Outcome Based Education – ADCET (CSE)

MANUAL FOR OUTCOME BASED EDUCATION (OBE)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

ANNASAHEB DANGE COLLEGE OF ENGINEERING AND TECHNOLOGY ASHTA

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Contents

Outcome-Based Education (OBE): Shaping the Future of Learning

Outcome-Based Education (OBE), Outcome-Based Teaching and Learning (OBTL), and Outcome-Based Assessment collectively form a comprehensive framework that has gained prominence in contemporary education. This paradigm shift focuses on clearly defining what students should know and be able to do at the end of their educational journey. This document explores these concepts individually and examines their interconnectedness, emphasizing the importance of a holistic approach to education.

Outcome-Based Education (OBE):

OBE is an educational philosophy that places learning outcomes at the forefront of the curriculum development process. Instead of concentrating on what content should be covered, OBE prioritizes what students should achieve by the end of their educational experience. This approach is rooted in the idea that education should be purposeful and that the ultimate goal is to produce competent, well-rounded individuals.

The key characteristic of OBE is the identification and articulation of learning outcomes. These outcomes are clear, measurable statements that describe what students are expected to know, understand, and be able to demonstrate. By defining these outcomes, educators create a roadmap for curriculum design, instruction, and assessment. OBE aims to ensure that students not only acquire knowledge but also develop essential skills and competencies that are relevant to their chosen field and the broader demands of society.

Outcome-Based Teaching and Learning (OBTL):

OBTL is the practical implementation of OBE principles in the classroom. It involves aligning teaching methods and learning activities with the predefined learning outcomes. In OBTL, the focus shifts from the traditional teacher-centered approach to a more student-centered one. Educators design instructional strategies that actively engage students in the learning process, fostering critical thinking, problem-solving, and other essential skills.

In OBTL, the role of the teacher becomes that of a facilitator, guiding students through the learning journey. Various pedagogical approaches, such as project-based learning, collaborative learning, and experiential learning, are often employed to create a dynamic and interactive classroom environment. The aim is to not only transmit information but to cultivate a deep understanding and application of knowledge.

By integrating OBTL into their teaching practices, educators tailor their methods to suit diverse learning styles and promote a deeper understanding of the subject matter. This approach encourages students to take responsibility for their learning, promoting lifelong learning skills that extend beyond the confines of the classroom.

Outcome-Based Assessment:

Assessment in the OBE framework is designed to measure the extent to which students have achieved the specified learning outcomes. Unlike traditional assessments that focus primarily on testing recall of information, outcome-based assessment evaluates a broader range of competencies, including critical thinking, problem-solving, and practical application of knowledge.

Assessment tasks are aligned with the defined outcomes, ensuring that the evaluation process is directly linked to the educational goals. These assessments can take various forms, such as exams, projects, presentations, and portfolios. The emphasis is on authentic assessments that mirror real-world scenarios, allowing students to showcase their skills and knowledge in practical contexts.

Outcome-based assessment provides valuable feedback not only to students but also to educators and institutions. It serves as a means of continuous improvement, allowing for the refinement of teaching methods and curriculum design. By identifying areas where students may be struggling or excelling, educators can make informed decisions to enhance the overall learning experience.

Interconnectedness of OBE, OBTL, and Outcome-Based Assessment:

The synergy among OBE, OBTL, and outcome-based assessment is crucial for the success of this educational approach. OBE sets the overarching goals and defines what success looks like in terms of student learning outcomes. OBTL translates these goals into action by shaping instructional strategies that actively engage students and promote deep learning. Outcome-based assessment then measures the attainment of these outcomes, providing feedback to both students and educators and closing the loop for continuous improvement.

The interconnectedness ensures a coherent and purposeful educational experience. Learning outcomes guide instructional design, which in turn informs the development of assessments. This cyclical relationship promotes a holistic approach to education that goes beyond the mere transmission of information and focuses on the development of skills and competencies that are relevant in the real world.

At Department of Computer Science and Engineering, Annasaheb Dange College of Engineering we follow Outcome based teaching learning and Outcome based assessment practices to ensure holistic education for students.

Vision and Mission

Vision and mission statements are integral components of an organization's identity, providing a sense of purpose and direction. While they are related, they serve distinct roles in articulating the essence and goals of an entity.

Vision Statement Philosophy:

Definition: A vision statement outlines an organization's long-term aspirations and the future state it envisions. It is a concise and inspiring declaration that communicates the desired impact or outcome the organization aims to achieve.

Purpose: The primary purpose of a vision statement is to motivate and guide internal stakeholders (students, faculties, management) and external stakeholders (society, industries, parents, alumni) by presenting a compelling picture of what the organization aims to become.

Mission Statement Philosophy:

Definition: A mission statement articulates the fundamental purpose of an organization, explaining why it exists, what it does, and for whom. It is a concise expression of the organization's core values, activities, and its overall reason for being.

Purpose: The mission statement serves as a guiding principle for daily operations and decision-making. It provides a framework for aligning actions with the organization's values and objectives.

In essence, the vision statement looks forward and paints a picture of what success looks like in the long run, while the mission statement focuses on the present and describes the organization's fundamental purpose and activities. Together, these statements contribute to a comprehensive understanding of an organization's identity, helping to communicate its values, aspirations, and commitment to stakeholders.

Vision of Institute

To be a Leader in producing professionally competent engineers.

Mission of Institute

We, Annasaheb Dange College of Engineering & Technology, Ashta, are committed to achieve our vision by,

- M1. Imparting effective outcome based education.
- M2. Preparing students through skill oriented courses to excel in their profession with ethical values.
- M3. Promoting research to benefit the society.
- M4. Strengthening relationship with all the stakeholders.

Vision of Computer Science and Engineering Department

To be a leader at serving society by producing professionally competent computer engineers.

Mission of Computer Science and Engineering Department

We at Department of Computer Science and Engineering are committed to achieve our vision by,

- M1: Imparting academic excellence through outcome based education.
- M2: Transforming students through skill oriented courses with ethical values.
- M3: Grooming students for employment, higher studies and entrepreneurial ventures.
- M4: Strengthening relationship with stakeholders for continuous development.

Program Educational Objectives

Program Educational Objectives (PEOs) are specific statements that describe the expected accomplishments and achievements of graduates from a particular academic program. These objectives are designed to align with the overall mission and goals of the educational institution. PEOs provide a framework for assessing the effectiveness of a program in preparing students for their professional careers and contributing to society. Here are key aspects related to Program Educational Objectives:

- **Long-term Career and Professional Accomplishments:**
  - PEOs typically focus on the long-term success of graduates in their professional careers. They articulate the skills, knowledge, and attributes that students are expected to have acquired several years after completing the program.

- **Alignment with Institutional and Department Mission:**
  - PEOs should align with the broader mission and goals of the educational institution. They reflect the institution's commitment to producing graduates who are well-prepared, ethically responsible, and capable contributors to their respective fields.

- **Stakeholder Involvement:**
  - The development of PEOs often involves input from various stakeholders, including faculty, industry professionals, alumni, and employers. This collaborative approach ensures that the objectives are comprehensive and relevant to the needs of the profession and society.

- **Measurable and Achievable Outcomes:**
  - PEOs are framed as specific, measurable, and achievable outcomes. They provide a basis for assessment and evaluation, allowing educational programs to gauge their success in meeting the stated objectives.

- **Focus on Continuous Improvement:**
  - PEOs contribute to the continuous improvement of educational programs. By regularly assessing the extent to which graduates meet these objectives, institutions can identify areas for enhancement and make informed decisions to refine their curricula and teaching methodologies.

Program Educational Objectives of Department of Computer Science and Engineering

Graduates of Computer Science and Engineering possess

- PEO-1: Knowledge of Computer Science that will act as a foundation for solving real life problems with the help of team work, critical thinking and effective communication. (**Domain Knowledge**)
- PEO-2: Ability to solve hardware and software engineering problems by their knowledge in core computer science and allied engineering. (**Core Competency**)
- PEO-3: Awareness of environmental and societal issues in computer science and engineering while they get engaged into employment, higher studies or entrepreneurial ventures. (**Professionalism**)
- PEO-4: Ability to adapt to changing environment by making use of contemporary technologies and tools. (**Lifelong Learning**)

Program Outcomes (POs):

Program Outcomes (POs) are broad statements that define the knowledge, skills, and attitudes that students are expected to possess upon completion of an academic program. These outcomes are designed to reflect the overarching goals of the program and are typically aligned with industry expectations and standards. POs serve as a comprehensive guide for curriculum development, assessment, and continuous improvement.

Key characteristics of Program Outcomes

Comprehensive Skill Set:

POs encompass a broad range of competencies, including both technical and non-technical skills relevant to the field of study. They address the overall development of students, preparing them for success in their chosen professions.

Alignment with Accreditation Standards:

POs are often aligned with accreditation standards set by professional bodies or accrediting agencies. This alignment ensures that the program meets industry benchmarks and prepares students for the expectations of the workforce.

Long-Term Goals:

POs focus on the long-term development of students, outlining the knowledge and abilities that should endure beyond the immediate academic context. They contribute to the institution's mission by preparing graduates for professional success and societal contributions.

Program Outcome of Computer Science and Engineering Department

The Program Outcome statements are directly taken from Graduate Attributes as per the Washington Accord.

