latest technologies to analyze, synthesize the problems in power system and multidisciplinary sectors.

PEO 2 Industrial awareness and research

Design, develop innovative products and services in the field of electrical power systems with the latest technology and toolset.

PEO 3 Successful employment and professional ethics

Inculcate research attitude and life-long learning for a successful career.

PEO 4 Being a leader professional and societal environment

Attain intellectual leadership skills to cater the needs of power industry, academia, society and

environment.

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:

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

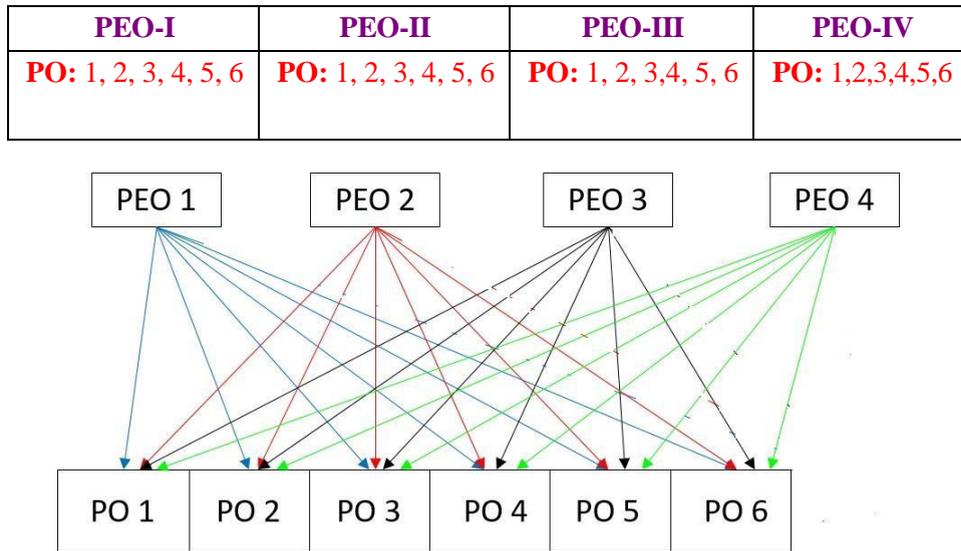


FIGURE 1: Correlation between the PEOs and the POs

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 3 POs and departement has defined 3 more and totally 6 POs are followed for the course. 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.

M. Tech (EPS) - PROGRAM OUTCOMES (PO's)	
A graduate of the Electrical and Electronics Engineering Program will demonstrate:	
PO1	An ability to independently carry out research/investigation and development work to solve practical problems.

PO2	Write and present a substantial technical report / document
PO3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.
PO4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

4 Relation between the Program Educational Objectives and the POs

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

PEO's → ↓ PO's		(1)	(2)	(3)	(4)
		Success in Electrical Power Systems	Industrial awareness and research	Being a leader professional and societal environm ent	Being a leader professional and societal environment
PO1	An ability to independently carry out research/investigation and development work to solve practical problems	3	3	3	3
PO2	Write and present a substantial technical report / document..	2	2	3	3
PO3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically..	2	3	2	3

O4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	2	3	2	3
PO5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment..	2	2	2	2
PO6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	3	3	3	3

Relationship between Program Outcomes and Program Educational Objectives

Key: 3 = High; 2 = Medium; 1= Low

- The assessment process of POs 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.

5 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.

5.1 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 2: Revised version of Bloom's taxonomy

5.2 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.

5.3 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
<ul style="list-style-type: none"> • Knowledge of terminologies • Knowledge of specific details and elements 	<ul style="list-style-type: none"> • Knowledge of classifications and categories • Knowledge of principles and generalizations • Knowledge of theories, models and structures 	<ul style="list-style-type: none"> • Knowledge of subject specific skills and algorithms • Knowledge of subject specific techniques and methods • Knowledge of criteria for determining when to use appropriate procedures 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Choose • Define • Find • How • Label • List • Match • Extend 	<ul style="list-style-type: none"> • Classify • Compare • Contrast • Demonstrate • Explain • Illustrate • Infer • Interpret 	<ul style="list-style-type: none"> • Apply • Build • Choose • Construct • Develop • Interview • Make use of • Model 	<ul style="list-style-type: none"> • Analyze • Assume • Categorize • Classify • Compare • Discover • Dissect • Distinguish 	<ul style="list-style-type: none"> • Agree • Appraise • Assess • Award • Choose • Criticize • Decide • Deduct • Importance 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Name • Omit • Recall • Relate • Select • Show • Spell • Tell • What • When • Where • Which • Who • Why 	<ul style="list-style-type: none"> • Outline • Relate • Rephrase • Show • Summarize • Translate • Experiment with • Illustrate • Infer • Interpret • Outline • Relate • Rephrase • Show • Summarize • Translate • Experiment with 	<ul style="list-style-type: none"> • Organize • Plan • Select • Solve • Utilize • Identify • Interview • Make use of • Model • Organize • Plan • Select • Solve • Utilize • Identify 	<ul style="list-style-type: none"> • Divide • Examine • Function • Inference • Inspect • List Motive • Simplify • Survey • Take part in • Test for Theme • Conclusion • Contrast 	<ul style="list-style-type: none"> • Defend • Determine • Disprove • Estimate • Evaluate • Influence • Interpret • Judge • Justify Mark • Measure • Opinion • Perceive • Prioritize • Prove • Criteria • Criticize • Compare • Conclude 	<ul style="list-style-type: none"> • Create • Design • Develop • Estimate • Formulate • Happen • Imagine • Improve • Make up • Maximize • Minimize • Modify • Original • Originate • Plan • Predict • Propose • Solution

6 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)

6.1 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.

