IARE

INSTITUTE OF
AERONAUTICAL ENGINEERING

OUTCOME BASED EDUCATION

PROCESS MANUAL (BT-23)

Computer Science and Engineering (AI & ML)

Contents

OVERVIEW

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

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

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

Vision

To become a leading force in Artificial Intelligence with skills and knowledge to develop innovative and sustainable AI solutions and AI based ventures.

Mission

To empower students with advanced knowledge and skills in Artificial Intelligence and Machine Learning, fostering innovation, ethical practice, and sustainable AI solutions that drive technological and societal impact.

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.

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 Computer Science and Engineering (AI & ML):
Students will establish a strong foundation in computer science, artificial intelligence and machine learning principles enabling them to design, develop, and implement intelligent systems for diverse applications.

Program Educational Objective – II: Industrial awareness and research:
Students will apply artificial Intelligence and machine Learning techniques to solve real-world problems, contribute to new advancements through research and explore entrepreneurial opportunities in emerging technologies.

Program Educational Objective – III: Successful employment and professional ethics: Students will demonstrate their ability to adapt to a rapidly changing environment by having learned and applied new skills and new technologies.

Program Educational Objective – IV: Being a leader in professional and societal environment:
Students will demonstrate ethical integrity, social responsibility, and effective teamwork while developing AI-driven solutions that address real-world problems ensuring inclusivity, fairness, and sustainability. 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 Computer Science and Engineering (AI & ML) 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:

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

PEO-I	PEO-II	PEO-III	PEO-IV
PO: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	PO: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	PO: 1, 2, 3, 5, 6, 7, 8, 9, 10, 11	PO: 6, 7, 8, 9, 10, 11

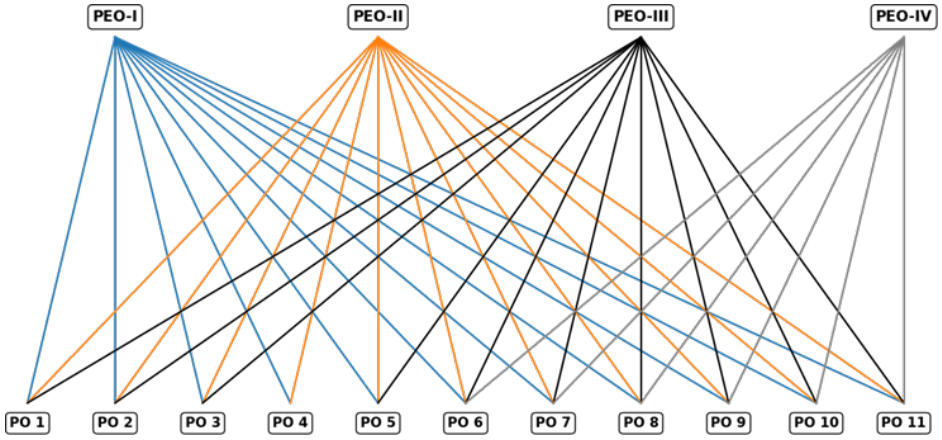

FIGURE 1: Correlation between the PEOs and the POs

The following Figure 2 shows the correlation between the PEOs and the PSOs

PEO-I	PEO-II	PEO-III	PEO-IV
PSO: 1, 2, 3	PSO: 1, 2, 3	PSO: 1, 2, 3	PSO: 1,2,3

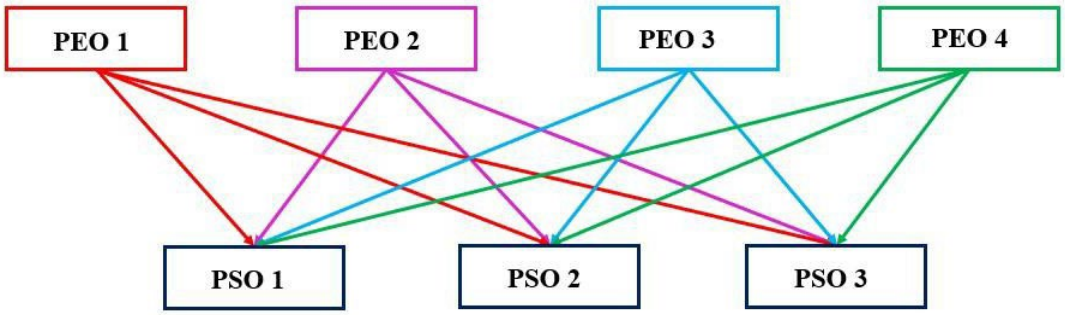

FIGURE 2: Correlation between the PEOs and the PSOs

3 Program Outcomes (POs)

Program outcomes are the statements of what a student is expected to know, understand and/or be able to demonstrate after completion of a process of learning. The Process of learning could be, for example, a lecture, module, or an entire program. These POs mainly relate to the knowledge, skills and attitudes that students acquire while progressing through the program. Specifically, it is to be established that the students have acquired the defined Program Outcomes. The program must demonstrate that by the time of graduation the students have attained a certain set of knowledge, skills and behavioral traits, at-least to some acceptable minimum level. The minimum threshold value should not be less than 50% even to begin with; however, as the program progresses through its evolution, it is expected that this minimum threshold value would subsequently be raised to higher value. Specifically, it is to be demonstrated that all students of a batch to be accredited have acquired the following POs set by NBA as shown in below table.

#	PROGRAMME OUTCOMES	DESCRIPTION
1	Engineering Knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization in Artificial Intelligence and Machine Learning to the solve of complex Computer Science engineering problems. (WK1 to WK4)
2	Problem Analysis:	Identify, formulate, review research literature, and analyse complex engineering problems in Artificial Intelligence and Machine Learning reaching conclusions using first principles of mathematics, natural sciences, and engineering sciences. (WK1 to WK4)
3	Design / Development of Solutions	Design and develop intelligent computing solutions for complex problems including AI-driven systems, software components, and data-centric processes that meet specified functional and performance requirements, with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.(WK5)
4	Conduct Investigations of Complex Problems	Conduct systematic investigations of complex problems in Artificial Intelligence and Machine Learning using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.(WK8)
5	Modern Tool Usage	Create, select, and effectively apply appropriate algorithms, computational techniques and modern IT and AI/ML tools to solve complex problems, including prediction, simulation, and modelling to complex engineering activities with an understanding of the limitations.((WK2 and WK6)
6	The Engineer and The World	Analyze and evaluate the societal, ethical, legal, economic, and environmental aspects of AI and computing solutions while addressing complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).
7	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering and responsible AI practice. (WK9)
8	Individual and Team Work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings while contributing to the development and deployment of Artificial Intelligence and Machine Learning solutions. (WK9)
9	Communication	Communicate effectively on complex Computer Science problems in Artificial Intelligence and Machine Learning 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. (WK1 and WK9)
10	Project Management and Finance	Demonstrate knowledge and understanding of the engineering and management principles and apply these to Artificial Intelligence and Machine Learning projects, as a member and leader in a team, to manage projects and in multidisciplinary environments. (WK2 and WK5)
11	Life-Long Learning	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning to keep pace with rapid technological advancements in Artificial Intelligence and Machine Learning and related emerging domains. (WK8)

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 Computer Science and Engineering (AI & ML) is given below.