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society**: Demonstrate understanding of contemporary knowledge of engineering to assess societal, health, safety, legal and cultural issues and the consequent responsibilities.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities, write effective reports, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

Program Specific Outcomes (PSOs) are more detailed and specific than Program Outcomes. They are statements that describe the specific skills and knowledge that students are expected to acquire in a particular specialization or concentration within an academic program. PSOs provide a finer level of granularity, allowing for a targeted assessment of student learning in specialized areas.

Key characteristics of Program Specific Outcomes

Specialized Knowledge and Skills:

PSOs focus on the unique aspects of a specific program or concentration within a broader field. They articulate the specialized knowledge and skills that students should attain to excel in their chosen sub-discipline.

Tailored to Concentrations:

In programs with multiple concentrations or specializations, PSOs are tailored to each specific track. For example, a computer science program may have distinct PSOs for software engineering and data science concentrations.

Enhanced Assessment Precision:

PSOs allow for a more precise assessment of student learning within a specialized context. Faculty and administrators can use PSOs to evaluate how well students are meeting the objectives of a particular concentration.

Program Specific Outcomes of Department of Computer Science and Engineering

- PSO 1: An ability to adapt to latest trends in software engineering practices and strategies in real-time software development lifecycle using open-source programming environment or commercial environment.
- PSO 2: An ability to get acquainted with contemporary trends in industrial / research areas and thereby provide solutions to real life problems, by specifically using knowledge and skills in the areas of Data Analytics, Machine Learning, Internet of Things, Cloud Computing and Security

Course Outcomes

Course outcomes are specific statements that describe the knowledge, skills, and abilities that students are expected to acquire by the end of a particular course. These outcomes are often formulated by educators or instructional designers and serve as a guide for designing, delivering, and assessing the course. Course outcomes provide a clear picture of what students should know and be able to do upon completing the course.

Key characteristics of course outcomes

Clear and Measurable: Course outcomes should be clear and specific, leaving no room for ambiguity. They often use action verbs that are observable and measurable, making it easier to assess whether students have achieved the intended objectives.

- **Aligned with Learning Goals**: Course outcomes are aligned with broader learning goals, program objectives, or institutional mission statements. They ensure that individual courses contribute to the overall educational objectives of a program or institution.
- **Reflective of Bloom's Taxonomy**: Course outcomes often span different levels of Bloom's Taxonomy, encompassing a range of cognitive processes from basic recall of information to higher-order thinking skills such as analysis, synthesis, and evaluation.
- **Realistic and Attainable**: While course outcomes should be challenging, they need to be realistic and attainable within the scope of the course. They should consider the time, resources, and instructional methods available.
- **Student-Centered**: Course outcomes focus on what students will be able to do, emphasizing a student-centered approach to education. This perspective shifts the focus from teaching to learning, encouraging educators to design instructional strategies that facilitate student achievement of the outcomes.
- **Contextually Relevant**: Course outcomes are contextually relevant to the subject matter and the specific goals of the course. They reflect the unique content and objectives of the course, tailored to the needs of the students and the discipline.
- **Assessment Guides**: Course outcomes guide the development of assessments. They provide a basis for creating assignments, exams, and other evaluation methods that align with the intended learning objectives.
- **Dynamic and Iterative**: Course outcomes are not set in stone. They can be revised and refined based on feedback, changing educational needs, or advancements in the field. The process of defining and refining course outcomes is often iterative.

Performance, Criteria and Condition Components in Course Outcomes

When framing a Course Outcome Statement, it's essential to consider the Performance, Criteria, and Condition components. These components help create clear, measurable, and specific statements that guide the design, delivery, and assessment of a course. Let's delve into each component:

Performance:

The performance component refers to the specific behaviour or action that students are expected to demonstrate to show they have achieved the course outcome. It involves using action verbs that are observable and measurable. The performance component outlines what students should be able to do as a result of their learning in the course.

Examples of performance verbs include:

- Analyze
- Design
- Evaluate
- Solve
- Create
- Explain

For example, if the course outcome is related to data analysis in a statistics course, the performance component might be: "Students will be able to analyze and interpret statistical data."

Criteria:

The criteria component outlines the standards or benchmarks against which student performance will be assessed. It provides clarity on the expectations and sets the level of proficiency required for a student to be considered successful in achieving the outcome. Criteria help in evaluating the quality of student work and ensure consistency in assessment.

Examples of criteria may include:

- Accuracy
- Clarity
- Creativity
- Logical reasoning
- Application of concepts
- Depth of analysis

Continuing with the previous example, the criteria might be: "Students will be able to analyze and interpret statistical data with a high degree of accuracy, demonstrating an understanding of central statistical concepts."

Condition:

The condition component specifies the context or circumstances under which the performance is expected. It sets the stage for how and where the learning outcome should be demonstrated. Conditions may vary depending on the nature of the course, the learning environment, or the specific skills being assessed.

Examples of conditions may include:

- Using specific tools or software
- Working individually or collaboratively
- Applying knowledge in real-world scenarios
- Demonstrating skills in a laboratory setting

Building on the previous examples, the condition might be: "Given a dataset, students will be able to analyze and interpret statistical data using appropriate software tools."

Putting it all together:

"Given a dataset, students will be able to analyze and interpret statistical data with a high degree of accuracy, demonstrating an understanding of central statistical concepts using appropriate software tools."

Sample Course Outcomes for a course in Data Structure at Computer Science and Engineering Department

Course Outcome No	Course Outcome Statement	Performance Component	Criteria Component	Condition Component
2CSPC202_1	Describe fundamentals in data structures for solving problems using a programming language	Describe fundamentals in data structures	for solving problems	using a programming language
2CSPC202_2	Explain the fundamental concepts of structuring, managing and organizing the data for solving problems using linear data structures with ADTs	Explain the fundamental concepts of structuring, managing and organizing the data	for solving problems	using linear data structures with ADTs
2CSPC202_3	Apply appropriate linear data structure to solve the problem using a programming language	Apply appropriate linear data structure	to solve the problem	using a programming language
2CSPC202_4	Explain the fundamental concepts of structuring, managing and organizing the data for solving problems using non-linear data structures with ADTs.	Explain the fundamental concepts of structuring, managing and organizing the data	for solving problems	using non-linear data structures with ADTs.
2CSPC202_5	Apply appropriate non-linear data structure to solve the problem using a programming language	Apply appropriate non linear data structure	to solve the problem	using a programming language
2CSPC202_6	Compare and analyze different data structure algorithms and searching, sorting methods for solving problems using complexity methods	Compare and analyze different data structure algorithms and searching, sorting methods	for solving problems	using complexity methods

Mapping of Course Outcome and Program Outcomes

Mapping of course outcomes and program outcomes is carried out on the basis of performance indicators and competencies defined in the department for the undergraduate program B. Tech in Computer Science and Engineering. The reference for this performance indicators and competencies is taken from the AICTE Examination Reforms document. Below mentioned is the Performance Indicators and Competencies list for B.Tech in Computer Science and Engineering

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.	
Competency	**Indicators**
1.1. Demonstrate competence in mathematical modelling	1.1.1 Apply the knowledge of discrete structures, linear algebra, statistics and numerical techniques to solve problems
	1.1.2 Apply the concepts of probability, statistics and queuing theory in modeling of computer-based system, data and network protocols.
1.2. Demonstrate competence in basic sciences	1.2.1 Apply laws of natural science to an engineering problem
1.3. Demonstrate competence in engineering fundamentals	1.3.1 Apply engineering fundamentals
1.4. Demonstrate competence in specialized engineering knowledge to the program	1.4.1 Apply theory and principles of computer science and engineering to solve an engineering problem
PO 2: Problem analysis: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	
Competency	**Indicators**
2.1. Demonstrate an ability to identify and formulate complex engineering problem	2.1.1 Evaluate problem statements and identifies objectives
	2.1.2 Identify processes/modules/algorithms of a computer-based system and parameters to solve a problem
	2.1.3 Identify mathematical algorithmic knowledge that applies to a given problem
2.2. Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.1 Reframe the computer-based system into interconnected subsystems
	2.2.2 Identify functionalities and computing resources.
	2.2.3 Identify existing solution/methods to solve the problem, including forming justified approximations and assumptions
	2.2.4 Compare and contrast alternative solution/methods to select the best methods
	2.2.5 Compare and contrast alternative solution processes to select the best process.
2.3. Demonstrate an ability to formulate and interpret a model	2.3.1 Able to apply computer engineering principles to formulate modules of a system with required applicability and performance.
	2.3.2 Identify design constraints for required performance criteria.