6.2 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.

6.3 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).”

6.4 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

6.5 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.
- Analyze a character's motivation and portray that character before an audience.
- Differentiate among five major approaches to literary analysis
- List the major ethical issues one must consider when planning a human-subjects study.
- Locate and critically evaluate information on current political issues on the Web.
- List and describe the functions of the major components of the human nervous system.
- Correctly classify rock samples found in...
- Conduct a systems analysis of a group interaction.
- Demonstrate active listening skills when interviewing clients.
- Apply social psychological principles to suggest solutions to contemporary social problems.

A more detailed model for stating learning objectives requires that objectives have three parts: a condition, an observable behavior, and a standard. The table below provides three examples.

S No	Condition	Observable Behavior	Standard
1	Given a list of drugs	the student will be able to classify each item as amphetamine or barbiturate	with at least 70% accuracy
2	Immediately following a fifteen-minute discussion on a topic.	the student will be able to summarize in writing the major issues being discussed.	mentioning at least three of the five major topics.
3	Given an algebraic equation with one unknown.	the student will be able to correctly solve a simple linear equation	within a period of five minutes.

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

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

Examples 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?

6.6 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 7: Process for mapping the values for CO-PO Matrix

Type	POs	Action Verb(s) in POs	Bloom's level(s) for POs	Bloom's level(s) for COs
Technical	PO1	Apply	L3	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
	PO2	Build	L6	
		Discover	L4	
	PO3	Analyze	L4	
		Choose	L5	
	PO4	Illustrate	L2	
		Build	L6	
	PO5	Explain	L2	
		Develop	L3	
	PO6	Develop	L3	
Solve		L6		

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).

6.7 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.

6.8 Method for Articulation

1. Identify the key competencies of POs 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 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 and your course syllabus for writing the justification.
3. Make a table with number of key competencies for CO – PO 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 mapping with reference to the maximum given Key Attributes for Assessing Program Outcomes.
5. Finally, Course Articulation Matrix (CO - PO Mapping) is prepared with COs and POs 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

$0-0 \leq C \leq 5\%$ - No correlation. $1-5 < C \leq$

40% - Low / Slight. $2-40\% < C < 60\%$ -

Moderate

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

7 Key Competencies for Assessing Program Outcomes:

PO Number	PO Statement / Key Competencies Features (KCF)	No.of KCF(s)
PO 1	<p>An ability to independently carry out research/investigation and development work to solve practical problems</p> <ol style="list-style-type: none"> 1. Independence and Self-direction in solving practical problems 2. Scope definition and deliverables by referring related literature 3. Work breakdown structure including resource identification, schedule and implementation 	4
PO 2	<p>An ability to write and present a substantial technical report / document.</p> <ol style="list-style-type: none"> 1. Students should demonstrate the ability to communicate effectively in writing / orally. The following parameter should be available in the technical report as well as presentations of the students: 2. Clarity (Writing) 3. Grammar/Punctuation (Writing) 4. References (Writing) 5. Less than 10 % plagiarism (Writing) 6. Speaking Style and Body language (Oral) 7. Subject Matter (Oral) 	7
PO 3	<p>Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.</p> <ol style="list-style-type: none"> 1. Analysis and synthesis of systematic procedure to examine modern power system, protection renewable energy sources through practical ideas. 2. Assess, inspect, survey and analyze energy flow in environmental aspects. 3. Adapt in-depth knowledge in Power system and related areas to control and manage the power generation and utilization to improve the safety and societal needs 4. Adopt the engineering professional code and conduct. 5. Explore ideas to carry out research / investigation independently to solve practical problems through continuing education. 6. Evolve into green energy and assess results to satisfy cultural, ethical and environmental needs. 	7

	7. Potential contribution of clean and renewable energy for rural development	
PO 4	<p>Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.</p> <ol style="list-style-type: none"> 1. Analyze the operational control and protection of electrical power system using advanced level computing techniques. 2. Assess the interconnected power system using emerging engineering field like Cyber Security, Optimization Techniques, Machine learning, Data science etc. 3. Formulate reliability, efficiency and compliant operation of electrical power systems. 4. Compose and familiarize the safety, legal and health norms in electrical system. 	4
PO 5	<p>Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.</p> <ol style="list-style-type: none"> 1. Choose explicit software and programming tools for electrical systems. 2. Adapt emerging area resources and literature search for theory as well as laboratories. 3. Construct model, algorithm, program for operation and control of modern electrical Power Systems through Artificial intelligence and optimization techniques. 4. Identify protocols/techniques to work in various environments Interpretation of results in related domain 5. Create interdisciplinary environment through solution of power system related problem /prototype development/implementation/hands-on -training in AI using MATLAB, PSCAD etc. 	5
PO 6	<p>Engage in life-long learning for continuing education in doctoral level studies and professional development.</p> <ol style="list-style-type: none"> 1. Excel in Project management and research orientation / Ph.D/ Academia 2. Strengthen in advanced / emerging concepts 3. Personal continuing education efforts through literature, courses 4. Ongoing learning – stays up with industry trends/ new technology 5. Continued personal development in all aspects of life. 	5

