IARE
INSTITUTE OF
AERONAUTICAL ENGINEERING

Outcome Based Education (OBE) Manual
(BT25)

Department of Aeronautical Engineering

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Outcome Based Education (OBE) Manual

at Program and Course Level that Align with NBA

Table of contents

PREAMBLE

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

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

National Board of Accreditation (NBA) is an authorized body for the accreditation of Higher education institutions in India. NBA is also a full member of the Washington Accord. It accredits only the programs but not the institutions.

Higher Education Institutions are classified into two categories by NBA

Tier - 1: Institutions consist 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 consist 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 AND CORE VALUES

Institute Vision

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

Institute Mission

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

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

Department Vision

To build a strong community of dedicated graduates with expertise in the field of Aerospace science and engineering suitable for industrial needs having a sense of responsibility, ethics and ready to participate in aerospace activities of national and global interest.

Department Mission

To actively participate in the technological, economic and social development of the nation through academic and professional contributions to aerospace and aviation areas, fostering academic excellence and scholarly learning among students of aeronautical engineering.

The Aeronautical Engineering Department is committed to

- **M1:** To provide an **extensive and exceptional education** that equips students with the knowledge, skills, and professionalism required to excel in their careers and contribute effectively to the aerospace industry.
- **M2:** To nurture **creative leadership qualities** and develop the ability to address complex technical challenges with innovation, critical thinking, and ethical responsibility.
- **M3:** To promote **research and innovation** aimed at generating new knowledge, advancing aerospace technologies, and fostering a culture of lifelong learning.
- **M4:** To **encourage entrepreneurship and economic development**, empowering graduates to create sustainable solutions and contribute to the advancement of the wider community and the nation.

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. OUTCOME BASED EDUCATION

Outcome-based education emphasizes clearly defined, high-quality demonstrations of meaningful learning outcomes in authentic contexts. This approach organizes the educational system to ensure that all students develop the critical knowledge, skills, and competencies needed for success by the end of their learning journey.

This means starting with a clear picture of what is important for students to be able to do, then organising the curriculum, instruction, and assessment to make sure this learning ultimately happens to all students.

The curriculum structure and features of the programs offered at IARE are developed in accordance with the principles of Outcome Based Education (OBE) and accredited by the National Board of Accreditation (NBA), India is one of the signatory members of the Washington Accord, an international agreement that recognizes engineering degrees from other member countries that are signatories to the Accord.

Employability statement: This curriculum embeds the development of employability skills throughout the course and is designed to equip students with the ability to relate the knowledge and skills that they have learnt to real world contexts in which they work or may work in the future. The use of expert guest lecturers from industry is the important assets for students attending the program.

What does OBE address?

OBE addresses the following **key questions:**

WHAT do we want the students to be able to do?	Have knowledge, practical engineering skills (Lab-Fab-App) and be able to solve problems.
HOW can we help students best to achieve it?	Student Centric Learning
HOW will we know whether the students have achieved it?	Through various assessment schemes
HOW Do we close the loop for further improvement? (Continuous Quality Improvement)?	Plan – Do – Check – Act.

2.1 OBE Implementation

Outcome-Based Education (OBE) is a student-centric learning model that helps teachers to plan the course delivery and assessment. It is implemented as per the following steps:

- Define Vision statements, Mission statements for the Institute and department
- Define Program Educational Objectives
- Program Outcomes and Program Specific Outcomes Statements
- Role of Knowledge and Attitude Profiles (WKs)
- Engineering Competencies (EC): Role of Engineering competencies for Complex engineering problems solving and complex engineering activities
  - Define Course Outcomes
  - Map courses with Program Outcomes
  - Define Course Outcomes with Bloom's Taxonomy for each course
  - Map topics with Course Outcomes
  - Prepare lecture-wise Course Lesson Plan – Schedule of instruction
  - Define pedagogical tools for course outcomes delivery
- Define Self Learning and Term Work activities like complex engineering problems, tutorial, practical, seminar, Mini Project, Assignments, Seminars, Course Projects, Industrial Visits, Case Studies, Digital Certifications, etc.,
- Use **Aakansha** Learning Management Portal for course full stack
- Use of **Effective Students Learning Outcomes (ESLO)** tool to measure the attainment of each Course Outcomes and POs /PSOs
- Track students' performance
- Identify Gaps in the Curriculum and adopt suitable measures to bridge the Gap
- Compare PO/PSO for last 3 academic years and propose remedial actions
- Assess the attainment of Program Educational Objective.

2.2 OBE Outcomes and Profiles

The list of outcome-based education outcomes and profiles are as follows:

- Program Educational Objectives (PEO)
- Program Outcomes (PO)
- Program Specific Outcomes (PSO)
- Knowledge and Attitude Profiles (WK)

- Engineering Competencies (EC): Range of Complex Engineering Problems (CP) and Complex Engineering Activities (CA)
- Learning Domains (LD)
- Sustainable Development Goals (SDGs)

PEO and PSO have been established through a rigorous process involving key stakeholders (which include faculty, industries, students, and parents). The process was initiated in 2024 through a series of workshops and assessments.

The lists of WKs are obtained from the recent document published by NBA (August, 2024). The list of LDs is based on the three categories of cognitive, affective and psychomotor domains based on the revised Bloom's Taxonomy.

3. PLANNING AND DEVELOPMENT OF LEARNING OUTCOMES BASED APPROACH TO CURRICULUM

The basic objective of the learning outcome-based approach to curriculum planning and development is to focus on demonstrated achievement of outcomes (expressed in terms of knowledge, understanding, skills, attitudes and values) and academic standards expected of a program of study. Learning outcomes specify what graduates completing a particular program of study are expected to know, understand and be able to do at the end of their program of study.

The expected learning outcomes are used to set the benchmark to formulate the course outcomes, program specific outcomes, program outcomes and engineering competencies. These outcomes are essential for curriculum planning and development, and in the design, delivery and review of academic programs. They provide general direction and guidance to the teaching-learning process and assessment of student learning levels under a specific program.

The overall objectives of the learning outcomes-based curriculum framework are to:

- Attain program outcomes, program specific outcomes and course outcomes that are expected to be demonstrated by the holder of a qualification.
- Enable prospective students, parents, employers and others to understand the nature and level of learning outcomes (knowledge, skills, attitudes and values) or attributes a graduate of a program should be capable of demonstrating on successful completion of the program of study.
- Maintain national standards and international comparability of learning outcomes and academic standards to ensure global competitiveness, and to facilitate student/graduate mobility.
- Provide higher education institutions an important point of reference for designing teaching-learning strategies, assessing student learning levels, and periodic review of programs and academic standards.

Two words "**knowledge and skill**" can describe a person's competence! Both seem synonymous at first glance but given more thought, they depict different concepts.

Knowledge refers to learning concepts, principles and information regarding a particular subject(s) by a person through books, media, encyclopaedias, academic institutions and other sources. The following is the categorization of different levels of mastery: Assessment, Usage, and Familiarity. The **Assessment** encompasses both Usage and Familiarity, and **Usage** encompasses Familiarity

- **Familiarity**: The student understands what a concept is or what it means. This level of mastery concerns a basic awareness of a concept as opposed to expecting real facility with its application. It provides an answer to the question "What do you know about this?"
- **Usage:** The student is able to use or apply a concept in a concrete way. Using a concept may include, for example, appropriately using a specific concept in a program, using a particular proof technique, or performing a particular analysis. It provides an answer to the question "What do you know how to do?"