Competency	Indicators
2.4. Demonstrate an ability to execute a solution process and analyze results	2.4.1 Applies engineering mathematics to implement the solution.
	2.4.2 Analyze and interpret the results using contemporary tools.
	2.4.3 Identify the limitations of the solution and sources/causes.
	2.4.4. Arrive at conclusions with respect to the objectives.
PO 3: Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.	
Competency	**Indicators**
3.1. Demonstrate an ability to define a complex/ open-ended problem in engineering terms	3.1.1 Able to define a precise problem statement with objectives and scope.
	3.1.2 Able to identify and document system requirements from stake- holders.
	3.1.3 Able to review state-of-the-art literature to synthesize system requirements.
	3.1.4 Able to choose appropriate quality attributes as defined by ISO/IEC/IEEE standard.
	3.1.5 Explore and synthesize system requirements from larger social and professional concerns.
	3.1.6 Able to develop software requirement specifications (SRS).
3.2. Demonstrate an ability to generate a diverse set of alternative design solutions	3.2.1 Able to explore design alternatives.
	3.2.2 Able to produce a variety of potential design solutions suited to meet functional requirements.
	3.2.3 Identify suitable non-functional requirements for evaluation of alternate design solutions.
3.3. Demonstrate an ability to select optimal design scheme for further development	3.3.1 Able to perform systematic evaluation of the degree to which several design concepts meet the criteria.
	3.3.2 Consult with domain experts and stakeholders to select candidate engineering design solution for further development
3.4. Demonstrate an ability to advance an engineering design to defined end state	3.4.1 Able to refine architecture design into a detailed design within the existing Constraints.
	3.4.2 Able to implement and integrate the modules.
	3.4.3 Able to verify the functionalities and validate the design.
PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	
Competency	**Indicators**
4.1. Demonstrate an ability to conduct investigations of technical issues	4.1.1 Define a problem for purposes of investigation, its scope and importance
	4.1.2 Able to choose appropriate procedure/algorithm, dataset and test cases.

consistent with their level of knowledge and understanding	4.1.3 Able to choose appropriate hardware/software tools to conduct the experiment.
4.2. Demonstrate an ability to design experiments to solve open-ended problems	4.2.1 Design and develop appropriate procedures/methodologies based on the study objectives
4.3. Demonstrate an ability to analyze data and reach a valid conclusion	4.3.1 Use appropriate procedures, tools and techniques to collect and analyze data
	4.3.2 Critically analyze data for trends and correlations, stating possible errors and limitations
	4.3.3 Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions
	4.3.4 Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions
PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	
Competency	**Indicators**
5.1. Demonstrate an ability to identify/create modern engineering tools, techniques and resources	5.1.1 Identify modern engineering tools, techniques and resources for engineering activities
	5.1.2 Create/adapt/modify/extend tools and techniques to solve engineering problems
5.2. Demonstrate an ability to select and apply discipline- specific tools, techniques and resources	5.2.1 Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs.
	5.2.2 Demonstrate proficiency in using discipline-specific tools
5.3. Demonstrate an ability to evaluate the suitability and limitations of tools used to solve an engineering problem	5.3.1 Discuss limitations and validate tools, techniques and resources
	5.3.2 Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.
PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	
Competency	**Indicators**
6.1. Demonstrate an ability to describe engineering roles in a broader context, e.g. pertaining to the environment, health,	6.1.1 Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level

safety, legal and public welfare	
6.2. Demonstrate an understanding of professional engineering regulations, legislation and standards	6.2.1 Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public
PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and the need for sustainable development.	
Competency	**Indicators**
7.1. Demonstrate an understanding of the impact of engineering and industrial practices on social, environmental and in economic contexts	7.1.1 Identify risks/impacts in the life-cycle of an engineering product or activity
	7.1.2 Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability
7.2. Demonstrate an ability to apply principles of sustainable design and development	7.2.1 Describe management techniques for sustainable development
	7.2.2 Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline
PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	
Competency	**Indicators**
8.1. Demonstrate an ability to recognize ethical dilemmas	8.1.1 Identify situations of unethical professional conduct and propose ethical alternatives
8.2. Demonstrate an ability to apply the Code of Ethics	8.2.1 Identify tenets of the ASME professional code of ethics
	8.2.2 Examine and apply moral & ethical principles to known case studies
PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	
Competency	**Indicators**
9.1. Demonstrate an ability to form a team and define a role for each member	9.1.1 Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
	9.1.2 Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.
9.2. Demonstrate effective individual and	9.2.1 Demonstrate effective communication, problem-solving, conflict resolution and leadership skills

team operations--communication, problem- solving, conflict resolution and leadership skills	9.2.2 Treat other team members respectfully
	9.2.3 Listen to other members
	9.2.4 Maintain composure in difficult situations
9.3. Demonstrate success in a team-based project	9.3.1 Present results as a team, with smooth integration of contributions from all individual efforts
PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with the 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	
Competency	**Indicators**
10.1. Demonstrate an ability to comprehend technical literature and document project work	10.1.1 Read, understand and interpret technical and non-technical information
	10.1.2 Produce clear, well-constructed, and well-supported written engineering documents
	10.1.3 Create flow in a document or presentation - a logical progression of ideas so that
	the main point is clear
10.2. Demonstrate competence in listening, speaking, and presentation	10.2.1 Listen to and comprehend information, instructions, and viewpoints of others
	10.2.2 Deliver effective oral presentations to technical and non-technical audiences
10.3. Demonstrate the ability to integrate different modes of communication	10.3.1 Create engineering-standard figures, reports and drawings to complement writing and presentations
	10.3.2 Use a variety of media effectively to convey a message in a document or a presentation
PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	
Competency	**Indicators**
11.1. Demonstrate an ability to evaluate the economic and financial performance of an engineering activity	11.1.1 Describe various economic and financial costs/benefits of an engineering activity
11.2. Demonstrate an ability to compare and contrast the costs/benefits of alternate proposals for an engineering activity	11.2.1 Analyze and select the most appropriate proposal based on economic and financial considerations.
11.3. Demonstrate an ability to plan/manage an engineering activity	11.3.1 Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks.

within time and budget constraints	
PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	
Competency	**Indicators**
12.1. Demonstrate an ability to identify gaps in knowledge and a strategy to close these gaps	12.1.1 Describe the rationale for the requirement for continuing professional development
	12.1.2 Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap
12.2. Demonstrate an ability to identify changing trends in engineering knowledge and practice	12.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current
	12.2.2 Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field
12.3. Demonstrate an ability to identify and access sources for new information	12.3.1 Source and comprehend technical literature and other credible sources of information
PSO 1: An ability to adapt to latest trends in software engineering practices and strategies in real-time software development lifecycle using open-source programming environment or commercial environment.	
Competency	**Indicators**
PSO 1.1. Demonstrate an ability to identify and apply recent trends and strategies in software engineering practices	PSO-1.1.1 Identify software engineering practices used in industry such as agile methodology, design thinking etc.
	PSO-1.1.2 Apply recent trends and strategies in software project development
PSO 1.2. Demonstrate an ability to adapt recent technologies and environments	PSO-1.2.1. Select/Identify and apply appropriate open source technologies to solve real world problems
	PSO-1.2.2. Apply appropriate commercial technologies / environments to solve real world problems
PSO 2: An ability to get acquainted with contemporary trends in industrial / research areas and thereby provide solutions to real life problems, by specifically using knowledge and skills in the areas of Data Analytics, Machine Learning, Internet of Things, Cloud Computing and Security.	
Competency	**Indicators**
PSO 2.1 Demonstrate an ability to solve problems identified by industry.	PSO-2.1.1. Design appropriate methodologies to solve industrial problems.
	PSO-2.1.2. Develop solutions for industrial problems using cutting edge technologies.
PSO 2.2. Demonstrate an ability to address	PSO-2.2.1. Identify research trends in computer science and engineering.

diverse research issues at local, regional, national and global level and solve the same	PSO-2.2.2.Comprehend technical literature and analyze existing solutions to identify research gaps
	PSO-2.2.3. Address and justify different socio-economic problems in the domain of thrust areas.
	PSO-2.2.4. Design and develop solutions for identified socio-economic problems.

Every course coordinator prepares the CO PO mapping based on the correlation of course outcome and above indicator statements. Below mentioned is sample of one course outcome

Course Outcome	**Program Outcome**	**Competencies**	**Correlated Indicators**	**Correlation Percentage**	**Average %**	**Average %**
1	1	1.1	1.1.1	50	50.00	62.50
			1.1.2	50		
		1.2	1.2.1	50	50.00	
		1.3	1.3.1	100	100.00	
		1.4	1.4.1	50	50.00	

Below table represent the conversion of the average percentage to the correlation level.

Average %	**Correlation Level**
> 70	3
> 40	2
> 0	1
0	-

The final CO-PO mapping for all course outcomes is prepared for all course outcome statement. Below mentioned is one sample CO-PO mapping.