B. Tech (CSE (AI & ML)) - PROGRAM SPECIFIC OUTCOMES	
A graduate of the Computer Science and Engineering (AI&ML) Program will demonstrate:	
PSO1	Apply advanced analytical and problem-solving skills for the application of AI in solving organizational challenges and new value creation. (WK1 to WK6)
PSO2	Analyze big contextual data sets to improve AI applications. (WK2 to WK6)
PSO3	Asses ethical, societal and legal considerations related to AI technologies. (WK6 to WK9)

5 Relation between the Program Educational Objectives and the POs

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

PEO's→ ↓ PO's		(1) Success in Professional career	(2) Design / Development of Solutions	(3) Lifelong learning and Re-search	(4) Effective Contribution to Society
PO1	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	3	3	3	2
PO2	Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)	3	3	2	2

PO3	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 re-quired. (WK5).	3	3	2	2
PO4	Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).	3	3	2	2
PO5	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)	3	3	2	2
PO6	Analyze and evaluate societal and environmental aspects while solving com-plex engineering problems for its im-pact on sustainability with reference to economy, he a l t h , safety, legal frame-work, culture and environment. (WK1, WK5, and WK7).	2	3	3	3
PO7	Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)	2	2	3	3
PO8	Function effectively as an individual, and as a member or leader in diverse/-multidisciplinary teams. (WK9)	2	2	3	3

PO9	Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences (WK1 and WK9)	2	3	3	3
PO10	Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multi-disciplinary environments. (WK2 and WK5)	2	3	3	3
PO11	Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii)adaptability to new and emerging technologies iii) critical thinking in the broadest context of technological change. (WK8)	2	3	3	3

Relationship between Program Outcomes and Program Educational Objectives Key: 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 Professional career	(2) Design / Development of Solutions	(3) Lifelong learning and Research	(4) Effective Contribution to Society

PSO1	Apply advanced analytical and problem-solving skills for the application of AI in solving organizational challenges and new value creation. (WK1 to WK6)	2	3	3	2
PSO2	Analyze big contextual data sets to improve AI applications. (WK2 to WK6)	3	2	3	2
PSO3	Asses ethical, societal and legal considerations related to AI technologies. (WK6 to WK9)	2	2	2	3

Relationship between Program Specific Outcomes and Program Educational Objectives Key: 3 = High; 2 = Medium; 1= Low

Note:

- The assessment process of POs and PSOs can be direct or indirect.
- The direct assessment will be done through interim assessment by conducting continuous internal exam and semester end exams.
- The indirect assessment on the other hand could be done through student's programme exit questionnaire, alumni survey and employment survey.

7 Knowledge and Attitude Profile (WK)

The list of WKs defines indicated volume of learning and attributes against which graduates must be able to perform. The list is used to extend and clarify the definition of the Program Outcomes. In order to inculcate different dimensions of thinking mathematical, computational, design and creativeness among students in cognitive, affective and psychomotor domains, the curriculum is designed to cover the following nine knowledge and attitude profiles. These profiles reflect an indicated volume of learning and the work attitude against which graduates must be able to perform. This list of WKs extracted verbatim from the 2024 NBA document are shown in below. table 10, and table 11 is representing their indicators of attainment.

WK	Knowledge and attitude Profile
WK1	A systematic, theory-based understanding of the **natural sciences** applicable to the discipline and awareness of relevant **social sciences**.
WK2	Conceptually-based **mathematics**, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
WK3	A systematic, theory-based formulation of **engineering fundamentals** required in the engineering discipline.
WK4	Engineering **specialist knowledge** that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
WK5	Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports **engineering design and operations** in a practice area.
WK6	Knowledge of **engineering practice** (Technology) in the practice areas in the engineering discipline.
WK7	**Knowledge of** the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.
WK8	Engagement with selected knowledge in the current **research literature** of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
WK9	**Ethics, inclusive behaviour and conduct**. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

Table 3: Knowledge and Attitude Profiles

7.1 Engineering Competencies:

A professionally or occupationally competent person has the attributes necessary to perform the activities within the profession or occupation to the standards expected in independent employment or practice. The engineering competence (EC) profiles - complex engineering problems (CP) and complex engineering activities (CA) record the elements of competence necessary for performance that the professional is expected to be able to demonstrate in a holistic way the stage of attaining registration. Complex Engineering Problems have characteristic WK1 and some or all of WK2 to WK9. Also, there are a Range of Complex Engineering Activities (CA) involved in when solving complex engineering problems.

Engineering competence can be described using a setoff attribute corresponding largely to the program outcomes (POs), but with different emphases. For example, at the professional level, the ability to the responsibility in the real-life situation is essential. Unlike the program outcomes, engineering competence is more than a set of attributes that can be demonstrated individually. Competence must be assessed holistically TWELVE elements of engineering competences for a global benchmarking are mentioned in below table.

The engineering competence profiles are stated generically and are applicable to all engineering disciplines. The application of a competence profile may require application in different regularly, disciplinary, occupational or environment contexts.

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.

8 Sustainable Development Goals:

SDG #	SDG GOALS		INITIATIVES
1		**End poverty**	• Ensure equitable access to education for students from low-income backgrounds. • Enhance academic success and graduation rates of economically disadvantaged students. • Increase research output and community engagement related to poverty alleviation. • Strengthen partnerships with LMICs (Lower-Middle-Income Countries) for academic and research collaboration. • Promote social mobility through scholarships and inclusive campus support.
2		**End hunger**	• Ensure access to nutritious and sufficient food for all students, especially those from low-income backgrounds. • Contribute to the reduction of hunger in local communities through outreach and innovation. • Promote sustainable food systems and zero food waste on campus. • Enhance awareness and action among students on food security and nutrition.
3		**Ensure healthy lives**	• Promote physical and mental well-being among all students and staff. • Ensure access to affordable, quality health services and emergency care on campus. • Encourage a healthy lifestyle and prevent non-communicable diseases (NCDs) through education and activities. • Support community health outreach and awareness.
4		**Ensure quality education**	• Ensure inclusive, equitable, and quality technical education for all students. • Promote lifelong learning opportunities through continuous skill development. • Reduce educational disparities across gender, economic status, and social background. • Improve teaching quality, curriculum relevance, and graduate employability. • Promote education for sustainable development, ethics and global citizenship.
5		**Achieve gender equality**	• Achieve gender parity in student enrolment, faculty recruitment, and leadership. • Promote a safe, respectful, and inclusive learning environment for all genders. • Eliminate gender-based discrimination and harassment on campus. • Empower women in STEM education, research, and innovation.
6		**Ensure access to water and sanitation**	• Ensure universal access to safe drinking water and adequate sanitation facilities on campus. • Improve water use efficiency and promote water conservation practices. • Prevent contamination and ensure safe discharge of wastewater. • Increase awareness and responsibility among students

			and staff for sustainable water usage.
7		**Ensure access to affordable energy**	• Ensure access to affordable, reliable, and modern energy services for all on campus. • Increase the share of renewable energy in campus energy consumption. • Enhance energy efficiency across academic and residential infrastructure. • Promote research and education in sustainable energy technologies.
8		**Promote economic growth**	• Promote inclusive and sustainable economic growth through skilled graduate output. • Enhance employability, entrepreneurship, and industrial collaboration. • Ensure safe, productive, and equitable working conditions for staff and students. • Strengthen innovation, internship, and incubation ecosystems on campus.
9		**Build infrastructure**	• Develop resilient and modern infrastructure that supports inclusive education and innovation. • Promote sustainable industrial collaboration and R&D activities. • Foster innovation ecosystems for students and faculty. • Strengthen the integration of advanced technologies into teaching and infrastructure.
10		**Reduce inequality**	• Ensure equitable access to quality education for all, regardless of background. • Promote inclusion of marginalized, disadvantaged, and differently-abled students and staff. • Reduce economic and social disparities in student support and academic outcomes. • Create an inclusive and non-discriminatory campus environment.
11		**Make cities sustainable**	• Develop a sustainable, inclusive, and resilient campus infrastructure. • Promote sustainable urban planning concepts through education and innovation. • Strengthen partnerships with local communities for inclusive development. • Reduce the college's ecological and environmental footprint.
12		**Ensure sustainable consumption**	• Ensure efficient and sustainable use of natural and institutional resources. • Reduce waste generation and promote circular economy practices. • Foster responsible consumption habits among students and staff. • Integrate sustainability principles into education, research, and operations.
13		**Take action on climate change**	• Strengthen institutional capacity to address climate-related risks. • Reduce greenhouse gas emissions and environmental footprint of the campus. • Foster climate literacy and research-driven action among students and faculty. • Promote climate-resilient infrastructure and practices.