- **Assessment:** The student is able to consider a concept from multiple viewpoints and/or justify the selection of a particular approach to solve a problem. This level of mastery implies more than using a concept; it involves the ability to select an appropriate approach from understood alternatives. It provides an answer to the question "Why would you do that?"

Skill on the other hand refers to the ability of using that information and applying it in a context. Knowledge refers to theory and skill refers to successfully applying that theory in practice and getting expected results. The table 1, shows the details of Knowledge, Skill and Competence with their sub - strand in education.

Table 1: Details of Knowledge, Skill, Competence and Deposition with their sub - strand in education.

Strand	Sub-strand	Description
Knowledge	Breadth	How broad is the learner's knowledge?
	Type	What characteristics and quality of knowing has the learner engaged in?
Skill	Range	What is the breadth of the physical, intellectual, social and other skills acquired by the learner?
	Selectivity	How does the learner select the skills learned to address a range of problems? What is the nature of the complexity of the problems and how does the learner engage with them?
Dispositions	Application of knowledge-skill pairs.	Outline the "know-why" component of the skilled application of knowledge and capture the nuances brought about by the contextual application of knowledge-skill pairs. There is often a character and quality of application inherent in the domain and context of application.
Competence	Autonomy and responsibility	How does the learner demonstrate the taking of responsibility personally and in groups? How does the learner deploy skills acquired in managing interactions with others and working on their own?
	Self-development	To what extent can the learner operate in new environments, acquire new knowledge and skills; and assimilate these to their existing body of knowledge and skills?
	Role in Context	Can the learner apply/deploy their knowledge and skills in a range of relevant contexts?

Competency-based approach

A competency is the graduate's ability to apply knowledge, skills, and dispositions (called attitudes) to effectively complete tasks.

This philosophy and definition acknowledge cognitive (Thinking, and learning.) and metacognitive skills (knowledge and understanding), demonstrated use of knowledge and applied skills, and interpersonal skills that often work in concert.

Hence competencies are the traits, behaviours, and abilities, the graduate must demonstrate to capably perform in a job, role, function, task, or duty. Job-relevant behaviours, motivations, and technical knowledge-skills are utilized together in the accomplishment of the task.

Benefits of Competency-based approach are

- Competencies focus on what the students need to learn, not what educators need to teach.
- Competencies effectively communicate expectations of graduates to external stakeholders.
- Competencies encourage reflection on student learning.
- Competencies can be used globally in diverse contexts.
- Competencies fit well with most accrediting agencies that use an outcome-focused approach

Competency = [Knowledge + Skills + Dispositions] in Task as shown in figure 3.

Knowledge is the "know-what" component of a competency that is most familiar and commonly associated with any curriculum. These are the factual elements we embed in our catalogues, syllabi, lectures, and associated materials. These are critically important nouns that **define the "what" that is taught in an IS curriculum.** Available through the publications and other intellectual contributions from scholars and practitioners.

Skills are the verbs in competency-task statements that suggest the approach to the application of knowledge. Skill development requires a progression through experience and the application of higher orders of cognitive load adopting a modified Bloom's taxonomy of learning objectives as shown in Figure 1, for clarity on complexity and specificity as well.

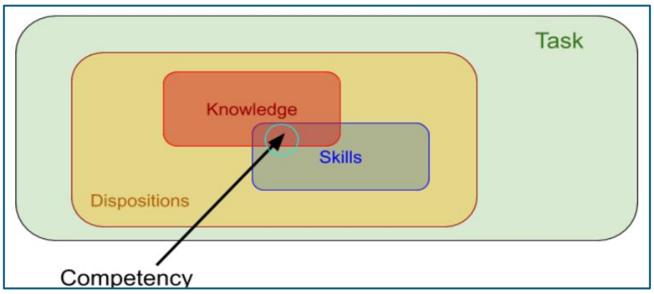

Figure 1: Bloom's Cognitive Skill List

The inclusion of Bloom's levels illustrates in Table 2, the close linkage between knowledge-based and competency-based approaches.

On the lower skill levels, students are expected to "**remember" or "understand" knowledge**, which refers to more cognitive aspects of learning.

However, to reach the level "applying" or higher, assignments where students practice the **use of knowledge** in specific tasks provided by a teacher are required.

Table 2: Bloom's Taxonomy action verbs

Definitions	I. Remembering	II. Understanding	III. Applying	IV. Analyzing	V. Evaluating	VI. Creating
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 solutions.
Verbs	• Choose • Define • Find • How • Label • List • Match • Name • Omit • Recall • Relate • Select • Show • Spell • Tell • What • When • Where • Which • Who • Why	• Classify • Compare • Contrast • Demonstrate • Explain • Extend • Illustrate • Infer • Interpret • Outline • Relate • Rephrase • Show • Summarize • Translate	• Apply • Build • Choose • Construct • Develop • Experiment with • Identify • Interview • Make use of • Model • Organize • Plan • Select • Solve • Utilize	• Analyze • Assume • Categorize • Classify • Compare • Conclusion • Contrast • Discover • Dissect • Distinguish • Divide • Examine • Function • Inference • Inspect • List • Motive • Relationships • Simplify • Survey • Take part in • Test for • Theme	• Agree • Appraise • Assess • Award • Choose • Compare • Conclude • Criteria • Criticize • Decide • Deduct • Defend • Determine • Disprove • Estimate • Evaluate • Explain • Importance • Influence • Interpret • Judge • Justify • Mark • Measure • Opinion • Perceive • Prioritize • Prove • Rate • Recommend • Rule on • Select • Support • Value	• Adapt • Build • Change • Choose • Combine • Compile • Compose • Construct • Create • Delete • Design • Develop • Discuss • Elaborate • Estimate • Formulate • Happen • Imagine • Improve • Invent • Make up • Maximize • Minimize • Modify • Original • Originate • Plan • Predict • Propose • Solution • Solve • Suppose • Test • Theory

4. ARCHITECTURE OF B.TECH CURRICULUM

The architecture is proposed in Figure 2, as a guide for a model curriculum. Constructs on the **left represent the traditional curriculum design view**, (program – program outcome, course – course learning outcomes) and the right represent entities of competency models: **Competency realm, area, competency, knowledge-skill pairs, and dispositions**. Definitions for the terms are presented in Table 3.

The structure is divided into two levels. Level 1 includes the six major elements: Program, Program Learning Outcome, Competency Realm, Competency Area, Competency Statement, and Course.

Level 2 includes **Course Learning Outcome and Competency** which is further defined through three elements, namely Knowledge, Skill, and Disposition. Each Competency Area (CA) has a set of detailed competencies.

These competencies are defined using a combination of Competency Statement, Knowledge, Skills and Dispositions that one must have to demonstrate a specific competency under a Competency area. These concepts allow a more detailed comparison of the learning objectives in a course, based on tasks assigned for students, and associated knowledge areas, skill levels, and dispositions. Level 2 aligns with the competency.