Course Outcome (COs)	**Program Outcomes (POs)**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
2CSPC202_1	2	2	-	-	-	-	-	-	-	-	-	-	2	-
2CSPC202_2	2	2	-	-	-	-	-	-	2	3	-	-	2	-
2CSPC202_3	3	3	2	2	-	-	-	2	2	3	-	1	2	-

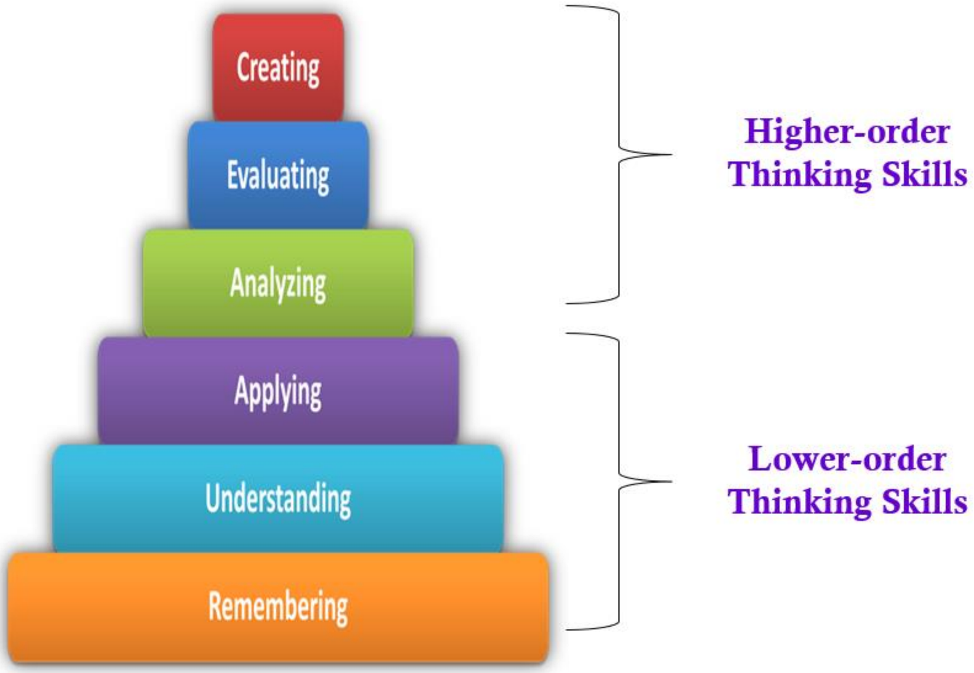
Course Outcome (COs)	**Program Outcomes (POs)**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
2CSPC202_4	2	2	-	-	-	-	-	-	2	3	-	-	2	-
2CSPC202_5	3	3	2	2	-	-	-	2	2	3	-	1	2	-
2CSPC202_6	3	3	2	2	-	-	-	2	2	3	-	1	2	-
Total	15	15	6	6	-	-	-	6	10	15	-	3	12	-
Average	2.5	2.5	2	2	-	-	-	2	2	3	-	1	2	-
2CSPC202	**3**	**3**	**2**	**2**	**-**	**-**	**-**	**2**	**2**	**3**	**-**	**1**	**2**	**-**

Blooms Taxonomy

Bloom's Taxonomy is a hierarchical framework that categorizes educational objectives based on cognitive complexity. It was first developed by Benjamin Bloom and a group of educational psychologists in the 1950s and further revised. The taxonomy provides a systematic way to understand and organize different levels of thinking skills and learning objectives. Bloom's Taxonomy consists of six main levels, arranged in ascending order of complexity:

- **Remembering**:
  - Definition: Recall of information from memory.
  - Example activities: Memorization, recitation, listing, naming, identifying, and describing.
  - Key question: Can the student recall or remember the information?
- **Understanding**:
  - Definition: Comprehension and interpretation of information.
  - Example activities: Summarizing, explaining, paraphrasing, classifying, comparing, and discussing.
  - Key question: Can the student explain the meaning of the information?
- **Applying**:
  - Definition: Using learned information in new situations.
  - Example activities: Applying, implementing, using, solving, demonstrating, and illustrating.
  - Key question: Can the student use the information in a new context?
- **Analyzing**:
  - Definition: Breaking down information into parts and understanding relationships.
  - Example activities: Analyzing, categorizing, comparing, contrasting, examining, and organizing.
  - Key question: Can the student identify patterns or relationships in the information?
- **Evaluating**:
  - Definition: Making judgments about the value of information or methods.
  - Example activities: Evaluating, judging, critiquing, testing, appraising, and defending.
  - Key question: Can the student assess the validity or effectiveness of the information?
- **Creating**:
  - Definition: Synthesizing information to produce something new.
  - Example activities: Designing, constructing, planning, producing, inventing, and composing.
  - Key question: Can the student generate new ideas or products based on the learned information?

Educators use Bloom's Taxonomy to guide the design of learning objectives, assessments, and instructional strategies. By aligning educational activities with specific levels of the taxonomy, instructors can ensure that students engage in a variety of cognitive processes and progressively develop their thinking skills. The taxonomy is widely used in educational settings to promote a more comprehensive and thoughtful approach to teaching and learning.



Sample Verb List

Here is a list of verbs that can be used in Bloom's Taxonomy for framing questions at each cognitive level:

Remembering	Understanding	Applying	Analyzing	Evaluating	Creating
Define	Explain	Apply	Analyze	Evaluate	Create
Recall	Summarize	Solve	Differentiate	Assess	Design
List	Paraphrase	Demonstrate	Distinguish	Judge	Invent
Name	Discuss	Use	Compare and contrast	Critique	Construct
Identify	Interpret	Implement	Break down	Appraise	Compose
Recognize	Describe in your own words	Calculate	Investigate	Estimate	Develop
Match	Predict	Operate	Examine	Justify	Formulate
State	Compare	Illustrate	Categorize	Validate	Imagine
Count	Contrast	Relate	Classify	Argue	Generate
Retrieve	Clarify	Employ	Organize	Defend	Plan
Recite	Elaborate	Interpret	Relate	Decide	Produce
Memorize	Infer	Exhibit	Outline	Rank	Build
Repeat	Illustrate	Modify	Diagram	Select	Innovate
Outline	Give examples	Show	Survey	Prioritize	Originate
Classify	Demonstrate understanding	Build	Dissect	Choose	Devise
Select	Rewrite	Construct	Inventory	Measure	Combine

Remembering	Understanding	Applying	Analyzing	Evaluating	Creating
Point	Convert	Choose	Separate	Conclude	Rearrange
Locate	Translate	Dramatize	Synthesize	Recommend	Organize
Label	Estimate	Sketch	Connect	Support	Hypothesize
Enumerate	Conclude	Practice	Deduce	Test	Author

When framing questions or designing assessments, educators can choose verbs from the appropriate level of Bloom's Taxonomy to align with the intended cognitive skills they want students to demonstrate. Using a variety of these verbs ensures a diverse range of cognitive engagement and challenges students at different levels of thinking.

Sample Questions

Examples of questions for each level of Bloom's Taxonomy in the context of Computer Science Engineering courses:

Remembering:

- Define: Can you define the basic principles of object-oriented programming?
- Recall: Recall the syntax for declaring a multidimensional array in a programming language of your choice.
- List: Provide a list of the main components of a computer system and briefly describe the function of each.
- Identify: Identify three types of sorting algorithms commonly used in computer science.
- Recognize: Recognize the significance of Moore's Law in the context of hardware development.

Understanding:

- Explain: Explain the concept of data normalization and its importance in database design.
- Summarize: Summarize the key features and advantages of cloud computing.
- Discuss: Discuss the differences between TCP and UDP in networking protocols.
- Interpret: Interpret the output of a complex algorithm and explain its implications in a real-world scenario.
- Describe in your own words: Describe, in your own words, the process of dynamic memory allocation in programming languages.

Applying:

- Apply: Apply the principles of software engineering to design a solution for a given problem statement.
- Demonstrate: Demonstrate how to implement a simple recursive function in a programming language of your choice.
- Use: Use a specific software tool to analyze and optimize the performance of a computer program.
- Implement: Implement a basic sorting algorithm (e.g., bubble sort) in a programming language.
- Operate: Operate a version control system to manage a collaborative software development project.

Analyzing:

- Analyze: Analyze the code of a given program to identify and fix potential bugs or inefficiencies.
- Differentiate: Differentiate between encryption and hashing algorithms in the context of cyber security.
- Examine: Examine the architecture of a microprocessor and identify its key components.
- Categorize: Categorize programming languages into different paradigms and explain the characteristics of each.
- Organize: Organize the steps involved in the software development life cycle and discuss their interdependencies.

Evaluating:

- Evaluate: Evaluate the trade-offs between using relational and NoSQL databases for a specific application.
- Assess: Assess the security vulnerabilities of a web application and propose measures for improvement.
- Judge: Judge the efficiency of different algorithms for a specific computational problem.
- Critique: Critique the user interface design of a mobile application, suggesting improvements based on usability principles.
- Appraise: Appraise the ethical considerations associated with the use of artificial intelligence in autonomous systems.

Creating:

- Create: Create a conceptual design for a new programming language, outlining its syntax and key features.
- Design: Design an algorithm for a self-driving car to navigate through a city environment.
- Invent: Invent a new data structure that addresses specific challenges in a certain type of application.
- Construct: Construct a prototype for a hardware device that solves a real-world problem in the field of robotics.
- Compose: Compose a comprehensive project plan for the development of a software application, including timelines and milestones.

These examples demonstrate how questions can be framed at different levels of Bloom's Taxonomy to engage students in various cognitive processes within the context of Computer Science Engineering courses.

Consider a Course Outcome statement

Evaluate different linear data structures for solving computational problems by assessing their algorithmic complexities.

Below given are some examples of how can a course coordinator frame questions for same course outcome at Level 5 or below.

Question: Choose appropriate linear data structure and justify your choice to solve the below problem statement.

Bracket Matching: Write logic to check the validity of a sequence of brackets in a given string. The program should determine if the brackets are properly matched and nested. **(K5)**

Question: Analyze the complexity for solving below problem by using stack data structure.