14		**Conserve marine resources**	• Increase awareness and knowledge on marine ecosystems and sustainable aquatic practices. • Minimize campus-driven water pollution and impact on aquatic ecosystems. • Promote research and innovation on marine sustainability, water technologies, and conservation. • Engage in community and academic partnerships to support aquatic biodiversity.
15		**Life on land**	• Promote the conservation and sustainable use of terrestrial ecosystems. • Increase green cover and biodiversity on and around the campus. • Encourage research and community outreach related to afforestation, reforestation, and land restoration. • Integrate sustainable land and resource management into education and innovation.
16		**Peace, justice, and strong institutions**	• Foster a peaceful, inclusive and safe learning environment. • Promote ethical behavior, integrity, and accountability in academic governance. • Strengthen student voice, grievance redressal, and institutional transparency. • Encourage civic responsibility, democratic values, and legal awareness among students.
17		**Partnerships for the goals**	• Strengthen multi-stakeholder collaborations for sustainable development goals. • Build international, national, and regional partnerships to enhance education and research. • Mobilize resources and knowledge-sharing to achieve institutional and global goals. • Promote global citizenship and cross-border cooperation among students and faculty.

9 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.

9.1 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.

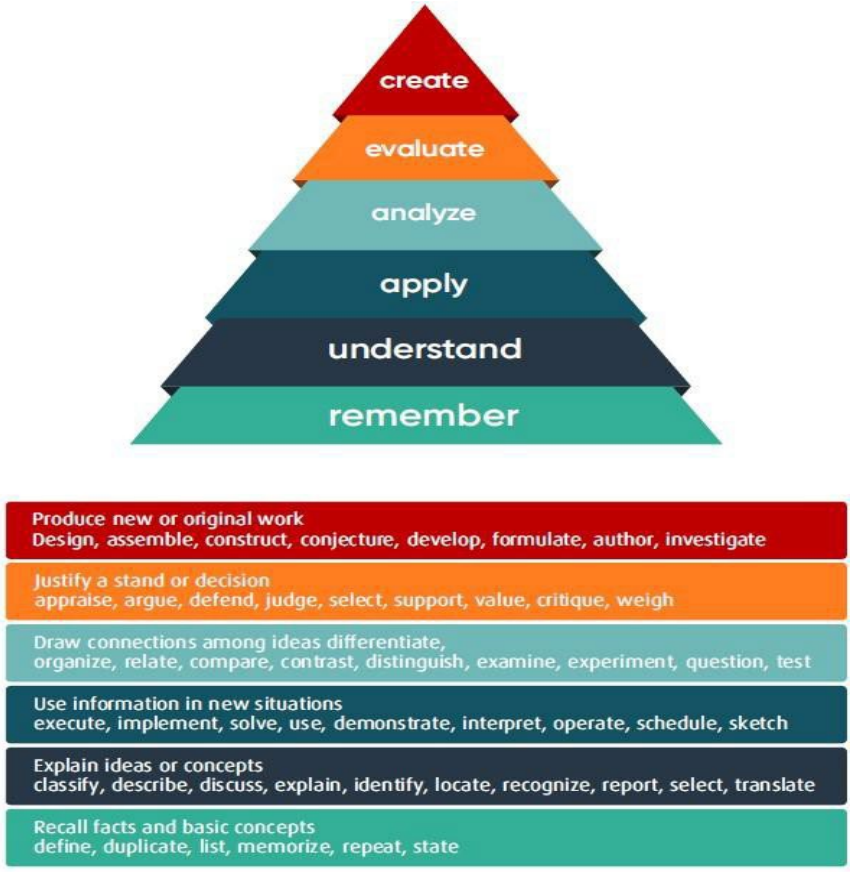

FIGURE 4: Revised version of Bloom's taxonomy

9.2 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.

9.3 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 (co-ordinating, 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 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

10 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)

10.1 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.

10.2 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.

10.3 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)."

10.4 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

10.5 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.
3	Given an algebraic equation with one unknown.	the student will be able to correctly solve a simple linear equation	within a period of five minutes.

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

Original course out- come	Evaluation of language used in this course outcome	Improved course outcome
Explore in depth the literature on an aspect of teaching strategies.	Exploration is not a measur- able 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?

10.6 CO-PO Course Articulation Matrix (CAM) Mapping

Course Articulation Matrix shows the educational relationship (Level of Learning achieved) be-tween 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="11">Technical</td><td>PO1</td><td>Apply</td><td>L3</td><td rowspan="11">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><td rowspan="6">Non-Technical</td><td>PO6</td><td colspan="3" rowspan="6">Thumb Rule:
If Bloom's L1 Action Verbs of a CO: Correlates with any of PO6 to PO11, then assign 1.
If Bloom's L2 to L3 Action Verbs of a CO: Correlates with any of PO6 to PO11, then assign 2.
PO6 to PO11, 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>
</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 com-posing 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).

10.7 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.

10.8 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 refer-ence 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

0–0 ≦ C ≦ 5% - No correlation.

1 – 5 < C ≦ 40% - Low / Slight.

2 – 40% < C < 60% - Moderate

3 – 60% ≦ C < 100% - Substantial / High

11 Indicators of Attainment for Assessing Program Outcomes / Program Specific Outcomes:

Number	Indicators of attainment (IA)		No of Indicators of Attainment
WK1	**Application of Natural sciences**		**01**
	WK 1a	Applying concepts of natural sciences viz., physics, chemistry, social science, and discipline specialized engineering science fundamentals for solving respective problems / applications	
WK2	**Analytical skills -Numerical analysis, data analysis, statistics, modelling and Modern engineering & IT tools**		**08**
	WK 2a	The use of algorithms and numerical approximation techniques in mathematical analysis as applied to engineering problems	
	WK 2b	Development of an analytical, numerical, or empirical description of a real system	
	WK 2c	The knowledge and skills required to analyse data (data awareness, cleaning, discovery, ethics, exploration, tools, and visualization) including developing an analytical plan; selecting and using appropriate statistical techniques and tools; and interpreting, evaluating, and comparing results with other findings	
	WK 2d	Ability to use statistical principles to summarize data and draw conclusions from it	
	WK 2e	Identifies all relevant constraints and requirements and formulates an accurate description of the problem	
	WK 2f	Develop the models that can be mathematical or physical in nature and are created with the specific intent of describing, analysing, testing, demonstrating, and/or predicting behaviours, properties, or other characteristics of the system	
	WK 2g	The knowledge and skills to use computer systems to store and manipulate large quantities of information	
	WK 2h	Use algorithms, computational tools, simulation and modelling techniques with data visualization for effective analysis.	
WK3	**heory-based formulation**		**03**
	WK 3a	Gathers engineering knowledge from the open literature and discerns the most relevant	
	WK 3b	heoretical problem identification, model formulation and data collection	
	WK 3c	valuates the analysis for accuracy and validity of assumptions made.	
WK4	**Engineering specialist knowledge**		**03**
	WK 4a	Applying engineering specialist knowledge for evaluation and validation of the assumptions made.	
	WK 4b	Understanding of standards, innovation and critical analysis for accepted practices	
	WK 4c	Apply engineering management principles to effectively implement economic decision-making.	