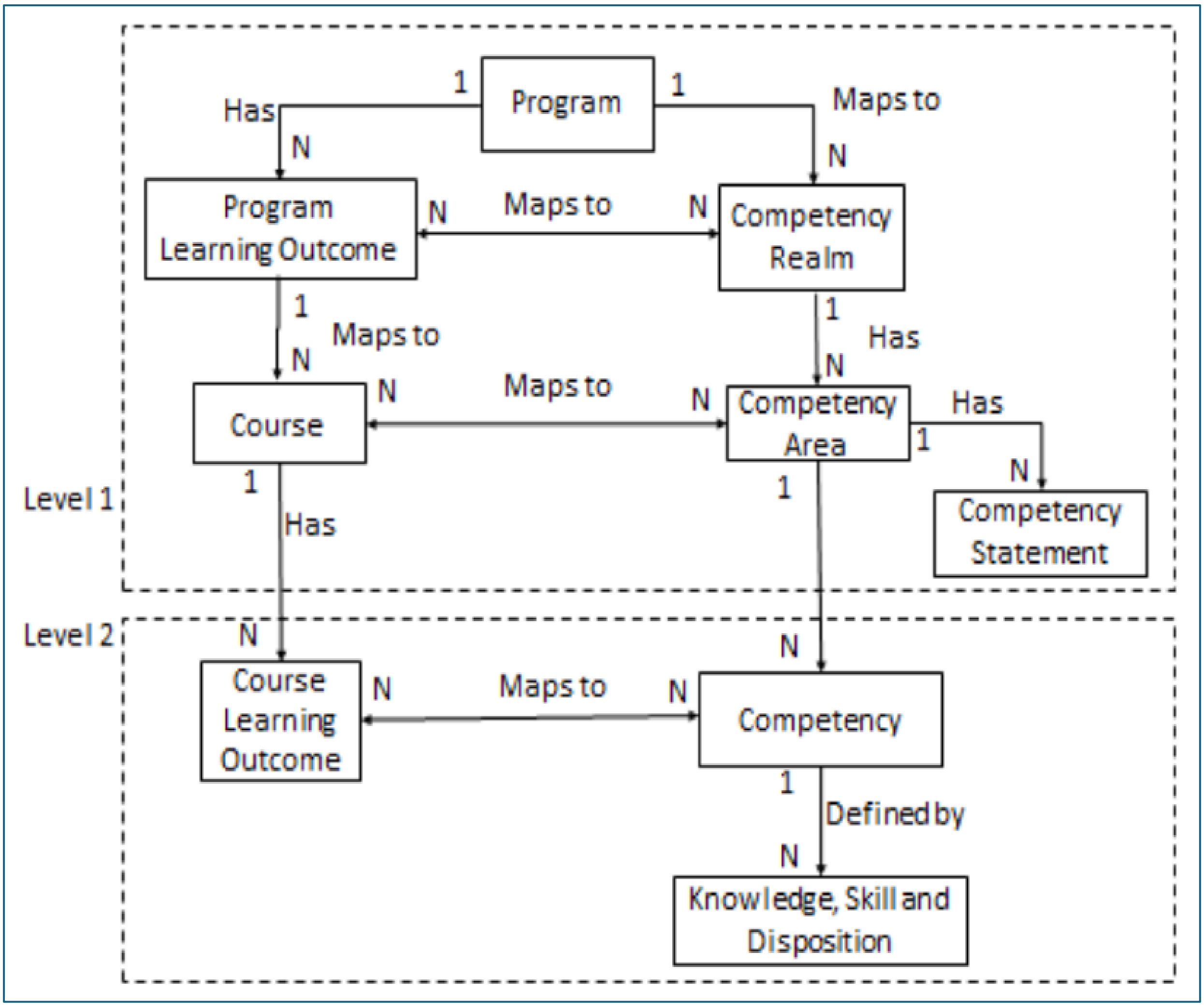

Figure 2: Curriculum Structure of B.Tech Program

Table 3: Definition of Terms Used in the Curriculum structure

Term	Term Definition
Program	Program A major or a complete undergraduate degree program in IS.
Program Learning Outcomes	Defines what students are expected to know and be able to do on completing the program. They are similar to ABET Student Outcomes.
Competency Realm	Broad areas of study relevant to an IS graduate
Competency Area	A component of the Competency Realm

Competency Statement.	A high-level description of the capability to apply or use a set of knowledge and skills required to successfully perform broad work functions related to a Competency Area.
Course description	A description of what will be covered in the course. They are generally less broad than Program Learning Outcomes and broader than Course Learning Outcomes.
Course Learning Outcome	A detailed description of what a student must be able to do on completion of a course. When writing outcomes, it is helpful to use verbs that are measurable or that describe an observable action.
Competency	A detailed description of the capability to apply or use a set of knowledge, skills, and dispositions to successfully perform specific work tasks related to a Competency Area

5 PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Broad statements that describe the career and professional accomplishments of graduates within five (5) years upon graduation. The graduates are expected to achieve one or more of the following PEO:

1. Excel in engineering practices in various industries.
2. Establish themselves as leaders in their professional careers.
3. Earn an advanced degree or professional certification.

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: Preparation & Learning Environment:

To prepare and provide student with an academic environment for students to excel in higher studies or to succeed in industry / technical profession and the life-long learning needed for a successful professional career in Aerospace Engineering and related fields

Program Educational Objective – II: Core Competence:

To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve engineering problems and also to pursue higher studies

Program Educational Objective – III: Breadth:

To train students with good scientific and engineering breadth so as to comprehend, analyse, design, and create novel products and solutions for the real-life problems.

Program Educational Objective – IV: Professionalism:

To inculcate in students professional and ethical attitude, effective communication skills, team- work skills, multidisciplinary approach, and an ability to relate engineering issues to broader social context.

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.

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

Mapping program educational objectives to program outcomes and program specific outcomes shown in table 5 and table 6 respectively which ensures the curriculum aligns with key competencies, enabling students to develop the skills and knowledge required for professional success.

Table 4: The correlation between the PEOs and POs

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

Table 5: 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

6. PROGRAM OUTCOMES (POs)

A Program Learning Outcome is broad in scope and be able to do at the end of the program. POs are to be in line with the graduate attributes as specified in the Washington Accord. POs are to be specific, measurable and achievable. NBA has defined 11 POs as shown in Table 6 and you need not define those POs by yourself and it is common for all the institutions in India. In the syllabus book given to students, there should be clear mention of course objectives and course outcomes along with CO-PO course articulation matrix for all the courses.

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 behavioural 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.

Table 6: Program Outcomes with Learning Taxonomy

PO Number	Category	Description	Learning Taxonomy
PO1	**Engineering Knowledge** Breadth, depth and type of knowledge, both theoretical and practical	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**.	Cognitive
PO2	**Problem Analysis** Complexity of analysis	Identify, formulate, review research literature and analyse **complex engineering problems** reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4).	Cognitive
PO3	**Design / Development of Solutions** Breadth and uniqueness of engineering problems i.e., the extent to which problems are original and to which solutions have not previously been identified or codified	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)	Cognitive

PO4	**Conduct Investigations of Complex Problems** Breadth and depth of investigation and experimentation	Conduct investigations of **complex engineering problems** using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8)	Cognitive, Psychomotor
PO5	**Engineering Tool Usage** Level of understanding of the appropriateness of technologies and tools	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).	Cognitive, Psychomotor
PO6	**The Engineer and the World** Level of knowledge and responsibility for sustainable development	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)	Cognitive, Affective
PO7	**Ethics** Understanding and level of practice	Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)	Cognitive, Affective
PO8	**Individual and Collaborative Team work** Role in and diversity of team	Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.	Cognitive, Affective
PO9	**Communication** Level of communication according to type of activities performed	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.	Affective
PO10	**Project Management and Finance** Level of management required for differing types of activity	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 multidisciplinary environments.	Cognitive, Affective
PO11	**Life-Long Learning** Duration and manner	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)	Affective

7. PROGRAM SPECIFIC OUTCOMES (PSOs)

Program specific outcomes (PSOs) include subject-specific skills and generic skills, including transferable global skills and competencies, the achievement of which the students of a specific program of study should be able to demonstrate for the award of the degree. Program Specific Outcomes for each program, they are permitted up to **3 (three)**.