Bracket Matching: Write logic to check the validity of a sequence of brackets in a given string. The program should determine if the brackets are properly matched and nested. **(K4)**

Question: Apply stack data structure to check the validity of a sequence of brackets in a given string. The program should determine if the brackets are properly matched and nested. **(K3)**

Question: Explain with help of suitable example, working of Push and Pop operation in stack data structure. **(K2)**

Question: Define Stack. Define Push operation in stack. List various operations of stack. **(K1)**

Rubrics

Rubrics are scoring tools or guidelines used to assess and evaluate the quality of students' work. They provide a structured framework with criteria and performance levels to make the assessment process more transparent, consistent, and objective. Rubrics are employed across various educational settings, from K-12 schools to higher education, and they can be applied to assess a wide range of assignments, projects, presentations, or other forms of student work.

Key components of a typical rubric

- **Criteria:**
  - Clearly defined aspects or dimensions of the assignment that will be evaluated. These criteria outline what is expected in the student's work.
- **Performance Levels:**
  - Descriptions of different levels of achievement or proficiency for each criterion. These levels often range from "Excellent" to "Needs Improvement" or similar descriptors.
- **Descriptors:**
  - Detailed descriptions or characteristics that illustrate what performance looks like at each level. Descriptors provide clarity about the expectations for each performance level.
- **Scoring Scale:**
  - Numerical or categorical scale that assigns scores to each level of performance. This scale helps quantify the evaluation and provides a basis for calculating grades.
- **Feedback:**
  - Space for comments or feedback on specific strengths and areas for improvement. This section allows instructors to offer constructive feedback to guide students in enhancing their performance.

Using a rubric offers several advantages in the assessment process:

- **Transparency**: Students have a clear understanding of the expectations, making the assessment process more transparent.
- **Consistency**: Rubrics help ensure consistency in grading among different assessors, reducing subjectivity.
- **Feedback**: Instructors can provide specific feedback, guiding students on how to improve and excel in their work.
- **Efficiency**: Rubrics streamline the grading process, making it more efficient for educators.
- **Learning Tool**: Rubrics can be used as a learning tool, helping students understand the criteria for success and facilitating self-assessment.

Overall, rubrics are valuable tools for both educators and students, fostering a more structured and objective approach to the assessment of academic work.

Sample Rubrics

Rubric for Continuous Assessment of Laboratory Work

	Excellent	Good	Average	Poor	Grading
Cognitive Domain (10)	Shows excellent understanding of theory and procedure taught	Shows minimal understanding of theory and procedure taught	Shows poor understanding of theory and procedure taught	Unable to relate to the procedures and theory taught	
Psychomotor (10)	Successfully completes the experiments procedure independently	Successfully completes the experiments procedure with minimal supervision	Successfully completes the experiments procedure with moderate supervision	Successfully completed experiments with total supervision	
Affective (5)	Explain end results with good presentation skills and in systematic way	Explain end results with good presentation skills	Explain end results with average presentation skills	Poor in presenting the end results	
				Total (Out of 25)	

Rubric for Case Study

	Excellent	Good	Average	Poor	Grading
Case Presentation (Out of 5)	• discusses all important aspects of the background of the case • demonstrates all unique features of the case • identifies all problems in the case	• discusses most important aspects of the background of the case • demonstrates most unique features of thecase • identifies most problems in the case	• discusses some important aspects of the background of the case • demonstrates some unique features of the case • identifies some problems in the case	• discusses few of the important aspects of the background of the case • demonstrates few unique features of the case • identifies a few problems in the case	

	Excellent	Good	Average	Poor	Grading
Analysis/ Solution Options (Out of 10)	• discusses an in-depth and critical assessment of the facts of the case in relation to available research • weighs and assesses a variety of alternative actions that address multiple issues in the case, all of which are realistic options	• discusses a mostly thorough assessment of the facts of the case in relation to available research • weighs and assesses a variety of alternative actions that address multiple issues in the case, most of which are realistic options	• discusses a somewhat thorough assessment of the facts of the case in relation to available research • weighs and assesses a limited variety of alternative actions that address multiple issues in the case, some of which are realistic options	• discusses a sparse assessment of the facts of the case, and some are not based on available research • weighs and assesses only one alternative solution for the case	
Recommendations /Final Plan Implementation (Out of 5)	• proposes a detailed action plan of final recommendations • justifies final decisions with specific evidence	• proposes an action plan of final recommendations • justifies some final decisions with specific evidence	• proposes a limited action plan of final recommendations • justifies some final decisions with specific evidence	• proposes a limited action plan of final recommendations • justifies few decisions with specific evidence	
				Total (OUT of 20)	

Rubric for Macro Project

	Excellent	Good	Average	Poor	Grading (1- Low to 5 - High)
Design Methodology	Division of problem into modules and good selection of computing framework. Appropriate design methodology and properly justification	Division of problem into modules and good selection of computing framework Design methodology not properly justified	Division of problem into modules but inappropriate selection of computing framework Design methodology not defined properly	Modular approach not adopted Design methodology not defined	
Planning of Project, Work and Team Structure	Time frame properly specified and being followed Appropriate distribution of project work	Time frame properly specified and being followed Distribution of project work inappropriate	Time frame properly specified, but not being followed Distribution of project work un-even	Time frame not properly specified In-appropriate distribution of project work	
Demonstration of Project	All defined objectives are achieved Each module working well and properly demonstrated. All modules of project are well integrated and system working is accurate	All defined objectives are achieved Each module working well and properly demonstrated Integration of all modules not done and system working is not very satisfactory	Some of the defined objectives are achieved Modules are working well in isolation and properly demonstrated Modules of project are not properly integrated	Defined objectives are not achieved Modules are not in proper working form that further leads to failure of integrated system	
Presentation	Contents of presentations are appropriate and well delivered Proper eye contact with audience and	Contents of presentations are appropriate and well delivered Clear voice with good spoken language but less eye contact	Contents of presentations are not appropriate Eye contact with few people and unclear voice	Contents of presentations are not appropriate and not well delivered Poor delivery of presentation	

	Excellent	**Good**	**Average**	**Poor**	**Grading (1- Low to 5 - High)**
	clear voice with good spoken language	with audience			
				Total (OUT of 20)	

Course Outcome Attainment

Course Outcome Attainment serves as the foundational compass guiding educational endeavours, ensuring a purposeful and measurable trajectory for students and institutions alike. It is the articulation of educational objectives, delineating the knowledge, skills, and competencies that learners are expected to acquire by the conclusion of a course. This strategic framework aligns educational pursuits with broader societal needs, fostering relevance and applicability.

In the dynamic landscape of education, Course Outcome Attainment becomes imperative for several reasons. Firstly, it provides clarity and transparency, offering a clear roadmap for both educators and students to navigate the learning journey. By defining specific learning outcomes, it establishes a tangible benchmark, facilitating assessment and evaluation of the educational process. Moreover, it enhances accountability by holding institutions responsible for delivering on promised educational outcomes.

Furthermore, Course Outcome Attainment facilitates continuous improvement, as regular assessments allow for the identification of strengths and weaknesses in the educational system. This iterative feedback loop empowers educators to adapt and refine teaching methodologies, ensuring the optimization of learning experiences. Ultimately, the pursuit of Course Outcome Attainment is synonymous with the pursuit of excellence in education, fostering a culture of continuous growth and development for all stakeholders involved.

Process for Course Outcome Attainment

Figure 1 indicates the process of course outcome attainment.

The Course Outcome Assessment for a theory course is carried out using different tools like

1. In Semester Evaluation – Activity Based Assessment
2. Mid Semester Examination – Written Examination
3. End Semester Examination – Written Examination

The Course Outcome Assessment for a practical course is carried out using different tools like