8 Program Outcomes Attained through course modules:

Courses offered in Electrical and Electronics Engineering Curriculum (PG-21) and Pos attained through course modules for I, II, III, IV semesters.

S. No	Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6
1.	BPSD01	Modern Power System Analysis	✓	-	✓	✓	✓	✓
2.	BPSD02	Economic Operation of Power Systems	✓	-	✓	✓	✓	✓
3.	BHSD01	Research Methodology & IPR	✓	✓	✓	-	-	✓
4.	BPSD03	HVDC Transmission and FACTS	✓	-	✓	✓	-	✓
5.	BPSD04	Smart Grid Technologies	✓	-	✓	✓	-	✓
6.	BPSD05	Internet of Things	✓	-	✓	✓	-	✓
7.	BPSD06	Renewable Energy Systems	✓	-	✓	✓	-	✓
8.	BPSD07	Reactive Power Compensation and Management	✓	-	✓	✓	-	✓
9.	BPSD08	Hybrid Electric Vehicles	✓	-	✓	✓	-	✓
10.	BPSD09	Advanced Digital Signal Processing	✓	-	✓	✓	-	✓
11.	BPSD10	Electrical Power Distribution System	✓	-	✓	✓	-	✓
12.	BHSD02	English for Research Paper Writing	✓	✓	-	-	-	✓
13.	BHSD03	Disaster Management	✓	-	-	-	✓	-
14.	BHSD04	Sanskrit for Technical Knowledge	✓	-	-	-	-	-
15.	BHSD05	Value Education	✓	-	-	-	✓	-
16.	BPSD11	Power System Computational Laboratory	✓	-	✓	✓	✓	✓
17.	BPSD12	Internet of Things Laboratory	✓	-	✓	✓	✓	✓
18.	BPSD13	Digital Protection of Power Systems	✓	-	✓	✓	✓	✓
19.	BPSD14	Power System Dynamics and Stability	✓	-	✓	✓	✓	✓
20.	BPSD15	Swarm Intelligence Techniques in Power Systems	✓	-	✓	✓	-	✓
21.	BPSD16	Industrial Load Modelling and Control	✓	-	✓	✓	-	✓
22.	BPSD17	Cyber Security in Power System	✓	-	✓	✓	-	✓
23.	BPSD18	Restructured Power Systems	✓	-	✓	✓	-	✓
24.	BESD19	AI Techniques in Power Systems	✓	-	✓	✓	-	✓
25.	BESD20	Power Quality	✓	-	✓	✓	-	✓
26.	BESD21	Data Science and Machine Learning for Modern Power Systems	✓	-	✓	✓	-	✓
27.	BESD22	High Frequency Magnetic Components	✓	-	✓	✓	-	✓
28.	BHSD06	Constitution of India	✓	-	-	-	✓	-
29.	BHSD07	Pedagogy Studies	✓	-	-	-	✓	✓
30.	BHSD08	Stress Management by Yoga	✓	-	-	-	✓	-
31.	BHSD09	Personality Development through Life Enlightenment Skills	✓	-	✓	✓	✓	✓
32.	BPSD23	Artificial Intelligence in Power Systems Laboratory	✓	✓	✓	✓	✓	✓
33.	BPSD24	Power Systems Laboratory	✓	✓	✓	✓	✓	✓
34.	BPSD25	Mini Project with Seminar	✓	✓	✓	✓	✓	✓
35.	BPSD26	SCADA System and Applications	✓	-	✓	✓	-	✓
36.	BPSD27	Power System Reliability	✓	-	✓	✓	-	✓
37.	BPSD28	Grid Instrumentation and Communication Systems	✓	-	✓	✓	-	✓
38.	BPSD29	Electrical Transients in Power Systems	✓	-	✓	✓	-	✓
39.	BPSD30	Data Analytics	✓	✓	-	-	-	✓
40.	BPSD31	Operational Research	✓	✓	-	-	-	✓

41.	BPSD32	Real Time Operating Systems	✓	✓	-	-	-	✓
42.	BPSD33	Waste to Energy	✓	✓	-	-	-	✓
43.	BPSD34	Dissertation (Phase-I)	✓	✓	✓	✓	✓	✓
44.	BPSD35	Dissertation (Phase-II)	✓	✓	✓	✓	✓	✓
45.	BPSD36	Dissertation Viva-Voce	✓	✓	✓	✓	✓	✓
No. of courses mapped with POs			45	12	34	34	18	40
Percentage of courses with POs (%)			100	26.66	75.55	75.55	40.00	88.88

9 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.