The program specific outcomes would also focus on knowledge, skills and competencies that prepare students for further study, employment, and citizenship. The evaluation of PSOs for a program is computed by gathering PSO attainment in all the courses comprising the program. The table 7, shows the list of Program specific Outcomes of the Department of Aeronautical Engineering.

Table 7: A list of PSOs for the department of Aeronautical Engineering

PSO1	Build the prototype of UAVs and aero-foil models for testing by using low speed wind tunnel towards research in the area of experimental aerodynamics
PSO2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.
PSO3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies

8. RELATION BETWEEN PROGRAM EDUCATIONAL OBJECTIVES AND PROGRAM OUTCOMES AS WELL AS PROGRAM SPECIFIC OUTCOMES

The relationship between Program Educational Objectives (PEOs) and Program Outcomes (POs) is crucial as it ensures that the educational goals are aligned with specific outcomes, equipping students with the skills and knowledge needed for their professional success. Broad relationship between the program educational objectives and the program outcomes is given in Table 8.

Table 8: Relationship between program educational objectives and the program outcomes

Program Outcomes		Program Educational objectives			
		PEO1	PEO2	PEO3	PEO4
		Preparation & Learning Environment	Core Competence	Breadth	Professionalism
PO1	**Engineering Knowledge** Breadth, depth and type of knowledge, both theoretical and practical	3	1	2	-
PO2	**Problem Analysis** Complexity of analysis	2	2	2	-
PO3	**Design / Development of Solutions** Breadth and uniqueness of engineering problems i.e., the extent to which problems are original and to which solutions have not previously been identified or codified	2	3	-	-
PO4	**Conduct Investigations of Complex Problems** Breadth and depth of investigation and experimentation	-	3	-	2
PO5	**Engineering Tool Usage** Level of understanding of the appropriateness of technologies and tools	-	2	-	2
PO6	**The Engineer and the World** Level of knowledge and responsibility for sustainable development	2	3	2	2
PO7	**Ethics** Understanding and level of practice	2	-	-	2
PO8	**Individual and Collaborative Team work** Role in and diversity of team	2	-	-	3
PO9	**Communication** Level of communication according to type of activities performed	2	1	2	3

P10	**Project Management and Finance** Level of management required for differing types of activity	1	2	-	2
PO11	**Life-Long Learning** Duration and manner	1	1	2	1

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

Note:

- The assessment process of POs can be direct and 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.

Relation between the Program Educational Objectives and the PSOs

The relationship between Program Educational Objectives (PEOs) and Program Outcomes (POs) is crucial as it ensures that the educational goals are aligned with specific outcomes, equipping students with the skills and knowledge needed for their professional success. Broad relationship between the program educational objectives and the program specific outcomes is given in Table 9.

Table 9: Relationship between program educational objectives and program specific outcomes

Program Specific Outcomes		Program Educational Objectives (PEO)			
		PEO 1	PEO 2	PEO 3	PEO 4
		Preparation& Learning Environment	Core Competence	Breadth	Professionalism
PSO1	Build the prototype of UAVs and aero-foil models for testing by using low speed wind tunnel towards research in the area of experimental aerodynamics.	3	2	1	1
PSO2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	1	2	3	1
PSO3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	2	2	1

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 examinations (CIE) and semester end examinations (SEE).

- The indirect assessment on the other hand could be done through student's programme exit survey, alumni survey and employer survey.

9. LEARNING DOMAINS (LD) - BLOOMS TAXONOMY

Benjamin Bloom in 1956 developed a 3-part model known as the Taxonomy of Learning Domains. He splits learning into 3 different categories:

1. Cognitive domain (intellectual capability, i.e., knowledge, or 'think')
2. Affective domain (feelings, emotions and behaviour, i.e., attitude, or 'feel')
3. Psychomotor domain (manual and physical skills, i.e., skills, or 'do')

Bloom's Taxonomy is commonly used for the cognitive domain, Simpson's for the psychomotor domain, and Krathwohl's for the affective domain.

Bloom sees the domains as progressive; with the learner moving through the 6 stages of each domain as their knowledge, attitude and skills increase or develop. For the purpose of student assessment, these categories will be reclassified into twelve levels of LD. These levels are listed are shown in below Tables 10, 11 and 12.

9.1 Six levels of the Cognitive Domain

Bloom's taxonomy / Cognitive Domain is frequently used for writing learning outcomes as it provides a ready-made structure and list of verbs. These verbs are the key to writing learning outcomes. since learning outcomes are concerned with what the students can do at the end of the learning activity, all of these verbs are active (action) verbs.

The framework (revised Taxonomy in 2001) elaborated by Bloom and his collaborators consisted of six major categories: Remember, Understand, Apply, Analyse, Evaluate and Create (graphic representation of revised Blooms taxonomy is shown in figure 3).

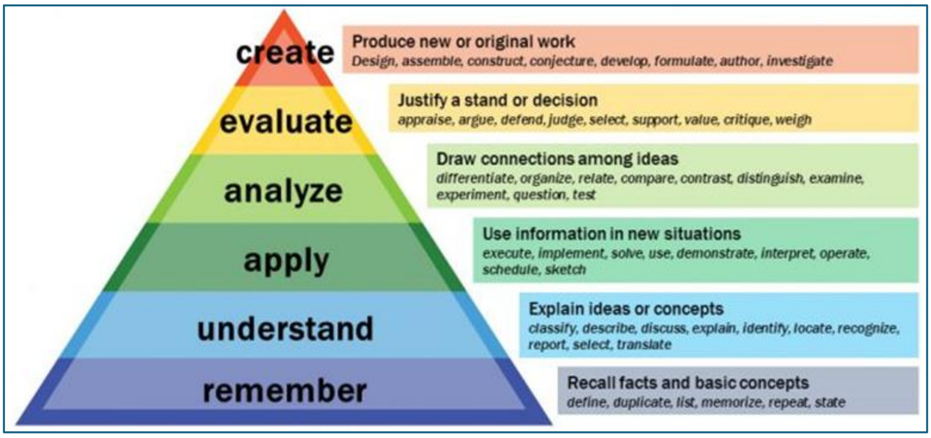

Figure 3: Graphic representation of revised Blooms Taxonomy

The categories after Knowledge were presented as "skills and abilities," with the understanding that knowledge was the necessary precondition for putting these skills and abilities into practice.

Bloom's taxonomy / Cognitive Domain is frequently used for writing learning outcomes as it provides a ready-made structure and list of verbs. These verbs are the key to writing learning outcomes as shown in table 2. Since learning outcomes are concerned with what the students can do at the end of the learning activity, all of these verbs are active (action words) verbs.