WK5	**Knowledge of resource use, Environmental impacts, Net-zero carbon support Engineering design and operations and Constraints and Boundaries**		**6**
	WK 5a	Demonstrates originality in developing design solutions that incorporate social values and local considerations of sustainable development impacts.	
	WK 5b	Use of modern modelling and computational tools for system design / component design / process design for problem analysis and re-use of sources for improving efficiency / optimization.	
	WK 5c	Evaluates the feasibility of alternative solutions in all relevant contexts which, as appropriate to the problem, may include: technical, sustainability, suitability for implementation, economic, aesthetic, ethical, health and safety, societal, environmental and cultural.	
	WK 5d	Investing in projects, implementing measures, identifying and reducing major sources of emissions such as improving energy efficiency, transitioning to renewable energy, and adopting low-carbon technologies	
	WK 5e	Waste minimization and resource reuse compliance with environmental regulations and impact assessment.	
	WK 5f	Describes the preferred solution and presents the findings including technical constraints, budgetary limitations, time constraints and secondary impacts in a coherent written form and defends those findings orally.	
WK6	**Knowledge of engineering practice (technology), in the practice areas in the engineering discipline**		**03**
	WK 6a	Identifies the range of current tools and resources available, selects one or more suitable tools and/or appropriate resources, and justifies the selection including considerations of the limitations of the tools available.	
	WK 6b	Applies such tools to simulate behaviour or model outcomes that might resolve a complex engineering problem, checks the results for validity, evaluates results and recognises the limitations on those results.	
	WK 6c	Integration of measurement systems for process parameters with engineering design in the practice areas.	
WK7	**Knowledge of the role of engineering in society, issues in engineering practice in the discipline and professional responsibility to public safety and sustainable development.**		**04**
	WK 7a	Identifies risks, develops and evaluates risk management strategies to minimize the likelihood of significant consequences (such as injury or loss of life, major environmental damage, or significant economic loss) occurring in unusual or unexpected circumstances.	
	WK 7b	Identifies hazards and justifies relevant strategies and systems to reasonably assure public health and safety (including as appropriate to the discipline, safety in construction/fabrication, operation, maintenance, deconstruction/disposal, failing-safe and occupational health and safety).	
	WK 7c	Identifies and justifies specific actions required for environmental protection in the event of failure and to address cultural or community concerns.	
	WK 7d	Advanced student project work involves students developing sustainable design solutions and undertakes life-cycle analysis and ensures relevant regulations and legislations for compliance.	
WK8	**Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking, creative approaches to evaluate emerging issues**		**07**
	WK 8a	Reviews the open research literature and identifies the needs for investigation methodologies.	
	WK 8b	Understanding of appropriate codes of practice and industry standards awareness of quality issues	
	WK 8c	Designs and executes valid forms of research, experimentation or measurement.	
	WK 8d	Use creative ability to identify, classify and describe the performance of	

		systems and components through the use of analytical methods and modelling techniques and including considering sources of error	
	WK 8e	Ability to apply qualitative and quantitative methods for evaluating emerging complex engineering problems.	
	WK 8f	Draws valid conclusions and justifies those conclusions.	
	WK 8g	Calibrates / validates the data collection methods and equipment.	
WK9	**Engineering ethics; Respect; Diversity and Inclusivity; Honouring all – Laws, Regulations and Codes**		**06**
	WK 9a	Demonstrates an understanding of the moral responsibilities of a professional engineer including need to self-manage in an orderly and ethical manner, to balance obligations to the interests of employers and clients, and to uphold standards in the engineering profession.	
	WK 9b	Identifies and justifies ethical courses of action when confronted with complex situations that might arise in the work of a professional engineer.	
	WK 9c	Identifies and justifies the use or otherwise of new technologies, such as but not limited to, Generative AI.	
	WK 9d	Evaluates the ethical dimensions of professional practice (diversity and inclusivity) and demonstrates ethical behaviour.	
	WK 9e	High degree of trust and integrity for professional obligations in an organization.	
	WK 9f	Comprehends how legislative, regulatory, contract law, other common law and professional obligations apply and manages own activities to comply.	

12 Program Outcomes and Program Specific outcomes Attained through course modules:

Courses offered in Computer Science and Engineering (AI&ML) Curriculum (IARE-BT23) and POs/PSOs attained through course modules for I and II semesters

Code	Subject	PO											PSO		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
B. Tech Courses up to II Semester															
ACSE01	Object Oriented Programming	✓	✓	✓		✓					✓				✓
ACSE03	Object Oriented Programming with Java Laboratory	✓	✓	✓		✓	✓		✓						✓
ACSE02	Essentials of problem solving	✓	✓	✓	✓	✓				✓		✓			
ACSE04	Front-End Web Development Laboratory	✓	✓											✓	

AHSE02	Engineering Workshop	✓	✓			✓					✓			✓	
AHSE04	Professional Communication									✓					
AHSE02	Matrices and Calculus	✓	✓												
AHSE07	English Language and Communication Skills Laboratory	✓	✓							✓					
AHSE05	Engineering Physics Laboratory			✓	✓	✓	✓	✓		✓					
ACSE05	Data Structures	✓	✓	✓	✓	✓	✓	✓			✓				✓
ACSE06	AI Foundations	✓	✓					✓							
AHSE03	Engineering Chemistry	✓	✓					✓							
AHSE06	Engineering Chemistry Laboratory	✓	✓		✓										
AHSE08	Ordinary Differential Equations and Vector Calculus	✓	✓												
AEEE01	Basic Electrical and Electronics Engineering	✓	✓		✓										
ACSE07	Programming for Problem Solving Laboratory	✓	✓		✓									✓	
ACSE09	AI Studio Laboratory	✓	✓										✓	✓	
ACSE08	Data Structures Laboratory	✓	✓	✓	✓	✓				✓		✓			✓

13 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

The above assessment indicators are detailed below.

13.1 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.

13.2 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.

13.3 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 re-medial 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.

13.4 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 /

indus-trial 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.

13.5 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.

13.6 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.

13.7 Alumni Survey

The survey asks former students of the department about the status of their employment and fur-ther 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.

13.8 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.

13.9 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 profes-sional 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.

13.10 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.

13.11 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 curricu-lum and Industry requirement and gives necessary feedback or advices to be taken to improve the curriculum.

13.12 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 imple-mentation of DAC's suggestions and guidelines. All these proceedings are recorded and kept for the availability of all faculties.

13.13 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.

14 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 is 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%

14.1 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	20	Answer script
		Alternative Assessment Tools (AAT)	Twice in a semester	20	Video / Quiz / assignment
		Semester End Examination	Once in a semester	60	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	20	Answer script

		Semester End Examination	Once in a semester	60	Answer script
3	Project Work	Presentation	Twice in a semester	40	Presentation
		Semester End Examination	Once in a semester	60	Thesis report
4	Comprehensive Examination	Written examination (objective type)	Once in a semester	50	Online assessment
		Oral examination	Once in a Semester	50	Viva

14.2 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 16: 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.

15 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 17: Attainment of PO/PSOs

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

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

15.1 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 out-come attainment.