1. Continuous Assessment Sheet
2. Micro Projects
3. Internal Performance Examination
4. External Performance Examination

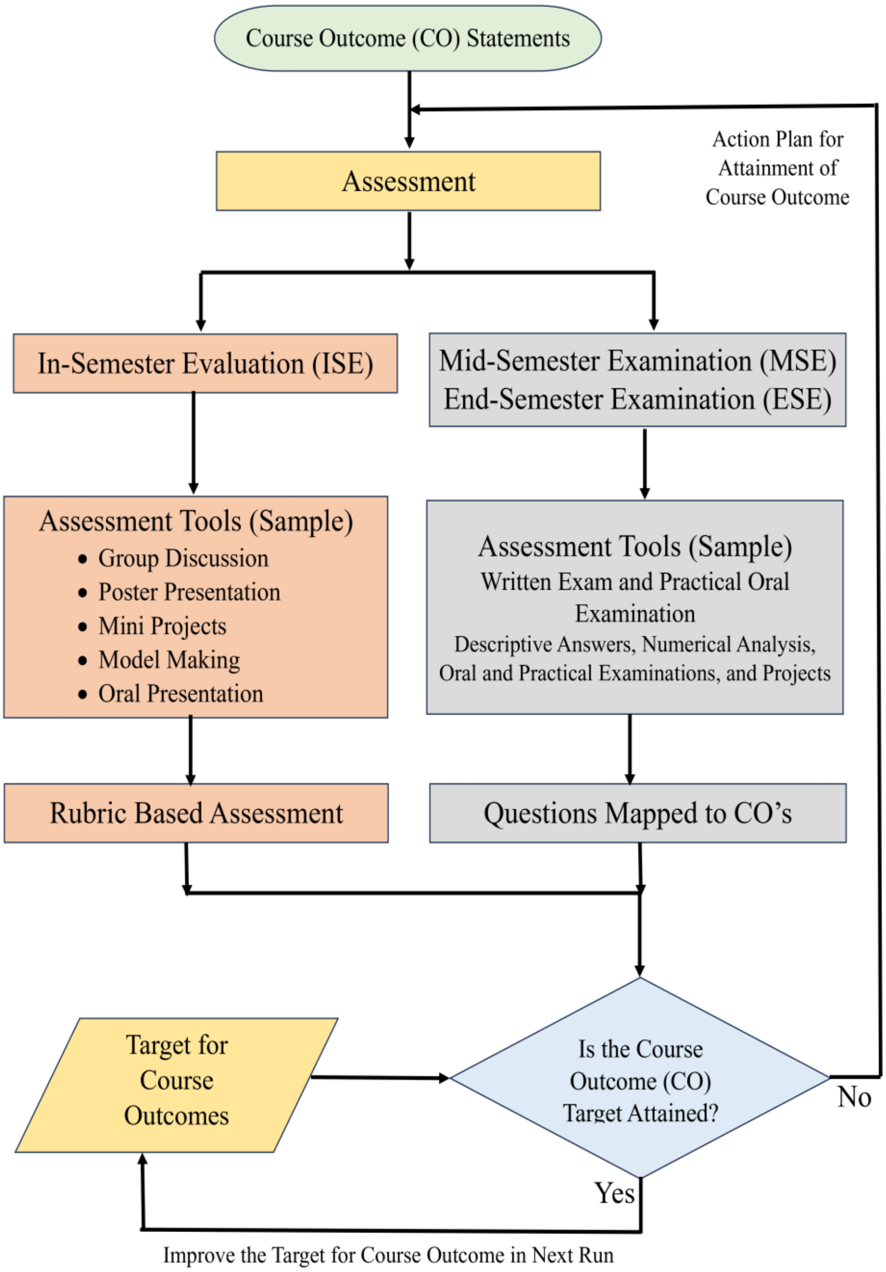


Figure 1: Process of CO Attainment

For ISE Activity based assessment rubrics are used as discussed in previous section. For Mid Semester Examination and End Semester Examination, written examination are conducted. Each question in the examination paper is mapped to the Course Outcome. The Blooms Cognitive Level is also mentioned in front of each question. In case options are to be provided in the question then the paper setter must ensure that all questions acting as option to each other must belong to the same course outcome.

DESIGN AND ANALYSIS OF ALGORITHMS [1CSPC305]

Day and Date:- Tuesday, 04.10.2022 Time: - 02:15 PM to 04:15 PM Total Marks:- 50

Instructions: -

1) All **questions** are **compulsory**
2) Make suitable assumptions **wherever** necessary, and mention them clearly in the **answer book.**
3) Figures to the **rights** indicate **full** marks and **Course Outcome [CO] and Bloom's Taxonomy (BL)** (K1-Remembering, K2- Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 - Creating)
4) Draw neat diagrams **whenever** necessary.
5) The row below the question statement shows the short **Marking Scheme [MS]** applicable to expected answers.

		Unit No. 01	Marks	CO	BL
Q. 1		**Solve the following questions,**	**[16]**		
	a)	Define an algorithm. Explain how algorithms performance is analyzed ? Describe asymptotic notation?	**08**	[305_1]	K2
		MS - Definition [02], explanation [02], algorithm [02], complexity [02]			
	b)	Explain Recursive Binary search algorithm with suitable examples.	**08**	[305_2]	K2
		MS - Explanation [02], Figure [02], algorithm and analysis [04]			
		OR			
	b)	Write a Merge Sort Algorithm and also solve time complexity using recurrence relation method .	**08**	[305_2]	K2
		MS–Algorithm [04] comppplexity[4]			
		Unit No. 02			
Q. 2		**Solve the following question,**	**[16]**		
	a)	What is the solution generated by job sequencing when n = 5, (P1, P2, P3, P4, P5) = (20, 15, 10, 5, 1), (d1, d2, d3, d4, d5) = (2, 2, 1, 3, 3)	**05**	[305_3]	K3
		MS - Each final answer and calculation [02x 04]			
	b)	Solve the following instance of knapsack problem where n=7, m=15 (P1, P2, P3, P4, P5, P6, P7) = (10, 5, 15, 7, 6, 18, 3) (W1, W2, W3, W4, W5, W6, W7) = (2, 3, 5, 7, 1, 4, 1)	**05**	[305_3]	K3
		MS - Each final answer and calculation [02x 04]			
	c)	What is a Minimum Cost Spanning tree? Explain Kruskal's Minimum cost spanning tree algorithm with suitable example and also find the time complexity.	**06**	[305_4]	K3
		MS – Deffinition[02] Explanation[06]			

The target is stated in terms of the class average percentage. If target for a course is 85% achieved then the course outcome is said to be attained. In case of course outcome attained, higher targets are set for next academic run of the same course whereas if the course outcome is not attained then action plan is decided by the course coordinator based on the analysis for the next academic run of the course.

Sample Course Outcome Attainment Sheet

Table below represents a sample course outcome attainment

Course Outcomes	Class Average Target	Attainment of CO Through					Percentage of CO Attainment	Remarks
		ISE I	MSE	ISE II	ESE	Average		
1CSPC305_1	80	76.81	36.61	75.73	63.43	63.15	78.93	Not Attained
1CSPC305_2	70		64.39		65.58	64.98	92.83	Attained
1CSPC305_3	75	72.46	74.43	74.87	65.58	71.78	95.71	Attained
1CSPC305_4	70	73.14	49.29	70.13	48.11	60.17	85.95	Attained
1CSPC305_5	75			74.53	61.23	67.88	90.51	Attained

Action Plan for CO Attainment

Based on the assessment and attainment of course outcomes, an action plan is prepared by the course coordinator for execution of the same course in next cycle. Below table represents the sample Action plan for the Course outcome attainment.

CO	Class Target	Percentage of CO attainment	CO Attained/ Not Attained	Remark/Action Plan
CO1	80	78.93	Not Attained	Think Pair Share activity can be conducted in next run to discuss different design methods of algorithms.
CO2	70	92.83	Attained	Target increased from 70 to 75%
CO3	75	95.71	Attained	Target increased from 75 to 80%
CO4	70	85.95	Attained	Target increased from 70 to 75%
CO5	75	90.51	Attained	Target increased from 75 to 80%

If course outcome is attained then the target is increased by 5% for the next cycle. If the course outcome is not attained, then course coordinator proposes the action to be taken for next cycle of the course (Action can be in terms of the teaching learning process or assessment methods)

Program Outcome Attainment

Program Outcome Attainment stands as a cornerstone in the edifice of higher education, embodying the collective aspirations and commitments of academic programs. It transcends individual courses, encapsulating the overarching goals and competencies that students are expected to master upon the culmination of their academic journey. This holistic perspective is indispensable, offering a panoramic view of educational efficacy and ensuring the comprehensive development of graduates.

The significance of Program Outcome Attainment lies in its ability to harmonize the diverse components of a curriculum, providing a cohesive narrative that aligns with the broader objectives of an academic program. It serves as a strategic compass, guiding educational institutions in their mission to produce well-rounded and competent graduates equipped to meet the challenges of a dynamic world.

Moreover, Program Outcome Attainment contributes to the assurance of quality in education by establishing a framework for continuous evaluation and enhancement. By delineating the knowledge, skills, and attributes that define program success, it fosters a culture of accountability and excellence. This framework not only benefits students by ensuring a robust and relevant education but also empowers institutions to adapt and innovate in response to evolving societal needs, contributing to the perpetual evolution of the academic landscape.

Process of Program Outcome Attainment

In PO and PSO attainment, the weightage to direct and indirect attainment is 90% and 10%, respectively. After the attainment computation of POs/PSOs, a thorough analysis of attainment levels is done by the department. This analysis includes finding the weak areas towards attaining POs/PSOs. Furthermore, a detailed action plan is prepared for the improvement.

Formulation for the calculation of attainment for POs and PSOs

PO / PSO attainment is calculated by considering 90 % weight to direct assessment and 10 % Weight to indirect assessment through surveys

The formula for attainment:

PO attainment (A) = 0.9* average of direct assessment + 0.1* average of indirect assessment

The Program Outcomes and Program Specific Outcome Attainment is calculated using the process mentioned in the Figure 2