Table 10: Cognitive domain levels

CLD*	Category	Description
CLD1	Remember	Recognizing or recalling knowledge from memory. Remembering is when memory is used to produce definitions, facts, or lists, or recite or retrieve material.
CLD2	Understand	Constructing meaning from different types of functions be they have written or graphic messages activities like interpreting, exemplifying classifying, summarizing, inferring, comparing, and explaining.
CLD3	Apply	Carrying out or using a procedure through executing, or implementing. Applying related and refers to situations where learned material is used through products like models, presentations, interviews or simulations.
CLD4	Analyse	Breaking material or concepts into parts, determining how the parts relate or interrelate to one another or to an overall structure or purpose. Mental actions included in this function are differentiating, organizing, and attributing, as well as being able to distinguish between the components or parts. When one is analysing, he/she can illustrate this mental function by creating spreadsheets, surveys, charts, or diagrams, or graphic representations.
CLD5	Evaluate	Making judgments based on criteria and standards through checking and critiquing. Critiques, recommendations, and reports are some of the products that can be created to demonstrate the processes of evaluation. In the newer taxonomy evaluation comes before creating as it is often a necessary part of the precursory behaviour before creating something.
CLD6	Create	Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing. Creating requires users to put parts together in a new way or synthesize parts into something new and different a new form or product. This process is the most difficult mental function in the new taxonomy.

CLD*: Course learning domain

These "action words" describe the cognitive processes by which thinkers encounter and work with knowledge:

- **Remember**
  - Recognizing
  - Recalling
- **Understand**
  - Interpreting
  - Exemplifying
  - Classifying
  - Summarizing
  - Inferring
  - Comparing
  - Explaining
- **Apply**
  - Executing
  - Implementing
- **Analyze**
  - Differentiating
  - Organizing
  - Attributing
- **Evaluate**
  - Checking
  - Critiquing

- **Create**
    - Generating
    - Planning
    - Producing

In the revised taxonomy, knowledge is at the basis of these six cognitive processes, but its authors created a separate taxonomy of the types of knowledge used in cognition:

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

9.2 Three levels (based on the original five categories) of the Affective Domain.

This domain is concerned with issues relating to the emotional component of learning and ranges from basic willingness to receive information to the integration of beliefs, ideas and attitudes. In order to describe the way in which things emotionally dealt.

Table 11: Levels of Affective domain

ALD*	Category	Description
ALD1	Receiving	This refers to the learner's sensitivity to the existence of stimuli – awareness, willingness to receive, or selected attention.
	Responding	This refers to the learners' active attention to stimuli and his/her motivation to learn – acquiescence, willing responses, or feelings of satisfaction.
ALD2	Valuing	This refers to the learner's beliefs and attitudes of worth – acceptance, preference, or commitment. An acceptance, preference, or commitment to value.
	Organization	This refers to the learner's internalization of values and beliefs involving (1) the conceptualization of values; and (2) the organization of a value system. As values or beliefs become internalized, the leaner organizes them according to priority.
ALD3	Characterization	This refers to the learner's highest of internalization and relates to behaviour that reflects (1) a generalized set of values; and (2) a characterization or a philosophy about life. At this level, the learner is capable of practising and acting on their values or beliefs.

ALD* = Affective Learning domain

9.3 Three levels (based on the five original categories) of the Simpson's Psychomotor Domain.

The psychomotor domain is commonly used in areas of laboratory science subjects, engineering and physical education (Sports).

Table 12: Levels of Psychomotor domain

PLD*	Category	Description
PLD1	Perception set	The ability to use sensory cues to guide motor activity. This ranges from sensory stimulation, through cue selection, to translation.
		Readiness to act. It includes mental, physical, and emotional sets. These three sets are dispositions that predetermine a person's response to different situations (sometimes called mindsets).
PLD2	Guided Response	The early stages in learning a complex skill that includes imitation and trial and error. Adequacy of performance is achieved by practicing.
	Mechanism	This is the intermediate stage in learning a complex skill. Learned responses have become habitual and the movements can be performed with some confidence and proficiency.
PLD3	Complex / Overt Response	The skilful performance of motor acts that involve complex movement patterns. Proficiency is indicated by a quick, accurate, and highly coordinated performance, requiring a minimum of energy. This category includes performing without hesitation and automatic performance. For example, players often utter sounds of satisfaction or expletives as soon as they hit a tennis ball or throw a football because they can tell by the feel of the act what the result will produce.
	Adaptation	Skills are well developed and the individual can modify movement patterns to fit special requirements.
	Origination	Creating new movement patterns to fit a particular situation or specific problem. Learning outcomes emphasize creativity based on highly developed skills.

PLD * = Psychomotor learning domain

Understanding what "domain" we are trying to enable learners to achieve can help us to write appropriate educational objectives as well as consider how to evaluate the success of these objectives.

If we are essentially providing information; we would be assessing the learner's knowledge following teaching.

If we are encouraging students to consider a subject from multiple perspectives and to develop a professional attitude; we are assessing the affective domain. Assessing the affective domain is more difficult as personal belief systems differ, however in education the process learners go through to develop attitudes can be assessed.

If we are assessing learners' ability to perform tasks etc, we are assessing the skills domain; the "know how".

10 KNOWLEDGE AND ATTITUDE PROFILE (WK) AND INDICATORS OF ATTAINMENT

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 Table 13, and Table 14 is representing their indicators of attainment.

Table 13: Knowledge and Attitude Profiles

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 14: List of WKs extracted verbatim from the 2024 NBA and their indicators of attainment.

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	**Theory-based formulation**		**03**
	WK 3a	Gathers engineering knowledge from the open literature and discerns the most relevant	
	WK 3b	Theoretical problem identification, model formulation and data collection	
	WK 3c	Evaluates 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.	

11. ENGINEERING COMPETENCE (EC) PROFILES

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. ***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 Table 15.

Table 15: Engineering Competence Profiles

EC	Attributes	Descriptors for Rubric Design
EC 1	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
EC 2	Depth of analysis required (CP)	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.
EC 3	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.
EC 4	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.
EC 5	Infrequently encountered issues (CP)	Conceptualises alternative engineering approaches and evaluates potential outcomes against appropriate criteria to justify an optimal solution choice.
EC 6	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.
EC 7	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
EC 8	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.
EC 9	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.
EC 10	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.
EC 11	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.
EC 12	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.

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.

Complex Engineering Problems need to think broadly and systematically in the context of

- Complex problems
- Difficult decision
- Uncertain strategy
- Confusion idea
- Contentious Product
- Interactable change

The differences between technical problems and complex engineering problems based on various criteria is as shown in Table 16.

Table 16: Differences between technical problems and complex engineering problems

Aspect	Technical Problems	Complex Engineering Problems
Definition	Problems with well-defined solutions that require basic technical knowledge.	Problems that are broad, ambiguous, and require advanced knowledge across multiple domains.
Scope	Narrow and well-defined.	Broad, involving multiple interconnected systems and disciplines.
Difficulty Level	Stable and /or predictable problem Parameters	Unstable and /or unpredictable problem Parameters
Knowledge Requirement	Multiple low risk experiments are possible.	Multiple experiments are not possible.
Solution Approach	Solutions are often straightforward and based on standard practices.	Solutions involve iteration, optimization, and may need novel approaches
No. of solutions	Limited set of alternative solutions	No bounded set of alternative solutions
Uncertainty	Low uncertainty; variables are usually known and controlled.	High uncertainty; may involve unknown variables and unpredictable factors.
Example	Single optimal and testing solutions and clearly recognized	No single optimal and /or objectively testable solutions
Collaboration Needed	Usually, can be solved by an individual or small team.	Requires collaboration among large, diverse teams and stakeholders.