9.1 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.

9.2 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 etc. The AAT chosen for this course is given in table.

9.3 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 advisory board (DAB) and to the principal for taking necessary actions to better the course for subsequent semesters.

9.4 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.

9.5 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 DAB meetings.

9.6 Programme Exit Survey

The programme exit 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 DAB for implementation purposes.

9.7 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 as 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.

9.8 Employer Survey

The main purpose of this employer questionnaire is to know employer's views about the skills they require of employees compared to the skills actually possessed by them. The purpose is also to identify gaps in technical and vocational skills, 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.

9.9 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.

9.10 Programme Assessment and Quality Improvement Committee (PAQIC)

PAQIC Monitors the achievements of Program Outcomes (POs) 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 motivates the faculty and students towards attending workshops, developing projects,

working models, paper publications and engaging in research activities.

9.11 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.

9.12 Faculty Meetings

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

9.13 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.

10 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%

10.1 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—
Department of Electrical and Electronics Engineering (M.Tech – Electrical Power Systems) 21

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

10.2 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 12: Tools used in Indirect assessment

Tools	Process	Frequency
Course end survey	<ul style="list-style-type: none"> • 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.

11 PO- Assessment tools and Processes

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

1. Direct method
2. Indirect method

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

TABLE 13: Attainment of PO

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

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

11.1 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.

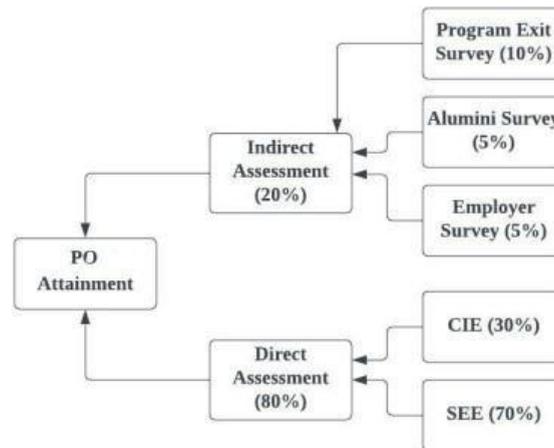


FIGURE 3: The evaluation process of PO attainment through course outcome attainment

12 Course Description:

The “Course Description” provides general information regarding the topics and content addressed in the course. A sample course description is given in Appendix – A 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
- How Program Outcomes are assessed
- Mapping of each CO with PO(s)
- Justification for CO – PO mapping- direct
- Total count of key competencies for CO – PO mapping
- Percentage of key competencies for CO – PO
- Course articulation matrix (PO mapping)
- Assessment methodology-direct
- Assessment methodology-indirect
- Syllabus
- List of Text Books / References / Websites
- Course Plan

Appendix A

Sample Course Description



INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal - 500 043, Hyderabad, Telangana

COURSE OUTLINE DESCRIPTION

SECTION 1: General Information about the Course	
Course Title	Power Electronics Applications to Power Systems
Course Code	BPSE03
Course Start	I
Course Type	Professional Elective
Regulation	IARE - MT 25
Prerequisite Courses	Power Electronics
Department	Electrical and Electronics Engineering
Number of Credits	3 Credit hours
Academic Year	2025-26
Method(s) of Instruction	Theory
Course Administrator	M.VARALAKSHMI , Assistant Professor of EEE IARE11072 m.varalakshmi@iare.ac.in
Course Coordinator's Name	M.VARALAKSHMI , Assistant Professor of EEE IARE11072 m.varalakshmi@iare.ac.in
Prior Learning Assessment and Recognition (PLAR)	Students interested in PLAR pathways for open learning can register one semester prior to the start of semester. Students will receive the necessary contact information one semester in advance.
Open Learning Faculty Member Information	Open Learning Faculty (OLF) is available to assist students. Students will receive the necessary contact information at the start of the course.
Course Webpage	https://onlinecourses.nptel.ac.in/noc24_ee130/preview
Course Description	This course introduces the principles and applications of power electronics in modern power systems. Students will explore how converters, inverters, and other electronic devices are integrated into power systems to enhance efficiency, flexibility, stability, and reliability—particularly in renewable energy integration, smart grids, HVDC transmission, and FACTS controllers. It bridges the gap between traditional power engineering and modern electronic control, emphasizing control, conversion, and effective utilization of electrical energy.