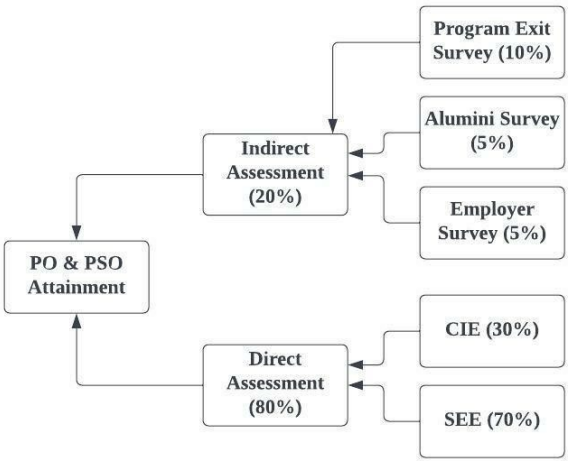

FIGURE 5: Evaluation process of POs/PSOs attainment

16 Course Outline Description:

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

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

COURSE OUTLINE DESCRIPTION

SECTION 1: General Information about the Course	
Course Title	**Essentials of Problem Solving**
Course Code	ACSE02
Course Start	First Semester
Course Type	Core
Regulation	IARE – BT23
Prerequisite Courses	Nil
Department	CSE (Artificial Intelligence & Machine Learning)
Number of Credits	3 Credit hours
Academic Year	2025-26
Method(s) of Instruction	Theory
Course Administrator	**Dr. Sreelakshmi Doma** Assistant Professor of AI & ML IARE10869 d.sreelakshmi@iare.ac.in
Course Coordinator's Name	**Dr. Sreelakshmi Doma** Assistant Professor of AI &ML IARE10869 d.sreelakshmi@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://akanksha.iare.ac.in/index?route=course/details&course_id=9
Course Description	This course aims to provide exposure to problem solving through programming. Useful graph theory concepts, numerical techniques, and their applications to real world problems are discussed. Graph theoretical notions and the use of algorithms, both in the mathematical theory of graphs and its applications are discussed. Student will also learn how to implement and interpret numerical solutions by writing a designed computer programs in regard to their efficiency and suitability for real-life applications.
Course Objectives	**The students will try to learn:** I. The fundamental concepts of graph theory and its properties. II. The basics related to paths and cycles using Eulerian and Hamiltonian cycles. III. The applications of graph coloring and traversal algorithms for solving real-time problems. IV. The numerical methods to solve algebraic equations.

Text and Reference Books	**Text Books** 1. Karin R Saoub, *Graph Theory: An Introduction to Proofs, Algorithms, and Applications,* 1 st edition, Chapman and Hall, 2021. 2. S S Sastry, *Introductory Methods of Numerical Analysis*, 5th edition, 2012. **Reference Books** 1. Mahinder Kumar Jain, *Numerical Methods: For Scientific and Scientific Computation, New Age International Pvt. Ltd., 7 th edition,* 2019. P Kandasamy, K Thilagavathy, K Gunavathi, *Numerical Methods, S Chand and Company, 2006*. 3. R Balakrishnan, K Ranganathan, *A Textbook of Graph Theory, Springer Exclusive, 2 nd edition,* 2019. 4. Jann Kiusalaas, *Numerical Methods in Engineering with Python, Cambridge University Press, 2 nd edition* 2010.
Learning Resources	**Course full stack** is made available in IARE learning management portal – Akansha, which includes lecture notes, tutorial question bank, definition and terminology, tech-talk topics, assignments, Model question papers (2 sets), complex engineering problem solving statements, power point presentations (PPTs) and ELRV lecture recordings at: https://www.youtube.com/watch?v=QMmA_BMDvIQ&list=PLzkMouYverALQmPhcIJpyJgK4ZBd0OQ8k
Supplemental Materials	**Readings, Videos, and Links** 1. https://akanksha.iare.ac.in/index?route=course/details&course_id=95 2. https://www.youtube.com/watch?v=QMmA_BMDvIQ&list=PLzkMouYverALQmPhcIJpyJgK4ZBd0OQ8k
Learningand Teaching Strategies	Online material will provide the foundation of the learning resources, requiring the students to log in and engage regularly throughout the sixteen weeks of the course. There will be a mix of suggested readings, discussions and video content containing embedded digital content and undertake the assessment tasks.

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	08	01	08
TLA 3	Case Study			
TLA 4	Problem Solving			
TLA 5	Demonstration			
TLA 6	Scheduled revision sessions	02	01	02
TLA 7	Guided independent study: Directed viewing of video materials / PPTs			15
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			15
TLA 14	Technical visit			
TLA 15	Field activities	0	0	0
			Total study hours	**90**
			Expected total study hours	**90**

SECTION 3A: Course Outcomes

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

Outcome Number	Course Outcomes	Learning Domain
CO1	Outline the graph terminologies, graph representation, and relate them to practical examples.	Understand
CO2	Build efficient graph routing algorithms for various optimization problems on graphs.	Understand
CO3	Use effective techniques from graph theory to solve problems in networking and telecommunication.	Understand
CO4	Interpret the fundamental concepts of polynomials, roots of equations and solve corresponding problems using computer programs.	Understand
CO5	Apply the knowledge of numerical methods to solve algebraic and transcendental equations arising in real-life situations.	Apply
CO6	Solve numerical integrals and ordinary differential equations to simulate discrete time algorithms.	Apply

SECTION 3B: Cognitive Levels

Blooms Taxonomy Level	Cognitive Level in Percentage (%)
Remember	0
Understand	67
Apply	33
Analyze	0
Evaluate	0
Create	0

SECTION 4: Content and Context of Elements of Electrical and Electronics Engineering

CO1	**Outline the graph terminologies, graph representation, and relate them to practical examples.**

	Graph terminology is essential for understanding graph theory, which is widely used in computer science, mathematics, and optimization problems. Below are the key terms: **Basic Terms** Graph (G): A collection of vertices (nodes) and edges (links), represented as G=(V,E)G = (V, E)G=(V,E), where: VVV is the set of vertices (nodes). EEE is the set of edges (connections between nodes). Vertex (Node): A fundamental unit of a graph, usually represented as v∈Vv Edge (Link): A connection between two vertices, represented as e∈Ee Degree of a Vertex: The number of edges connected to a vertex. In-degree: Number of edges directed into a vertex (for directed graphs). Out-degree: Number of edges directed out of a vertex (for directed graphs). Types of Graphs Undirected Graph: A graph where edges have no direction (i.e., if there is an edge between A and B, it can be traversed in both directions). Directed Graph (Digraph): A graph where edges have directions, meaning traversal is only allowed in the given direction. Weighted Graph: A graph where each edge has an associated weight or cost. Simple Graph: A graph that has no loops (edges that connect a vertex to itself) and no multiple edges between the same pair of vertices. Multigraph: A graph that allows multiple edges between the same set of vertices. Complete Graph (K_n): A graph where every pair of vertices is connected by an edge. Bipartite Graph: A graph whose vertices can be divided into two disjoint sets such that all edges connect a vertex from one set to a vertex from the other set.
CO2	**Build efficient graph routing algorithms for various optimization problems on graphs.**
	Efficient graph routing algorithms are essential for solving various optimization problems such as shortest path, network flow, traveling salesman problem, and vehicle routing. Below are some key graph routing algorithms optimized for different use cases. **1. Shortest Path Algorithms** Used in navigation, robotics, and network routing. **A. Dijkstra's Algorithm (Single-Source Shortest Path)** Use Case: Finds the shortest path from a single source to all other nodes in a graph with non-negative edge weights. Optimized Implementation: Use a min-heap (priority queue) for better performance. **B. Bellman-Ford Algorithm (Handles Negative Weights)** Use Case: Works on graphs with negative weights and detects negative weight cycles. Time Complexity: O(VE). Optimized Implementation: Early termination if no updates in a full iteration. **C. Floyd-Warshall Algorithm (All-Pairs Shortest Path)** Use Case: Computes shortest paths between all pairs of nodes in dense graphs. Time Complexity: O(V3) Optimized Implementation: Use matrix exponentiation for special cases. Use bitwise operations for faster updates. **D. A Algorithm (Heuristic Shortest Path) *** Use Case: Best for real-world navigation (e.g., Google Maps). Time Complexity: O(E)O(E)O(E) in the best case. Optimized Implementation: Use an admissible heuristic (e.g., Euclidean distance for grids). Use jump point search (JPS) for grid-based graphs.
CO3	**Use effective techniques from graph theory to solve problems in networking and telecommunication.**