12. GUIDELINES FOR WRITING COURSE OUTCOME STATEMENTS

A **Course Outcome** is a formal statement of what students should able to know, do and value by the end of the 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.

The CO statement is intended or desired learning gains, faculty members expect the students to develop, learn master during the course in terms of:

1. Declarative knowledge (factual, conceptual, procedural),
2. Functional knowledge (knowledge transfer),
3. Metacognitive knowledge (Improved Problem-Solving Skills)
4. Cognitive skills (Improved Critical Thinking, Stronger Analytical Skills and Greater Creativity)
5. Practical skills (Enhanced Technical Proficiency, Improved Application of Knowledge, Greater Adaptability, Increased Collaboration and Teamwork and Boosted Confidence in Real-World Tasks)

6. Habits of mind (Enhanced Persistence and Resilience, Greater Flexibility in Thinking, Increased Reflective Practice, Strengthened Ethical and Responsible Decision-Making)
7. Performance (Enhanced Skill Mastery, Stronger Communication and Presentation Skills) and
8. ways to respond to events and people as a result of the learning experiences in the course/module.

It contains the measurable action verbs, the substance/content to be learned, and the targeted competency level.

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 course outcomes need to be concise descriptions of what learning is expected to take place by course completion.

12.1 Developing Course Outcomes

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

- Limit the course outcomes to **5-6** statements for the entire course [more detailed outcomes can be developed for individual units, assignments, chapters, etc. if the instructor(s) wish (es)].
- Focus on overarching knowledge and/or skills rather than small or trivial details.
- 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.
- The keywords used to define COs are based on Bloom's Taxonomy.

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:

1. What faculty members want students to know at the end of the course and
2. What faculty members want **students to be able to do** at the end of the course?

Course outcomes have three major characteristics

1. They specify an action by the students/learners that is **observable**
2. They specify an action by the students/learners that is **measurable**
3. 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.

Relationship of Course Outcome to Program Outcome

The Course Outcomes need to link to the Program Outcomes. Use the following 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)."*

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

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 analyse 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 17, provides eight examples.

Table 17: Examples for writing effective course outcomes

S.No	Learning Objective	Condition	Observable Behaviour	Standard
1	Students will be able to solve algebraic equations	Given a set of algebraic equations	Solve linear and quadratic algebraic equations	Correctly solve 90% of equations presented in the exercise
2	Students will be able to write an **essay**.	After reading a provided article	Write a well-organized argumentative essay	The essay must have a clear thesis, supporting arguments, and a conclusion, with minimal grammatical errors
3	Students will be able to conduct a scientific experiment.	With a laboratory kit and procedure manual	Set up and conduct an experiment	Conduct the experiment according to the procedure with no major errors, and record accurate data
4	Students will be able to use proper punctuation in writing.	Given a short story to edit	Identify and correct punctuation errors in the text	Correct all punctuation errors with 95% accuracy
5	Students will be able to use critical thinking to solve problems.	Given a complex case study	Analyse the problem and propose a solution	Provide a solution that addresses at least three key issues with logical reasoning.
6	Students will be able to present a research project.	During a class presentation	Present findings to the class using visual aids	The presentation must be clear, within 10 minutes, and answer at least 3 questions from the audience.
7	Students will be able to use a spreadsheet program.	Using a computer with spreadsheet software	Create and format a spreadsheet with formulas	The spreadsheet must include at least 3 formulas and be formatted according to provided specifications.
8	Students will be able to participate in group discussions.	In a small group setting	Contribute relevant ideas and respond to peers' comments	Contribute at least 3 relevant ideas and respond to at least 2 peers during the discussion.

The following Table 18, is the example 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.

Table 18: Course Outcome which is not measurable

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

Examples that are TOO general and VERY HARD to measure…

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

Examples that are still general and HARD to measure…

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

Examples that are SPECIFIC and relatively EASY to measure…

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

An Introspection - Examine Your Own Course Outcomes

1. 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.
2. Look over your list and check the one most important student outcome. If you could only achieve one outcome, which one would it be?
3. Look for your outcome on the list of Indicators of Attainment or outcomes society is asking us to produce. Is it there? If not, is the reason a compelling one?
4. Check each of your other "most important" outcomes against the list of outcomes. How many are on the list of key competencies?
5. 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?

12.2 Writing 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?

13. CO-PO COURSE ARTICULATION MATRIX MAPPING

Course Articulation Matrix shows the educational relationship (Level of Learning achieved) between Course Outcomes and Program Outcomes for a Course. This matrix strongly indicates whether the students are able to achieve the course learning objectives. The matrix can be used for any course and is a good way to evaluate a course syllabus.

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 LD1 to Level LD 4. Again, if it is a programming course, restrict yourself between Blooms Level LD 1 to Level LD 3 but for the other courses, you can go up to Blooms Level LD 4.
3. For the laboratory courses, while composing COs, you need to restrict yourself between Blooms Level LD 1 to Level LD 5.
4. Only for main projects, you may extend up to Blooms Level 6 while composing COs.
5. For a given course, the course in-charge has to involve all the other Professors who teach that course and ask them to come up with the CO-PO mapping. The course in-charge has to take the average value of all of these CO-PO mappings and finalize the values or the course in-charge can go with what the majority of the faculty members prefer for. Ensure that none of the Professors who are handling the particular course discuss with each other while marking the CO-PO values.
6. If you want to match your COs with non-technical POs, then correlate the action verbs used in the course COs with the thumb rule given in the table and map the values. (Applies only for mapping COs to non-technical POs).

13.1 Assigning the values for mapping COs to POs/PSOs.

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-POs / PSOs articulation matrix. Use a combination of words found in the COs, POs / PSOs 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 / PSOs. 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.

13.2 Method for Articulation

1. Identify the Indicators of Attainment 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 Indicators of Attainment (IA) 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 Indicators of Attainment for CO – PO/PSO mapping with reference to the maximum given Key Attributes for Assessing Program Outcomes.
4. Make a table with percentage of Indicators of Attainment for CO – PO/PSO mapping with

reference to the maximum given Key Attributes for Assessing Program Outcomes.

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

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

14. INDICATORS OF ATTAINMENT FOR ASSESSING PROGRAM OUTCOMES

Indicators of attainment of Washington accord Knowledge and skill (WKs) are measurable benchmarks used to assess whether students have achieved the desired program outcomes. These indicators focus on key areas such as knowledge acquisition, practical skills, critical thinking, and communication. It helps students to prepare for professional success by focusing on measurable competencies and skills needed in the career. The indicators of attainment of Washington accord Knowledge and skill (WKs) for POs and PSOs are shown in table 19 and table 20.