Course Objectives	<p>The students will try to learn:</p> <ul style="list-style-type: none"> • Understand the principles of power electronic converters (AC–DC, DC–DC, DC–AC, AC–AC) and their operation within power systems. • Analyze how converters are used for power flow control, voltage regulation, and reactive power compensation. • Examine FACTS and HVDC technologies for modern grid operation. • Explore the role of power electronics in renewable energy systems and energy storage integration. • Understand control strategies and protection techniques used in converter-based power systems.
Text and Reference Books	<p>Text Books</p> <ol style="list-style-type: none"> 1. Text Books: 2. Ned Mohan, Tore M. Undeland, William P. Robbins – Power Electronics: Converters, Applications and Design, John Wiley & Sons, 2017. 3. P.S. Bimbhra – Power Electronics, Khanna Publishers, 2012. 4. Rashid M.H. – Power Electronics: Circuits, Devices, and Applications, Pearson, 2022. 5. Reference Books: 6. Hingorani N.G., Gyugyi L. – Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, IEEE Press, 2000. 7. Padiyar K.R. – HVDC Power Transmission Systems: Technology and System Interactions, New Age International, 2011.

Learning Resources	<p>The complete set of course materials is made available in the IARE Learning Management Portal – Akanksha, which includes:</p> <ul style="list-style-type: none"> • Lecture notes and PowerPoint presentations (PPTs) • Tutorial and problem-solving question banks • Technical talk topics and assignments • Model question papers (2 sets) • Complex engineering problem statements • MATLAB/Simulink simulation exercises • Recorded ELRV video lectures <p>https://akanksha.iare.ac.in</p>
Supplemental Materials	<p>Readings, Videos, and Links</p> <ol style="list-style-type: none"> 1. IEEE Xplore Digital Library – Power Electronics & Smart Grid Publications 2. Elsevier Energy Journal – Converter Control and Power Quality
Learning and Teaching Strategies	<p>Students will engage in lectures, tutorials, problem-solving sessions, and simulation-based modeling (MATLAB/Simulink). Learning resources include video lectures, assignments, case studies, and model question papers available through the IARE Learning Management Portal – Akanksha.</p>

SECTION 2: Teaching Learning Scheme

At least 48 lecture hours of scheduled teaching and learning activities (TLA) will be delivered in person, with the remaining hours for scheduled and self-scheduled teaching and learning activities delivered either in person or online.

Notional Study Time: 90 Hours (Lecture hours: 48, Tutorial hours: 8, Scheduled revision session hours: 2, Guided independent study hours: 15, Homework / Programming assignment hours: 10, Course project / Preparation for complex problem solving hours: 15)

TLA Code	Teaching and Learning Activities	Number	Duration (Hours)	Total Workload
TLA1	Lectures	48	01	48
TLA 2	Tutorials	00	01	00
TLA 3	Case Study			

TLA 4	Problem Solving			
TLA 5	Demonstration			
TLA 6	Scheduled revision sessions	00	01	00
TLA 7	Guided independent study: Directed viewing of video materials / PPTs			00
TLA 8	Independent private study			
TLA 9	Laboratory Exercises	0	0	0
TLA 10	Homework assignments / Programming assignments			10
TLA 11	Placement / work based learning or Specific practical training	0	0	0
TLA 12	Presentation / Seminar Preparation			
TLA 13	Course Project / Preparation for Complex Problem Solving			00
TLA 14	Technical visit			
TLA 15	Field activities	0	0	0
Total study hours				48
Expected total study hours				48

SECTION 3A: Course Outcomes

After successfully completing this course, the student will be able to:

Outcome Number	Course Outcomes	Learning Domain
CO1	Explain the fundamental principles of power electronic converters and their roles in modern power systems.	Understand
CO2	Analyze the operation, control, and performance characteristics of converters used in transmission systems such as HVDC and FACTS devices.	Analyze
CO3	Evaluate the application of power electronic controllers for voltage regulation, reactive power compensation, and stability improvement in power networks.	Evaluate
CO4	Design and model converter-based systems for distribution networks and microgrids, including custom power devices and solid-state transformers.	Apply
CO5	Apply power electronics concepts in integrating renewable energy sources and energy storage systems with the grid while ensuring power quality and reliability.	Apply
CO6	Use simulation tools (e.g., MATLAB/Simulink) to model, analyze, and validate the performance of power electronic systems in various power system applications.	Create

SECTION 3B: Cognitive Levels

Blooms Taxonomy Level	Cognitive Level in Percentage (%)
Understand	20
Analyze	20
Evaluate	15
Apply	30
Create	15

SECTION 4: Content and Context of Operation Research

CO1	Explain the fundamental principles of power electronic converters and their roles in modern power systems.
	<ul style="list-style-type: none"> • Role of power electronics in power systems • Basics of power converters: Buck, Boost, Buck-Boost • Control techniques: peak current mode, average current-mode • Switching and average models • Control design issues in voltage-fed DC–DC converters
CO2	Analyze the operation, control, and performance characteristics of converters used in transmission systems such as HVDC and FACTS devices.
	<ul style="list-style-type: none"> • High-power semiconductor switching characteristics • PWM algorithms • Three-phase voltage source inverter operation • Harmonic analysis: THD and HCF • DC bus capacitor design in AC/DC/AC converters
CO3	Evaluate the application of power electronic controllers for voltage regulation, reactive power compensation, and stability improvement in power networks.
	<ul style="list-style-type: none"> • Uncompensated AC line analysis • Series and shunt compensation • Overview of FACTS devices • Harmonic filtering: active, passive, hybrid • Power quality conditioners and dynamic voltage restorers
CO4	Design and model converter-based systems for distribution networks and microgrids, including custom power devices and solid-state transformers
	<ul style="list-style-type: none"> • Design and modeling of systems for microgrids and distribution networks • Custom power devices and solid-state transformers
CO5	Apply power electronics concepts in integrating renewable energy sources and energy storage systems with the grid while ensuring power quality and reliability.
	<ul style="list-style-type: none"> • Devices: SVC, STATCOM, SSSC • Voltage regulator design • Harmonic mitigation techniques • Protection and control strategies
CO6	Use simulation tools (e.g., MATLAB/Simulink) to model, analyze, and validate the performance of power electronic systems in various power system applications.
	<ul style="list-style-type: none"> • Applications in domestic and industrial settings • Power conditioning for renewable/distributed generation • Use of MATLAB/Simulink for modeling and analysis • Enhancing power quality and reliability