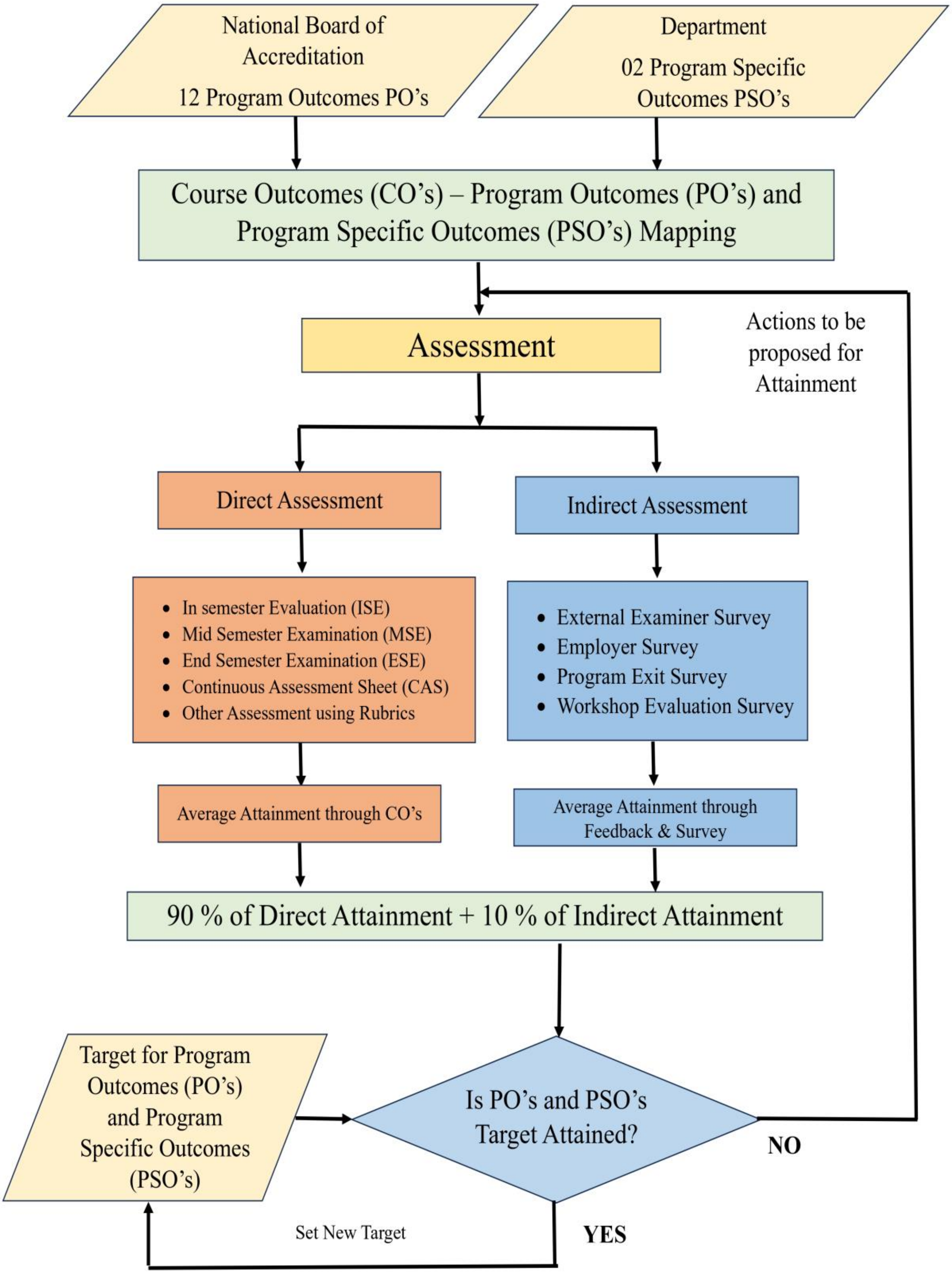


Figure 2: Process of PO and PSO Attainment

Direct PO Attainment through Courses

Program Outcome Attainment through courses is evaluated on the basis of the mapping performed by the course coordinator. Below given is one sample Course Outcome – Program Outcome Mapping and the CO Attainment Percentage table for one of the sample course.

Course Outcomes	PO's												PSO's	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1CSPC305_1	2	2							2	2				2
1CSPC305_2	2	2							2	2		2		2
1CSPC305_3	2	2	2											2
1CSPC305_4	3	2	2											2
1CSPC305_5	3	2	2	2								2		2

Course Outcomes	Blooms Level	Percentage of CO Attainment
1CSPC305_1	K2	84.35
1CSPC305_2	K2	69.12
1CSPC305_3	K3	97.82
1CSPC305_4	K3	79.86
1CSPC305_5	K4	96.62

Attainment:
84.35/100 *2 = 1.69

Program Outcome / Program Specific Outcome Attainment														
Course Outcomes	**PO's**												**PSO's**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1CSPC305_1	1.69	1.69							1.69	1.69				1.69
1CSPC305_2	1.38	1.38							1.38	1.38		1.38		1.38
1CSPC305_3	1.96	1.96	1.96											1.96
1CSPC305_4	2.40	1.60	1.60											1.60
1CSPC305_5	2.90	1.93	1.93	1.93								1.93		1.93
Average	**2.06**	**1.71**	**1.83**	**1.93**					**1.53**	**1.53**		**1.66**		**1.71**

On similar lines, PO Attainment through all courses is calculated. Average of all contributed courses gives Program Outcome/ Program specific outcome attainment through courses.

Course Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1CSBS101	1.98	0.99												
1CSBS102	1.98	0.98												
1CSES103	1.80	2.00												
1CSES104	2.96	1.98												
1CSES105	2.40	2.20												
1CSBS151	2.50	1.00						2.00	0.85	0.85				
1CSES152	2.00	2.00						1.00		2.00				
1CSES153	0.99				1.55			0.89	1.66	2.72				
1CSBS106	3.00	1.00												
1CSPC107	2.00													
1CSES108	1.80	0.88												
1CSES109	2.00	1.00												
1CSES110	1.92	1.00												
1CSES154	2.00	1.00						2.00	1.00	2.00				
1CSBS155	2.00				1.00			2.00	2.00	2.00				

Course Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1CSES156	1.47								1.18	1.18		1.80		
1CSBS2O1	2.69	1.96												
1CSPC202	2.5	2.07											1.66	
1CSPC203	1.47	1.47	1.22	1.49										1.47
1CSPC204	2.48			1.61										1.64
1CSPC205	2.71	1.83											2.39	
1CSPC251	1.82	1.82		1.84	1.85									
1CSPC252	2.84	1.9	1.89	1.89	1.9			2.89		2.81				1.9
1CSPC253	2			3	2							2		2
1CSES254	2.79	2.3		2.4	2.4			2		1.74				1.41
1CSBS206	2.13	1.25												
1CSPC207	2.8	1.96												
1CSPC208	2.85	1.44											2.06	
1CSPC209	2.88	2.29	2.29						1.95	1.95				1.92
1CSPC210	2.14	1.99	1.98	1.91	1.98	1.99								1.94
1CSPC255	1.94			2.91	1.93							1.94		1.94

Course Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1CSPC256	2.25	3		3	3					2		2		2
1CSES257	2.61	2.38		2.38	2.38			1.87		1.87				
1CSMC211	1.9	1.2	0.97	0.97	0.94	2.47	2.66	1.47	1.72	2.1	1	1.67		
1CSOE3*	2.23	1.53	0.74	0.11		0.24	0.42	0.46	0.63	0.46	0.17	0.36		
1CSPC304	1.88	1.46											1.59	
1CSPC305	2.06	1.71	1.83	1.93					1.53	1.53		1.66		1.71
1CSPC306	2.13	1.94	1.74						1.56	1.71		1.56		1.8
1CSPE307	1.44	1.44	1.55	1.81			1.04	1.04	1.3	1.04		1.3		1.6
1CSPE308	1.63	1.63			1.53	2		0.81		1.63		0.81		
1CSPE309	1.46	1.62								1.86				1.25
1CSPC351	1.86	1.89	1.83	1.83				2		1.77		1.91		1.89
1CSPC352	2.95	2.36	2.16	1.99	1.95				1.95	2.92		2.75		2.94
1CSPE353	1.88	1.88	2	1.88	1.88			1.87	1.87	1.88		1.88	1.88	
1CSPE354	2.79	1.99	1.99		2.98			1.99	1.99	2.98				1.99
1CSPR356	1.97	2.82	2.39	2.39	1.97	2.82	2.39	1.97	2.39	2.82	2.39	2.39	2.82	2.82
1CSPR357	2	3	2.75	3	2.67	2	2	2.67	3	2.33	2.33	2	3	3

Course Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1CSOE3**	2.12	1.52	0.74	0.98	0.91	0.74	0.5	0.98	0.81	0.88	0.15	0.76		
1CSHS313	1.47	1.47	1.47		1.58		1.46	1.47	1.47	1.58		1.47		
1CSPC314	2.18	1.77							1.42	1.94		1.94		1.54
1CSPC315	2	2	1.35	1.9	1.93			1.61	1.61	1.61		1.72		1.47
1CSPE316	2.25	1.74	1.74		1.72			1.72	1.72	1.72				2.6
1CSPE317	1.88	1.58	1.58	1.48								1.63		1.66
1CSPE318	1.78	1.63	1.6					0.59	1.78	1.78			0.8	
1CSPC358	2.81	2.19		2.19	2.19			1.83		1.88				1.86
1CSPC359	2.41	1.82	1.88	1.88				2.18	2.18	2.2				1.81
1CSPC360	2	2	2	2	2			3		3		3		2
1CSPC361	2.14	1.65	1.42	2.1	1.68			2.28	2.83		1.74	1.74		1.51
1CSPC362	2.71	2.71	2.21	2.71	2.71			2.86		2.71	2.71		2.96	
1CSPR363	2	3	2.75	3	2.67	2	2	2.67	3	2.33	2.33	2	3	3
1CSOE4**	2.43	1.52	0.2		0.91	0.07	0.13	0.33	0.5	1.37				
1CSHS403	1.9	1.6	1.9	0.8	1.81	1.82				1.65	1.85			1.44
1CSPC404	2.28	2.28		2.9	1.93			0.98	1.96	1.96		1.93		1.94

Course Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1CSPC405	2.04	1.9	1.81		1.81			1.6	1.81	1.6		1.47		1.69
1CSPE407	1.71	1.71	1.69		1.71				1.67	1.67		1.67		1.71
1CSPE408	1.96	1.92	1.96		2.94						2			1.89
1CSPC451	2.62	1.81	1.72		1.72		1.72	1.72				1.72		1.72
1CSPC452	2.85	1.9	1.91	2.14	2.38			1.9	1.9	2.85		1.9		1.9
1CSPE454	2.97	1.98		1.98	2.37			1.97	2.57	2.57		1.97		1.98
1CSPE455	1.96	1.92	1.96		2.94						2			1.89
1CSPR456	2.4	2	2	1.75	1.75	1.75	1.6	1.75	2	1.75	2	2	2	
1CSPE409	1.86	1.62	1.91	0.81	1.86	1.89				1.9	1.99			1.47
1CSPE410	1.79	1.79			1.54			1.49		1.49		1.32		1.49
1CSPE411	2.27	1.9	2.34	1.78	1.89									1.96
1CSPR457	2.4	2	2	1.75	1.75	1.75	1.6	1.75	2	1.75	2	2	2	
Direct Attainment	**2.17**	**1.81**	**1.78**	**1.96**	**1.97**	**1.66**	**1.46**	**1.72**	**1.75**	**1.92**	**1.76**	**1.76**	**2.18**	**1.89**

Indirect PO Attainment using Surveys

Department of Computer Science and Engineering use 4 surveys to perform indirect program outcome attainments.