Table 19: Indicators of attainment of WKs for assessing program specific outcomes

Program Outcome	Indicators of attainment (IA)		No of Indicators of Attainment
PO1	**Engineering Knowledge:** 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		**15**
	WK 1a	Applying concepts of natural sciences viz., physics, chemistry, social science, and discipline specialized engineering science fundamentals for solving respective problems / applications	
	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.	
	WK 3a	Gathers engineering knowledge from the open literature and discerns the most relevant	
	WK 3b	Theoretical problem identification, model formulation and data collection	
	WK 3c	Evaluates the analysis for accuracy and validity of assumptions made.	
	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.	
PO2	**Problem Analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)		15
	WK 1a	Applying concepts of natural sciences viz., physics, chemistry, social science, and discipline specialized engineering science fundamentals for solving respective problems / applications	
	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.	
	WK 3a	Gathers engineering knowledge from the open literature and discerns the most relevant	

	WK 3b	Theoretical problem identification, model formulation and data collection	
	WK 3c	Evaluates the analysis for accuracy and validity of assumptions made.	
	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.	
PO3	**Development of Solutions:** 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).		**06**
	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.	
PO4	**Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).		**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.	
PO5	**Engineering Tool Usage:** 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)		**09**
	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.	
	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.	
PO6	**The Engineer and The World:** 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).		**11**
	WK 1a	Applying concepts of natural sciences viz., physics, chemistry, social science, and discipline specialized engineering science fundamentals for solving respective problems / applications	
	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.	
	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.	
PO7	**Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)		**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.	
PO8	**Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams Adopted: WK 9		**06**
	1	Manages own activities with honesty and integrity and in an orderly manner to meet deadlines	
	2	In group situations students are guided to develop empathy for others and to adopt inclusive behavior and language.	
	3	Contributes constructively to team decision making, earns the trust and confidence of other team members.	
	4	Students have opportunities to contribute to a diverse range of team-based settings.	
	5	Provides leadership in a team environment by making informed decisions, keeping the team motivated and accepting and delegating responsibility.	
	6	Critically evaluates the effectiveness of their individual and overall team performance.	
PO9	**Communication:** 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 (Adopted: WK-1 & WK-9)		**07**
	1	Applying natural sciences, concepts of physics, chemistry, social science, Engineering science fundamentals and engineering science discipline specialization addressing engineering problems / applications **WK1**	
	2	Presents a range of written reports and other documentation relevant to the engineering discipline that convey information effectively and respectfully to both technical and diverse audiences.	
	3	Presents work verbally in a clear, appropriate and articulate manner, using visual aids appropriately in a range of contexts.	
	4	Comprehends and responds appropriately to written and verbal instructions and appropriately instructs or briefs others in group exercises.	
	5	Produces engineering specifications or design	
	6	Documentation that satisfies the requirements of the design brief.	
	7	Critically evaluates the effectiveness and appropriateness of their own communication methods such as body language and tone of Voice	
PO10	**Project Management and Finance:** 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 multidisciplinary environments (Adopted).		**16**

	1	Selects and justifies appropriate forms of contract for delivery of work by consultants or contractors.	
	2	Use of Engineering management principles for Economic decision-making	
	3	Selects and applies relevant systems or techniques for managing quality, reliability and risk in the context of engineering projects.	
	4	Selects and applies relevant project management techniques to the planning and execution of future work	
	5	Estimates the capital and on-going costs of engineering work	
	6	Team Leadership and Collaboration	
	7	Multidisciplinary Integration	
	8	Work Application and Adaptation	
	9	Identification of Stakeholders	
	10	Understanding Stakeholder Needs and Expectations	
	11	Involvement and Participation	
	12	Building Relationships	
	13	Feedback Mechanisms	
	14	Monitoring and Evaluation	
	15	Reporting and Accountability	
	16	Sustainability and Long-Term Engagement	
PO11	**Life-Long Learning:** 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).		**13**
	1	Curiosity and a desire for lifelong learning.	
	2	Self-knowledge	
	3	Growth mindset.	
	4	Reviews the open research literature.	
	5	Identifies the needs for research or investigation.	
	6	Understanding of appropriate codes of practice and industry standards awareness of quality issues	
	7	Identifies appropriate research or investigation methodologies.	
	8	Designs and executes valid forms of research, experimentation or measurement.	
	9	Use creative ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques.	
	10	Ability to apply qualitative and quantitative methods for evaluating emerging complex engineering problems	
	11	Draws valid conclusions and justifies those conclusions	
	12	Calibrates/validates the data collection methods and equipment.	
	13	Analyses the data including considering sources of error	

Table 20: Indicators of attainment of WKs for assessing program specific outcomes

PSO Number	PSO Statement / Indicators of attainment (IA)		Number of IAs
PSO 1	Build the prototype of UAVs and aero-foil models for testing by using low speed wind tunnel towards research in the area of experimental aerodynamics.		**12**
	WK 1a	Applying concepts of natural sciences viz., physics, chemistry, social science, and discipline specialized engineering science fundamentals for solving respective problems / applications	
	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.	
	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.	
PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.		**10**
	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.	
	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.	
	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.	
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.		**11**
	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.	
	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.	

15. ADOPTING UNITED NATION’S SUSTAINABLE DEVELOPMENT GOALS ENGINEERING PROGRAM

The Engineering Programs are vital for achieving sustainable development while addressing socio-economic issues and challenges envisaged in United Nation’s Sustainable Development Goals i.e. UNSDGs are shown in Figure 4.

Concept Note on the Incorporation of UN SDGs in Curriculum

The United Nations’ Sustainable Development Goals (SDGs) provide a global framework for addressing pressing societal and environmental challenges. In the context of engineering education and curriculum, integrating sustainable solutions is essential to contribute towards achieving these SDGs. This note explores how **complex engineering problem (CEP)** solving and **complex engineering activities (CEAs)** can align with specific SDGs and emphasizes the role of engineering in promoting sustainable development.

The CEP solving and CEAs play a pivotal role in developing innovative solutions that address societal challenges, fostering sustainable development. Thus, the analysis of a complex engineering problem needs to include consideration for sustainable development in the light of UN SDGs. Prospective sustainable solution resulting from a CEP-solving activity or CEA can be related to specific SDG(s).

It is pertinent to mention that is not mandatory for an HEI to map all 17 SDGs with its engineering program. Only those SDGs may be mapped which are covered in CEP solving activities, CEAs, semester projects, open-ended labs, capstone projects or co-and-extra-curricular activities with holistic consideration for sustainable development.

The documentation or any deliverable of the activity will stand as evidence of the addressal of the respective SDG. For example, embedding renewable energy concepts, such as solar and wind power, into class / lab CEPs / CEAs and final year/ capstone projects can align them with the targets set of for SDG-7. Similarly, focusing on cutting -edge technologies like the Internet of Things (IoT) and smart grids in class / lab projects and final-year projects can work for SDG-9. By addressing CEPs / CEAs aligned with specific SDGs, engineers can contribute significantly to global efforts to build a more sustainable and equitable word.

Figure 4: United Nation's Sustainable Development Goals (UNSDGs)

The effectiveness of the incorporation of SDG targets in class / lab projects or CEPs / CEAs can be further enhanced by encouraging the students to:

- Include Life Cycle Assessment (LCA) methods in class / lab projects or CEPs / CEAs to evaluate the environmental impact of products and systems.
- Collaborate with the students of other disciplines to address interconnected changes.
- Emphasize the use of sustainable materials and manufacturing processes in the design and production of components.
- Access the social implications of their projects, considering factors like community well-being, accessibility, and inclusivity.

16. CORRELATION MATRIX OF POS – ECS – WKS – UNSDGS

A correlation matrix has been established to link Program Outcomes (POs) with the corresponding engineering competencies, knowledge and attitude profiles, as well as the targeted UN Sustainable Development approved by NBA is shown in Table 21.