SECTION 5: Complex Engineering Problem Solving

Students will develop models for converter-based power systems, simulate FACTS devices for voltage regulation, and apply control strategies for renewable energy integration. They will use MATLAB/Simulink to optimize power quality and evaluate stability improvements.

SECTION 6A: Assessment Methods – Direct

Item	Evaluation Components	Week in / out	Marks
------	-----------------------	---------------	-------

AAT: 1 - 1	Tech-Talk	Week – 3 / 5	05
AAT: 1 - 2	Hack-a-thon	Week – 6 / 8	05
AAT: 2 - 1	Complex Engineering Problem Solving	Week – 9 / 12	05
AAT: 2 - 2	Hack-a-thon	Week – 13 / 15	05
CIE - 1	2 hours - Answer 4 out of 5 questions	Week - 9	10
CIE - 2	2 hours - Answer 4 out of 5 questions	Week - 17	10
SEE	3 hours - Answer 1 from each module	Week - 18	60
Total Marks			100
Department's Late Submission Policy:			
1. 1 – 24 hours: 25% of the mark will be deducted			
2. > 24 hours: Not accepted			
SECTION 6B: Assessment Methods –Indirect			
Course End Survey (End Semester OBE Feedback)			✓

SECTION 7: Engineering Competencies (ECs) Focused			
Please tick (✓) relevant engineering competency profile covered			
EC Number	Attributes	Profiles	(✓)
EC1	Depth of knowledge required (CP)	Ensures that all aspects of an engineering activity are soundly based on fundamental principles - by diagnosing, and taking appropriate action with data, calculations, results, proposals, processes, practices, and documented information that may be ill-founded, illogical, erroneous, unreliable or unrealistic requirements applicable to the engineering discipline	✓
EC2	Depth of analysis required (CP)	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.	✓
EC3	Design and development of solutions (CA)	Support sustainable development solutions by ensuring functional requirements, minimize environmental impact and optimize resource utilization throughout the life cycle, while balancing performance and cost effectiveness.	✓
EC4	Range of conflicting requirements (CP)	Competently addresses complex engineering problems which involve uncertainty, ambiguity, imprecise information and wide-ranging or conflicting technical, engineering and other issues.	-
EC5	Infrequently encountered issues (CP)	Conceptualizes alternative engineering approaches and evaluates potential outcomes against appropriate criteria to justify an optimal solution choice.	✓
EC6	Protection of society (CA)	Identifies, quantifies, mitigates and manages technical, health, environmental, safety, economic and other contextual risks associated to seek achievable sustainable outcomes with engineering application in the designated engineering discipline.	✓
EC7	Range of resources (CA)	Involve the coordination of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies) in the timely delivery of outcomes	-
EC8	Extent of stakeholder involvement (CP)	Design and develop solution to complex engineering problem considering a very perspective and taking account of stakeholder views with widely varying needs.	-
EC9	Extent of applicable codes, legal and regulatory (CP)	Meet all level, legal, regulatory, relevant standards and codes of practice, protect public health and safety in the course of all engineering activities.	-

EC10	Interdependence (CP)	High level problems including many component parts or sub-problems, partitions problems, processes or systems into manageable elements for the purposes of analysis, modelling or design and then re-combines to form a whole, with the integrity and performance of the overall system as the top consideration.	-
EC11	Continuing professional development (CPD) and lifelong learning (CA)	Undertake CPD activities to maintain and extend competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work.	✓
EC12	Judgement (CA)	Recognize complexity and assess alternatives in light of competing requirements and incomplete knowledge. Require judgement in decision making in the course of all complex engineering activities.	-

SECTION 8: Employability Skills

Example: Communication skills / Programming skills / Project based skills

Studying Data Structures equips the students with a range of employability skills that are highly valued in industries.

Employability Skills:

- Converter design and modeling
- Power system simulation (MATLAB/Simulink)
- Analytical and problem-solving skills
- Understanding of modern grid technologies
- Project-based and teamwork skills

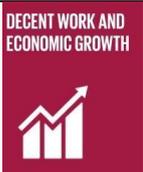
Project Management:

- Planning and organizing simulation studies
- Risk identification in converter-based systems
- Collaborative design in smart grid projects

- Collaborating and communicating with team members.
- Identifying and mitigating project risks.
- Testing and validating system performance.