	Graph theory plays a crucial role in solving networking and telecommunication problems by optimizing network design, routing, traffic management, and fault tolerance. Below are some effective techniques and their applications. **1. Network Topology Design** Used in planning efficient and resilient network infrastructures. **A. Minimum Spanning Tree (MST) for Backbone Networks** • **Problem**: Find the most cost-effective way to connect all network nodes with minimal wiring costs. • **Solution**: Use **Prim's** or **Kruskal's** algorithm to construct an MST. • **Example Application**: o Designing **fiber-optic networks** and **wireless mesh networks**. **B. Graph Partitioning for Load Balancing** • **Problem**: Divide a large network into smaller sub-networks to optimize load distribution. • **Solution**: Use **spectral clustering** or **Kernighan–Lin algorithm**. • **Example Application**: o **Data center network segmentation** for better resource allocation. **2. Routing Optimization** Used in packet switching, congestion control, and efficient data transmission. **A. Shortest Path Routing (Dijkstra's Algorithm)** • **Problem**: Find the fastest route for packet delivery. • **Solution**: Use **Dijkstra's algorithm** for **single-source shortest paths**. • **Example Application**: o **OSPF (Open Shortest Path First)** routing protocol in IP networks. **B. Load-Balanced Routing (Edge-Disjoint Paths)** • **Problem**: Prevent congestion by distributing traffic across multiple paths. • **Solution**: Compute **edge-disjoint shortest paths** to spread traffic. • **Example Application**: o **Multipath TCP (MPTCP)** for load balancing across multiple network interfaces. ***C. Delay-Tolerant Routing (A Algorithm)**** • **Problem**: Find an optimal path in a dynamic network where delays exist. • **Solution**: Use *A algorithm** with heuristic estimates of network delay. • **Example Application**: o **Mobile Ad-hoc Networks (MANETs)** and **Vehicular Ad-hoc Networks (VANETs)**.
CO4	**Interpret the fundamental concepts of polynomials, roots of equations and solve corresponding problems using computer programs.**

	Polynomials and their roots play a crucial role in various fields of mathematics, engineering, and computer science. Let's break down the key concepts and solve related problems using computer programs. **. Fundamental Concepts** **A. Polynomials** A polynomial is an algebraic expression of the form: P(x)=anxn+an−1xn−1+⋯+a1x+a0P(x) = a_n x^n + a_{n-1} x^{n-1} + \dots + a_1 x + a_0P(x)=an xn+an−1xn−1+⋯+a1x+a0 where: • an,an−1,...,a0a_n, a_{n-1}, ..., a_0an,an−1,...,a0 are **coefficients**. • xxx is the **variable**. • nnn is the **degree** of the polynomial. **B. Roots of Equations** The **roots** (or solutions) of a polynomial equation P(x)=0P(x) = 0P(x)=0 are the values of xxx that satisfy the equation. *Types of Roots:* 1. **Real Roots**: Roots that are real numbers. 2. **Complex Roots**: Roots that involve imaginary numbers (e.g., i=−1i = \sqrt{-1}i=−1). **Multiplicity of Roots**: If a root r is repeated mmm times, it has a **multiplicity** of m.
CO5	**Apply the knowledge of numerical methods to solve algebraic and transcendental equations arising in real-life situations.**
	Many real-world problems involve algebraic or transcendental equations that cannot be solved analytically. Numerical methods provide approximate solutions using iterative techniques. **1. Types of Equations** **A. Algebraic Equations** Equations of the form: P(x)=anxn+an−1xn−1+⋯+a1x+a0=0P(x) = a_nx^n + a_{n-1}x^{n-1} + \dots + a_1x + a_0 = 0P(x)=an xn+an−1xn−1+⋯+a1x+a0=0 Examples: • **Quadratic equations** (x2−4x+4=0x^2 - 4x + 4 = 0x2−4x+4=0) • **Cubic equations** (x3−6x2+11x−6=0x^3 - 6x^2 + 11x - 6 = 0x3−6x2+11x−6=0) • **Higher-degree polynomials** **B. Transcendental Equations** Equations involving non-algebraic functions like **trigonometric, exponential, and logarithmic functions**: Since transcendental equations **do not have closed-form solutions**, we use **numerical methods** to approximate their roots.

CO6	**Solve numerical integrals and ordinary differential equations to simulate discrete time algorithms.**

	In real-world problems, numerical integration and solving ODEs are essential for simulating discrete-time algorithms in physics, engineering, and machine learning. **Numerical Integration and ODEs in Discrete-Time Simulations** Numerical methods are essential for solving complex mathematical problems that arise in physics, engineering, finance, and computer science. Two fundamental problems in this area are **numerical integration** (approximating the area under a curve) and solving **ordinary differential equations (ODEs)** (which describe dynamic systems). **1. Numerical Integration** Numerical integration is used when an integral cannot be solved analytically. Common methods include: • **Trapezoidal Rule**: Approximates the integral as a series of trapezoids. • **Simpson's Rule**: Uses quadratic polynomials for better accuracy. **2. Solving Ordinary Differential Equations (ODEs)** ODEs describe how variables change over time. Since most real-world ODEs lack simple solutions, numerical methods approximate them. • **Euler's Method**: A simple but less accurate method that updates the solution using the derivative. • **Runge-Kutta (RK4)**: A higher-order method that balances accuracy and efficiency. **3. Applications in Discrete-Time Algorithm Simulations** These methods are used in: • **Physics**: Simulating motion and electric circuits. • **Biology**: Modeling population dynamics (e.g., predator-prey models). • **Engineering**: Control systems and signal processing. • **Machine Learning**: Training neural networks and optimization.

SECTION 5: Complex Engineering Problem Solving
Here's a breakdown of the process and key skills involved: **1. Problem Definition** · **Clearly state the problem:** Identify the unknowns, constraints, and desired outcomes. · **Understand the context:** What are the real-world implications of the problem? · **Gather information:** Collect relevant data, specifications, and any existing solutions. **2. Problem Analysis** · **Simplify the problem:** Break down the complex problem into smaller, manageable parts. · **Apply fundamental principles:** Use Ohm's Law, Kirchhoff's Laws, network theorems, and other relevant concepts to analyze the circuit or system. · **Develop a model:** Create a simplified representation of the system using circuit diagrams, equations, or simulations. **3. Solution Design** · **Explore potential solutions:** Brainstorm different approaches to solve the problem.

- **Evaluate feasibility:** Consider practical constraints like cost, materials, and time.
- **Select the best solution:** Choose the most efficient and effective solution based on your analysis.