1. Program Exit Survey
2. Industrial Visit Survey
3. External Oral Examiner Survey
4. Workshop Evaluation Survey

Below given is sample survey form for program exit survey.

Sr.No	**Performance Criteria**	**Ex.**		**Avg.**		**poor**
		5	**4**	**3**	**2**	**1**
1	How would you rate your overall grasp of fundamental engineering principles acquired during your B. Tech program? **(PO1)**					
2	Reflecting on your coursework, how confident do you feel in designing and conducting experiments to analyze engineering problems? **(PO2)**					
3	To what extent do you feel capable of designing and conducting experiments to address engineering challenges? **(PO3)**					
4	Evaluate your ability to effectively solve complex engineering problems using theoretical knowledge and practical skills.**(PO4)**					
5	How proficient do you consider yourself in utilizing modern engineering tools and software for analysis and design?**(PO5)**					
6	Reflect on how your engineering education has addressed the connection between engineering solutions and their impact on society. **(PO6)**					
7	Assess your understanding of environmental issues and sustainability in the context of engineering projects.**(PO7)**					
8	How well do you think your program has instilled ethical considerations in your engineering practice?**(PO8)**					

9	Reflect on your experience with individual and team work. How well were you prepared for collaborative engineering efforts?**(PO9)**					
10	Evaluate your communication skills, including written and verbal communication, in conveying technical information.**(PO10)**					
11	How well do you feel equipped to manage engineering projects, including financial aspects, based on your program experience? **(PO11)**					
12	To what extent do you feel your B. Tech program has instilled a mindset of lifelong learning and adaptability in the rapidly evolving field of engineering?**(PO12)**					
13	Reflect on the impact of the engineering solutions you have worked on during your program. How do you perceive their potential real-world impact?**(PSO1)**					
14	To what extent did your B. Tech program foster your technical curiosity and a desire to explore emerging technologies?(**PSO2**)					

Below given is sample survey form for industrial visit survey

Performance Criteria	**PO**	**Excellent**	**Average**	**Poor**	**Ex Grading Poor**				
					5	**4**	**3**	**2**	**1**
Communication skill	**10**	Students were able to communicate very well with employer/employees	The communication skill of students was average and need to be improved further	Students were not able to communicate to us in a proper language.					
Attitude and behavioral aspect of students	**8**	All or majority of the students were very much punctual and disciplined; arrived on time, followed the proper code of conduct during industrial visit	Some students were disciplined; Some of them were not following the code of conduct during industrial visit	All or majority of the students were not punctual and disciplined; arrived very late , not followed the proper code of conduct					

Performance Criteria	**PO**	**Excellent**	**Average**	**Poor**	**Ex Grading Poor**				
					5	**4**	**3**	**2**	**1**
				during industrial visit					
Technical Curiosity	**12**	All or majority of students were very much curious to know more about the minute details of SOPs /professional ethics / mechanisms	Some Students were keen and showing interest and some were moving casually in the industry premises	Majority or all of the students were very much casual and not interested to learn and know about SOPs /professional ethics /mechanisms					

Below given is survey form for External Oral Examination Survey

Performance Criteria	**Sub criteria**	**Excellent**	**Average**	**Poor**	**Ex. Avg. poor**				
					5	**4**	**3**	**2**	**1**
Engineering Knowledge and basic concepts (PO1)	i) Oral questions. ii) Plotting of graphs iii) Writing mathematical equations	Students Show thorough knowledge of the topic. Able to answer all the questions related with subject.	Students Show some basic knowledge of the topic. Able to answer some questions related with topic.	Students Show little or no knowledge of the topic. Unable to answer any questions related with topic.					
Design and conduct an experiment (PO4) **(Content)**	i)Performance of experiment ii)Understanding of experiment	Students conduct experiment thoroughly and find correct results within time.	Students conduct experiment partially and find some results within time.	Students unable to conduct experiment or find wrong results.					
Professional and ethical	i)Punctuality	Students exhibit	Students exhibit	Students work does					

Performance Criteria	Sub criteria	Excellent	Average	Poor	Ex. Avg. poor				
					5	4	3	2	1
behavior (PO8)	ii) Dressing iii)Student gestures iv)Decency in conversation	these qualities to an exceptional degree.	these qualities to some measurable degree.	not exhibit these qualities in any measurable way.					
Individual and Team Work (PO9)	i) Skills utilization ii) Participation	Group utilizes skills of each members for the project development	Group utilizes skills of some members for the project development	Group does not utilizes skills of each members for the project development					
Oral communication (PO10)	i) Use of grammar ii)Ability to express	Students make use of grammatically correct English sentences.	Students have some problems with language usage.	Students find it difficult to convey their message in English.					

Below given is survey form for Workshop Evaluation Survey

Performance Criteria	PO	Excellent	Average	Poor	Ex Grading Poor				
					5	4	3	2	1
Apply Basic Knowledge	**1**	Majority of students having sound knowledge of fundamentals; They were applying the fundamental knowledge during workshop/seminar.	The fundamentals of students were average and need to be focus further.	The fundamentals of students were poor and required immediate attention.					

Performance Criteria	PO	Excellent	Average	Poor	Ex Grading Poor				
					5	4	3	2	1
Hands-on Experience*	**4**	All or majority of the students were involved seriously in hands-on training.	Only some students were involved seriously in hands-on training.	All or majority of the students were not involved seriously in hands-on training.					
Attitude and Behavioral aspect of students	**8**	All or majority of the students were very much punctual and disciplined; arrived on time, following instructions	Some students were disciplined; Following instruction during workshop/seminar	All or majority of the students were not punctual and disciplined; arrived very late, not followed instructions.					
Communication Skill	**10**	Students were able to communicate very well with an expert	The communication skill of students was average and need to be improved further	Students were not able to communicate to us in a proper language.					
Technical Curiosity	**12**	All or majority of students were very much curious to know more about topic.	Some Students were keen and showing interest and some were attending casually.	Majority or all of the students were very much casual and not interested to learn.					
Contemporary Issues	**6**	Majority of the students aware about latest development/update in the field.	Few students aware about latest development/update in the field.	Students not aware about latest development/update in the field.					
Modern Engineering Tools*	**5**	Students were able to use modern software.	Very few students were able to use software.	Students were not able to use modern software.					

Based on the responses collected for all the surveys, indirect PO Attainment is calculated. Below mentioned is sample PO Attainment using indirect surveys.

Rubrics	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
External Oral Survey	2.65			2.59				2.59	2.57	2.4				
Workshop Evaluation Survey	2.83			2.66	2.83	2.74		2.74		2.4		2.83		
Industry Visit Survey								2.7		2.7		2.4		
Program Exit Survey	2.85	2.72	2.75	2.62	2.75	2.4	2.5	2.78	2.74	2.68	2.8	2.87	2.84	2.75
Indirect Attainment	**2.78**	**2.72**	**2.75**	**2.62**	**2.79**	**2.57**	**2.50**	**2.70**	**2.66**	**2.55**	**2.80**	**2.70**	**2.84**	**2.75**

PO/PSO Attainment is calculated as per below table

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
Direct Through Course	2.17	1.81	1.78	1.96	1.97	1.66	1.46	1.72	1.75	1.92	1.76	1.76	2.18	1.89
Indirect Through Surveys	2.78	2.72	2.75	2.62	2.79	2.57	2.50	2.70	2.66	2.55	2.80	2.70	2.84	2.75
Attainment (23 BATCH)	**2.23**	**1.90**	**1.87**	**2.02**	**2.05**	**1.75**	**1.56**	**1.82**	**1.84**	**1.98**	**1.87**	**1.85**	**2.25**	**1.98**
Target	2.39	2.01	2.00	2.21	2.23	1.98	1.75	1.95	2.03	2.24	1.87	2.03	2.45	2.12
Remarks	**Attained**	**Attained**	**Attained**	**Attained**	**Attained**	**Attained**	**Attained**	**Attained**	**Attained**	**Attained**	**Attained**	**Attained**	**Attained**	**Attained**