SECTION 9: Relevance to Sustainability goals

Brief description about the course and its correlation with Sustainability Development Goal (SDGs).

SDG Goals		Correlation with SDG
4	 <p>QUALITY EDUCATION</p>	Quality Education: This subject will prepare students for modern technological challenges, improving educational tools, and promoting skills essential for global development.
8	 <p>DECENT WORK AND ECONOMIC GROWTH</p>	Decent Work and Economic Growth: Prepares students for careers in technology-driven industries, boosting employability and fostering innovation in the digital economy.

CO3	80	67	67	71	82	-	-		-	-	-	-	53	90	90
CO4	85	67	67	71	82	-	-		-	-	-	-	53	90	90
CO5	85	67	67	71	82	-	-		-	-	-	-	53	90	90
CO6	85	67	67	71	82	80	-		-	-	-	-	53	90	90

SECTION 10C: Course Articulation Matrix of COs to Pos

0 No Contribution (0-5%)		1 Low (≥ 5 - $< 40\%$)					2 Moderate (≥ 40 - $< 60\%$)					3 High ($\geq 60\%$)		
Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3	3	3	-	-	-	-	-	-	-	-	2	-	-
CO2	3	3	3	3	3	-	-	-	-	-	-	2	-	3
CO3	3	3	3	3	3	-	-	-	-	-	-	2	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	2	3	3
CO5	3	3	3	3	3	-	-	-	-	-	-	2	3	3
CO6	3	3	3	3	3	3	-	-	-	-	-	2	3	3
Total	18	18	18	15	15	3	-	-	-	-	-	12	12	15
Average	3	3	3	2.5	2.5	0.5	-	-	-	-	-	2	2	2.5

SECTION 10D: Level of Contribution of the COs to POs and PSOs

Number	Programme Outcomes	Proficiency Assessed by	Contribution Level (from 1 to 3)
PO 1	Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems .	CIE / SEE / AAT:1 – 2 Assignments / Open-ended problems	3
PO 2	Identify, formulate, review research literature and analyse complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4).	CIE / SEE / AAT:1 – 2 Hack-a-thon	3
PO 3	Design creative solutions for complex engineering problems and design / develop systems / components/ processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)	CIE / SEE / AAT:2 – 1 Complex Engineering Problem Solving	3
PO 4	Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8)	CIE / SEE / AAT:2 – 1 Complex Engineering Problem Solving	3
PO 5	Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems . (WK2 and WK6).	CIE / SEE / AAT:2 – 2 Hack-a-thon	3
PO 6	Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7)	CIE / SEE / AAT:2 – 2 Hack-a-thon	3

PO 11	Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)	CIE / SEE / AAT:2 – 1 Complex Engineering Problem Solving	3
PSO 1	Understand, design and analyze computer programs in the areas related to Algorithms, System Software, Web design, and Big data, Artificial Intelligence, Machine Learning and Networking.	AAT: 1 – 1 Tech-Talk	2
PSO 2	Focus on improving software reliability, network security or information retrieval systems.	AAT: 2 – 1 Complex Engineering Problem Solving	3
PSO 3	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	AAT: 2 – 1 Complex Engineering Problem Solving	3

SECTION 11: Course Content

MODULE - I	POWER ELECTRONIC CONVERTERS (09)
	Role of power electronics in power systems, Fundamentals of power converter, Voltage-Fed DC-DC Converters, Buck Boost, Buck-Boost converters, Peak Current Mode Control, Average Current-Mode Control. Control Design Issues in Voltage-Fed DC-DC Converters, Developing Switching and Average Models
MODULE - II	THREE-PHASE GRID-CONNECTED CONVERTERS (09)
	High-Power Semiconductor Devices, High-Power Devices Operated as Simple Switches, PWM algorithms, Three phase voltage source inverter-Operation, Functions and Performance indices (Total Harmonic Distortion (THD), Harmonic Current Factor (HCF), Current Distortion Factor, DC Bus Capacitor within an AC/DC/AC Power Converter.
MODULE - III	LINE COMPENSATION (09)
	Analysis of Uncompensated AC Line, Compensation by a Series Capacitor Connected at the Mid-point of the Line, Passive Compensation, Various FACTS devices; Power Quality Requirements, types of loads, harmonics, Active and Passive filters, Shunt, series and hybrid filters, Power Quality Conditioners
MODULE - IV	PRINCIPLES OF CONVENTIONAL REACTIVE-POWER COMPENSATORS (09)
	Concepts of SVC Voltage Control, Static Var Compensator (SVC), SVC Controller, Voltage Regulator Design, Harmonics and Filtering, Protection Aspects. Static Synchronous Compensator (STATCOM), Static Synchronous Series Compensator
MODULE - V	UNINTERRUPTIBLE POWER SUPPLIES (09)
	Power electronics in domestic and industrial loads; Power conditioning units for renewable power generation and distributed generation systems. Power Quality and Introduction to Custom Power devices.