4. Implementation and Testing

- **Build a prototype:** If necessary, construct a physical circuit or system to test your design.
- **Simulate the design:** Use software tools to simulate the circuit and verify its performance.
- **Analyze results:** Compare the actual or simulated results with the desired outcomes.

5. Evaluation and Refinement

- **Assess the solution:** Does it meet the requirements and constraints?
- **Identify limitations:** What are the weaknesses or areas for improvement?
- **Refine the design:** Make necessary adjustments to optimize the solution.

Key Skills for Complex Problem Solving

- **Strong foundation in electrical principles:** A solid understanding of basic concepts is essential.
- **Analytical and problem-solving skills:** Ability to break down complex problems and apply appropriate techniques.
- **Mathematical and computational skills:** Proficiency in algebra, calculus, and using calculators or software for calculations.
- **Circuit analysis and design skills:** Knowledge of circuit components, their behavior, and how to analyze and design circuits.
- **Critical thinking and evaluation:** Ability to assess solutions, identify limitations, and refine designs.
- **Communication and teamwork skills:** Ability to effectively communicate ideas and collaborate with others.

Example Complex Engineering Problem

Design a power supply for a small electronic device that requires a stable 5V DC output from a 120V AC input. The device has a variable load current ranging from 0.1A to 1A.

Steps to Solve:

1. **Problem Definition:** Design a power supply with specific input/output requirements and load variations.
2. **Problem Analysis:** Analyze the AC input, determine the necessary rectification and filtering stages, and select appropriate components (transformer, diodes, capacitors, voltage regulator).
3. **Solution Design:** Choose a suitable rectifier circuit (bridge rectifier), calculate the transformer turns ratio, select appropriate filter capacitor, and choose a voltage regulator (e.g., LM7805).
4. **Implementation and Testing:** Build a prototype power supply, test it under different load conditions, and measure the output voltage and ripple.
5. **Evaluation and Refinement:** Analyze the results, adjust component values if necessary to achieve the desired output voltage and stability, and ensure it meets the load current requirements.

SECTION 6A: Assessment Methods – Direct

Item	Evaluation Components	Week in / out	Marks
AAT: 1 - 1	Tech-Talk	Week – 02 / 05	05
AAT: 1 - 2	Hack-a-thon	Week – 04 / 07	05
AAT: 2 - 1	Complex Engineering Problem Solving	Week – 09 / 12	05
AAT: 2 - 2	Hack-a-thon	Week – 12 / 15	05
CIE - 1	2 hours - Answer 4 out of 5 questions	Week - 09	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:**

- Problem-solving skills for designing efficient solutions.
- Logical and analytical thinking for data organization.
- Proficiency in programming languages like C / C++ / Java / Python.
- Optimization skills for time and space complexity.
- Knowledge of scalable and robust system design.
- Teamwork and collaboration in software development.
- Adaptability to learn and apply advanced data structures.

Project Management:

- Planning and organizing project timelines and tasks.
- Allocating resources efficiently.
- 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 correlationwith Sustainability Development Goal (SDGs).

SDG Goals		Correlation with SDG
4		**Quality Education:** This subject will prepare students for modern technological challenges, improving educational tools, and promoting skills essential for global development.
8		**Decent Work and Economic Growth:** Prepares students for careers in technology-driven industries, boosting employability and fostering innovation in the digital economy.
9		**Industry, Innovation, and Infrastructure:** Supports the development of efficient algorithms and systems crucial for advancing technological infrastructure and innovation.
11		**Sustainable Cities and Communities:** Enables the creation of smart city technologies (e.g., optimized traffic systems, resource management) using graph and tree structures.
17		**Partnerships for the Goals:** Facilitates collaboration in data-driven research and global educational initiatives through scalable and efficient data processing.

SECTION 10A: Mapping between COs and POs / PSOs

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	✓	✓		-	-	-	-	-	-	-			-	-
CO2	✓	✓				-	-	-	-	-			-	
CO3	✓	✓				-	-	-	-	-				
CO4	✓	✓				-	-	-	-	-				
CO5	✓	✓				-	-	-	-	-				
CO6	✓	✓					-	-	-	-				

Outcomes		WKS and Indicators of attainment and Justification for mapping(students will be able to)																																													IAs Coun
COs	POs	WK 1	WK 2								WK 3			WK 4			WK 5						WK 6			WK 7				WK 8							WK 9											
		a	a	b	c	d	e	f	g	h	a	b	c	a	b	c	a	b	c	d	e	f	a	b	c	a	b	c	d	a	b	c	d	e	f	g	a	b	c	d	e	f						
CO 1	PO 1	.	.	.	.	.	.		.			.	.	.																																		10
	PO 2	.	.	.	.	.	.		.			.	.	.																																		10
	PO 3																.	.	.			.																										4
	PO 11																													.	.	.			.	.												5
	PSO 1	.	.	.			.		.			.	.	.																																		8
CO2	PO 1	.	.	.	.	.	.		.			.	.	.																																		10
	PO 2	.	.	.	.	.	.		.			.	.	.																																		10
	PO 3																.	.	.			.																										4
	PO 4																													.	.	.			.	.												5
	PO 5		.	.	.	.	.		.														.	.	.																						9
	PO 11																													.	.	.			.	.												5
	PSO	.	.	.			.		.			.	.	.																																		8
	PSO 3		.	.			.		.			.	.	.									.	.	.																							10
CO3	PO 1	.	.	.	.	.	.		.			.	.	.																																		10
	PO 2	.	.	.	.	.	.		.			.	.	.																																		10
	PO 3																.	.	.			.																										4
	PO 4																													.	.	.			.	.												5
	PO 5		.	.	.	.	.		.														.	.	.																						9
	PO 11																													.	.	.			.	.												5
	PSO 1	.	.	.			.		.			.	.	.																																		8
	PSO 2		.	.			.		.			.	.	.									.	.	.																							10
	PSO		.	.			.		.			.	.	.									.	.	.																							10
CO4	PO 1	.	.	.	.	.	.		.			.	.	.																																		10
	PO 2	.	.	.	.	.	.		.			.	.	.																																		10
	PO 3																.	.	.			.																										4

	PO 4																																										5
	PO 5		.	.	.	.	.		.														.	.	.																	9
	PO 11																												.	.	.			.	.								5
	PSO 1	.	.	.			.		.			.	.	.																												8
	PSO 2		.	.			.		.			.	.	.								.	.	.																		10
	PSO 3		.	.			.		.			.	.	.								.	.	.																		10
CO 5	PO 1	.	.	.	.	.	.		.			.	.	.																												10
	PO 2	.	.	.	.	.	.		.			.	.	.																												10
	PO 3															.	.	.			.																					4
	PO 4																												.	.	.			.	.								5
	PO 5		.	.	.	.	.		.														.	.	.																	9
	PO 11																												.	.	.			.	.								5
	PSO 1	.	.	.			.		.			.	.	.																												8
	PSO 2		.	.			.		.			.	.	.								.	.	.																		10
	PSO 3		.	.			.		.			.	.	.								.	.	.																		10
CO 6	PO 1	.	.	.	.	.	.		.			.	.	.																												10
	PO 2	.	.	.	.	.	.		.			.	.	.																												10
	PO 3															.	.	.			.																					4
	PO 4																												.	.	.			.	.								5
	PO 5		.	.	.	.	.		.														.	.	.																	9
	PO 6	.														.	.	.			.												.	.		.						8
	PO 11																												.	.	.			.	.								5
	PSO 1	.	.	.			.		.			.	.	.																												8
	PSO 2		.	.			.		.			.	.	.																												10
	PSO 3		.	.			.		.			.	.	.																												10

SECTION 10B: Indicators of Attainment with COs to POs and PSOs														
Course Outcomes	Percentage of Indicators of Attainments (IA) with POs and PSOs													
	PO											PSO		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	100	40												
CO2	100	40												
CO3	100	40												
CO4	66.6	30												
CO5	66.6	40												
CO6	66.6	40												

SECTION 10C: Course Articulation Matrix of COs to POs														
0 No Contribution (0-5%)			1 Low (≥5 - <40%)				2 Moderate (≥40 - <60%)					3 High (≥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	1												
CO2	3	1												
CO3	3	1												
CO4	3	1												
CO5	3	1												
CO6	3	1												
Total	18	6												
Average	**3**	**1**												

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 Tech talk	**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 Assignments	**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 Assignments	**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	**GRAPH THEORY**
	Graph terminology, digraphs, weighted graphs, complete graphs, graph complements, bipartite graphs, graph combinations, isomorphisms, matrix representations of graphs, incidence and adjacency matrices, degree sequence.
MODULE - II	**GRAPH ROUTES**
	Eulerian circuit: Konigsberg bridge problem, touring a graph; Eulerian graphs, Hamiltonian cycles, the traveling salesman problem; Shortest paths: Dijkstra's algorithm, walks using matrices.
MODULE - III	**GRAPH COLORING AND GRAPH ALGORITHMS**
	Four color theorem, vertex coloring, edge coloring, coloring variations, first-fit coloring algorithm. Graph traversal: depth-first search, bread-first search and its applications; Minimum spanning trees: Kruskal's and Prim's algorithm, union-find structure.
MODULE - IV	**ALGEBRAIC AND TRANSCENDENTAL EQUATIONS**
	Algebraic equations, method of false position, bisection method, iteration method, Newton-Raphson method, Secant method, Ramanujan's Method, Muller's method (Approximation up to 2 decimals only).
MODULE - V	**NUMERICAL INTEGRATION AND ORDINARY DIFFERENTIATIAL EQUATIONS**
	Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Solution by Taylor's series, Euler's method of solving an ordinary differential equation numerically, Runge-Kutta's second order method of solving ordinary differential equations (Approximation up to 2 decimals only).

SECTION12		
	Tentative Schedule of Instructions	
Week Number	**Topics**	**Duration (Hours)**
1	1.1 Introduction to Graph Terminology 1.2 Basic definitions of graph circuits 1.3 Basics of digraphs 1.4 Basics of weighted graphs 1.5 Complete graphs	5
2	2.1 Graph complements 2.2 Bipartite graphs 2.3 Graph combinations 2.4 Isomorphisms 2.5 Matrix representations of graphs	5

3	3.1 Incidence and adjacency matrices 3.2 Degree sequence. 3.3 **Mock Test – I** 3.4 Eulerian circuit 3.5 Konigsberg bridge problem	5
4	4.1 Touring a graph 4.2 Eulerian graphs 4.3 Hamiltonian cycles 4.4 he traveling salesman problem 4.5 Shortest paths: Dijkstra's algorithm	5
5	5.1 Walks using matrices Representation of alternating quantities 5.2 Four color theorem, 5.3 Vertex coloring, 5.4 Edge coloring, coloring variations, first-fit coloring algorithm. **5.5. Mock Test -II**	5 e **15** of **18**
6	6.1 Touring a graph 6.2 Eulerian graphs 6.3 Hamiltonian cycles 6.4 The traveling salesman problem 6.5 Shortest paths: Dijkstra's algorithm	5
7	7.1 Revision of Incidence and adjacency matrices 7.2 Degree sequence. 7.3 **Mock Test – III** 7.4 Eulerian circuit 7.5 Konigsberg bridge problem	5
8	8.1 Hamiltonian cycles 8.2 The traveling salesman problem 8.3 Shortest paths: Dijkstra's algorithm 8.4 Eulerian circuit 8.5 Konigsberg bridge problem	5
CONTINIUOUS INTERNAL EXAMINATION (CIE- I)		
9	9.1 Revision 9.2 Graph traversal Problems 9.3 Depth-first search, 9.4 Bread-first search and its applications; 9.5 Working Operation of P-N Junction diode 9.6 V-I characteristics of P-N Junction diode 9.7 **Mock Test-IV**	5
10	10.1 Minimum spanning trees 10.2 Problems 10.3 Kruskal's and Prim's algorithm 10.4 Problems 10.5 Problems	5
11	11.1 Problems 11.2 Kruskal's and Prim's algorithm 11.3 Kruskal's and Prim's algorithm 11.4 Depth-first search Problems 11.5 Breadth -first search Problems	5
12	12.1 Algebraic equations 12.2 Method of false position 12.3 Bisection method 12.4 Iteration method 12.5 Problems	5
13	13.1 Newton-Raphson method 13.2 Secant method 13.3 Ramanujan's Method 13.4 Muller's method (Approximation up to 2 decimals only) 13.5 Problems	5

14	14.1 Trapezoidal rule, 14.2 Simpson's 1/3 rule, 14.3 Simpson's 3/8 rule, CC configurations 14.4 Problems 14.5 Problems	5
15	15.1 Runge-Kutta's second order method of solving ordinary differential equations (Approximation up to 2 decimals only). 15.2 Problems 15.3 Solution by Taylor's series 15.4 Problems 15.5 **Mock Test-V**	5
16	16.1 Euler's method of solving an ordinary differential equation numerically 16.2 Numerical problems 16.3 **Mock Test-VI** 16.4 Revision ofTaylor'sseries 16.5 Problems	5
	Total	**80**

SECTION 13: Specific Goals for the Course

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

Knowledge	Skills
Learners should understand: · Concepts in electrical technology · abstract electrical modules · the implementation of circuit laws · how to compare different circuit parameters · how to compare ac and dc models · how to construct machines · semiconductor device analysis · BJT characteristics analysis · Small signal models for transistors	**Learners can:** · make complex problems · develop network models · make use in circuit solving methods · implement in designing circuits · gains knowledge on supply systems · grab principles and application knowledge about machines · learn diode and transistor characteristics · learn various configurations · develop hybrid parameters · solve numerical models · implement in laboratory course · make use of theorems

Administrative Information

SECTION 14: History of changes

Regulations	Description of change	BOS Date
UG 20	Changes from R18 to UG 20 regulation · **MODULE-IV:** ALGEBRAIC AND TRANSCENDENTAL EQUATIONS: Algebraic equations, method of false position, bisection method, iteration method, Newton-Raphson method, Secant method, Ramanujan's Method, Muller's method (Approximation up to 2 decimals only).	17.11.2020
BT 23	Changes from UG 20 to BT 23 regulation **MODULE-V**: Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Solution by Taylor's series, Euler's method of solving an ordinary differential equation numerically, Runge-Kutta's second order method of solving ordinary differential equations (Approximation up to 2 decimals only).	21.08.2023

BT 25	Changes from BT 23 to BT 25 regulation In this regulation the course contains only theory no laboratory sessions. As the course introduce in I semester keeping in point of studentsbenefit.	

Course Outline Approvals	
Course Coordinator Name: Dr. Sreelakshmi Doma Signature: Date:	**Head of the Department** Name: Dr. M. Purushotham 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 /104/25*	
Dean of Outcome Based Teaching and Learning Name: Dr. CH Srinivasulu Signature: Date:	**Dean of Academics** Name: Dr. Chandrashekar 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	