SECTION 12: Tentative Schedule of Instructions

Week Number	Topics	Duration (Hours)
-------------	--------	------------------

1	Introduction to Power Electronics in Power Systems: Overview of power electronic applications, classification of converters, role in system stability and control.	3
2	DC–DC Converters: Buck, Boost, and Buck–Boost converters; voltage and current mode control; steady-state and dynamic analysis.	3
3	Control Design Issues: Peak current mode, average current mode control, switching and average modeling of DC–DC converters.	3
4	High Power Semiconductor Devices: IGBTs, MOSFETs, GTOs, and thyristors; switching characteristics and losses; PWM techniques for converters.	3
5	A Three-Phase Grid-Connected Converters: Structure, operation, and control of three-phase VSI; harmonic analysis (THD, HCF, CDF); DC link capacitor design.	3
6	AC Line Compensation: Need for compensation; analysis of uncompensated AC line; midpoint series capacitor compensation.	3
7	FACTS Devices – I: Principles and applications of shunt and series compensation; overview of SVC, STATCOM, and TCSC.	3
8	FACTS Devices – II: Active, passive, and hybrid filters; harmonic compensation; power quality conditioners	3
CONTINUOUS INTERNAL EXAMINATION (CIE- I)		
9	Reactive Power Compensation: Concepts of reactive power; voltage regulation techniques; SVC control strategies.	3
10	STATCOM and SSSC: Structure, control, voltage regulation, protection aspects; harmonic mitigation and dynamic performance	3
	poison arrivals 10.3 Threaded binary trees, application of trees	
11	HVDC Converters: Converter configurations (line-commutated and voltage-source converters), control of power flow, and reactive power.	3
12	Renewable Integration: Power electronic interfaces for solar PV and wind systems; grid synchronization; MPPT and inverter control.	3
13	Energy Storage Systems: Role of batteries, ultracapacitors, and flywheels in converter-based systems; bidirectional converters	3
14	Uninterruptible Power Supplies (UPS): Operation, control, and design of UPS systems; power conditioning units and load management.	3
15	Custom Power Devices: DVR, D-STATCOM, and Unified Power Quality Conditioner (UPQC); control and simulation aspects.	3
16	MATLAB/Simulink Case Studies and Course Review: Simulation of converter-based systems, stability analysis, and model validation.	3
Total		48

SECTION 14: Specific Goals for the Course

The following table shows the knowledge and skills covered by the unit outcomes:

Knowledge	Skills
-----------	--------

Learners should understand:

- The role of power electronics in improving efficiency, stability, and reliability of modern power systems.
 - The operation and control principles of power electronic converters (AC–DC, DC–DC, DC–AC, AC–AC).
 - The concepts of reactive power compensation, voltage regulation, and power flow control using FACTS and HVDC technologies.
 - The integration of renewable energy systems (solar PV, wind, and energy storage) with the electrical grid through converter interfaces.
 - The control and protection strategies for converter-based systems to ensure stable and reliable operation.
 - The importance of power quality and harmonic mitigation using active and passive filters.
 - The design philosophy of custom power devices such as STATCOM, DVR, and UPS for both industrial and distribution system
- Analyze and evaluate converter-based reactive power compensation and control strategies in transmission and distribution networks.
 - Develop control algorithms for FACTS and HVDC systems to enhance voltage stability and minimize losses.
 - Integrate renewable and distributed energy resources into the power grid while maintaining system stability and reliability.
 - Implement simulation studies to examine converter efficiency, THD, and harmonic mitigation.
 - Optimize converter control parameters for achieving power factor correction and voltage support in microgrids.
 - Demonstrate practical understanding of power electronic applications through mini-projects, case studies, and simulation exercises.

Course Outline Approvals	
Course Coordinator Name: M. Varalakshmi Signature: Date:	Head of the Department Name: Dr. Damodhar Reddy Signature: Date:
Course Outline Approvals: The course outline description approved by Outcome Based Teaching Learning (OBTL) committee on date in meetings IARE - OBTL – COD /10/4/25	
Dean of Outcome Based Teaching and Learning Name: Dr. Srinivasulu Signature: Date:	Dean of Academics Name: Dr. GVR Seshagri Rao Signature: Date:

Check List		
Section	Description	Please tick (✓)
1	General Information about the Course	
2	Notional Study Time	
3	A. Course Outcomes	
	B. Cognitive Levels	
4	Content and Context of the Course	
5	Complex Engineering Problem Solving	
6	A. Assessment Methods – Direct	
	B. Assessment Methods – Indirect	
7	Content Delivery / Instructional Methodologies	
8	Engineering Competencies (ECs) Focused	
9	Employability Skills	
10	Relevance to Sustainability goals	
11	A. Mapping between COs and POs / PSOs	
	B. Indicators of Attainment with COs to POs and PSOs	
	C. Course Articulation Matrix of COs to POs	
	D. Level of Contribution of the COs to POs and PSOs	
12	Syllabus	
13	Tentative Schedule of Instructions	
14	Specific Goals for the Course	
15	History of Changes	

Signature of Course Coordinator
M.VARALAKSHMI

HOD, EEE