Table 21: Correlation Matrix PLOs – ECs – WKs – SDGs

POs	ECs**	WKs	SDGs (Proposed)
PO1 **Engineering Knowledge:** Breadth, Depth and Type of Knowledge, both Theoretical and Practical	**EC 1:** Depth of knowledge required	**WK-1:** Natural Sciences and Awareness of Relevant Social Sciences **WK-2:** Mathematics and Computing **WK-3:** Engineering Fundamentals **WK-4:** Engineering Specialist Knowledge	SDG-9
PO2 **Problem Analysis:** Complexity of Analysis	**EC 4:** Range of conflicting requirements **EC 2:** Depth of analysis required **EC 10:** Interdependence	**WK-1:** Natural Sciences and Awareness of relevant Social Sciences **WK-2:** Mathematics & Computing **WK-3:** Engineering Fundamentals **WK-4:** Engineering Specialist Knowledge	Selected SDGs from SDG -1 to 17 (relevance as per curriculum)
PO3 **Design / Development of Solutions:** Breadth and Uniqueness of Engineering Problem i.e. the extent to which problems are original and so which solutions have not previously been identified or codified	**EC 4:** Range of conflicting requirements **EC 5:** Infrequently encountered issues **EC 8:** Extent of stakeholder involvement in design and development of solutions	**WK-5:** Engineering Design and Operations	SDG - 1, 2, 3, 6, 10, 11, 12, 13, 14 (relevance as per curriculum)
PO4 **Investigation:** Breadth and Depth of Investigation and Experimentation	**EC 5:** Infrequently encountered issues **EC 7:** Range of resources	**WK-8:** Research literature	SDG - 9

POs	ECs**	WKs	SDGs (Proposed)
PO5 **Total Usages:** Level of Understanding of Appropriateness of Technologies and Tools	**EC 2:** Depth of analysis required **EC 5:** Infrequently encountered issues	**WK-2:** Mathematics and computing **WK-6:** Engineering Practices	SDG - 9
PO6 **The Engineer and the World:** Level of Knowledge and Responsibility for Sustainable Development.	**EC 6:** Protection of Society **EC 9:** Extent of applicable Codes, Legal and Regulatory	**WK-1:** Natural sciences and awareness of relevant social sciences **WK-5:** Engineering design and operations **WK 7:** Engineering in Society	Selected SDGs from SDG - 1 to 17 (relevance as per curriculum)
PO7 **Ethics:** Understanding and Level of Practice	**EC 9:** Extent of applicable Codes, Legal and Regulatory	**WK-9:** Ethics, Inclusive behaviour and conduct	SDG - 5, 10, 16
PO8 **Individual and Collaborative Team Work** Role in and Diversity of Team	**EC 8:** Extent of stakeholder involvement in design and development of solutions	**WK 9:** Ethics inclusive behaviour and conduct	SDG - 5, 10, 16
PO9 **Communication:** Level of Communication According to Type of Activities Performed.	**EC 8:** Extent of stakeholder involvement in design and development of solutions	**WK-1:** Natural sciences and awareness of relevant social sciences **WK-9:** Ethics inclusive behaviour and conduct	SDG - 5, 10, 16
PO10 **Project Management and Finance:** Level of Management Required for Differing Types of Activity	**EC 10:** Interdependence **EC 7:** Range of resources **EC 12:** Judgement	**WK-2:** Mathematics & Computing **WK-5:** Engineering design and operation	SDG - 9
PO11 **Lifelong Learning:** Duration and Manner	**EC 11:** Continuing Professional Development (CPD) and lifelong hearing. **EC 12:** Judgement	**WK-8:** Research literature	SDG - 9, 13

** ECs are expected to be demonstrated by graduates during their practical experiences, which have been mapped with POs to reflect integration in the designed curriculum.

The relationship matrix has been generically designed as a guiding framework and is applicable to all engineering disciplines. When interpreting the matrix within a specific context revisions or amplifications may be incorporated to highlight particular emphasis or compliance with rationalized program requirements.

17. METHODS FOR MEASURING LEARNING OUTCOMES

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.

1. Continuous Internal Assessment (CIA)
2. Alternate Assessment Tools (AAT)
3. Semester end examination (SEE)
4. Laboratory and project work
5. Course exit survey
6. Program exit survey
7. Alumni survey
8. Employer survey
9. Course expert committee
10. Program Assessment and Quality Improvement Committee (PAQIC)
11. Department Advisory Board (DAB)
12. Faculty meetings
13. Professional societies

The above assessment indicators are detailed below.

17.1 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.

17.2 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.

17.3 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 sub- mitted to the Departmental Academic Council (DAC) and to the principal for taking necessary actions to better the course for subsequent semesters.

17.4 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.

17.5 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.

17.6 Program Exit Survey

The program 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.

17.7 Alumni Survey

The survey asks former students of the department about the status of their employment and further education, perceptions of institutional emphasis, estimated gains in knowledge and skills, involvement a sunder graduate student, and continuing involvement with Institute of Aeronautical Engineering. This survey is administered every three years. The data obtained will be analyzed and used in continuous improvement.

17.8 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.

17.9 Course Expert Committee

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

17.10 Program Assessment and Quality Improvement Committee (PAQIC)

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

17.11 Department Advisory Board (DAB)

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

17.12 Faculty Meetings

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

17.13 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.

18. CO - ASSESSMENT PROCESSES AND TOOLS

Course outcomes are evaluated based on two approaches namely direct and indirect assessment methods. The direct assessment methods are based on the Continuous Internal Assessment (CIA) and Semester End Examination (SEE) whereas the indirect assessment methods are based on the course end survey and program exit survey provided by the students, Alumni and Employer. The weightage in CO attainment of Direct and Indirect assessments are illustrated in Table 22.

Table 22: The weightage in CO attainment of Direct and Indirect assessments

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%

18.1 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 23.

- 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.

Table 23: The direct assessment tools used to assess the impact of delivery of course content

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	Course Outline Description
		Semester End Examination	Once in a semester	60	Answer script
2	Laboratory	Conduction of experiment	Once in a week	5	Work sheets
		Observation	Once in a week	5	Work sheets
		Result	Once in a week	5	Work sheets
		Record	Once in a week	5	Work sheets
		Viva	Once in a week	10	Work sheets
		Internal laboratory assessment	Once in a semester	10	Answer script
		Semester End Examination	Once in a semester	60	Answer script
3	Project Work	Presentation	Twice in a semester	40	Presentation
		Semester End Examination	Once in a semester	60	Thesis report

18.2 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 24.

Table 24: Tools and processes used in indirect assessment of course outcomes.

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.

19. PO ATTAINMENT USING DIRECT AND INDIRECT TOOLS

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

1. Direct method and Indirect method

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

Table 25: The methods for assessing attainment of Program Outcomes.

	Assessment	Tools	Weight
POs Attainment	Direct Assessment	CO attainment of courses	80%
	Indirect Assessment	Program 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.

19.1 POs Attainment

The attainment of POs/PSOs are calculated through direct and indirect assessment methods.

- Direct assessment is calculated through Continuous Internal Assessment (CIA) and Semester End Exam (SEE) and Indirect assessment through feedback form from program exit survey, employers/industry, and alumni The figure 5, represents the evaluation process of POs attainment.

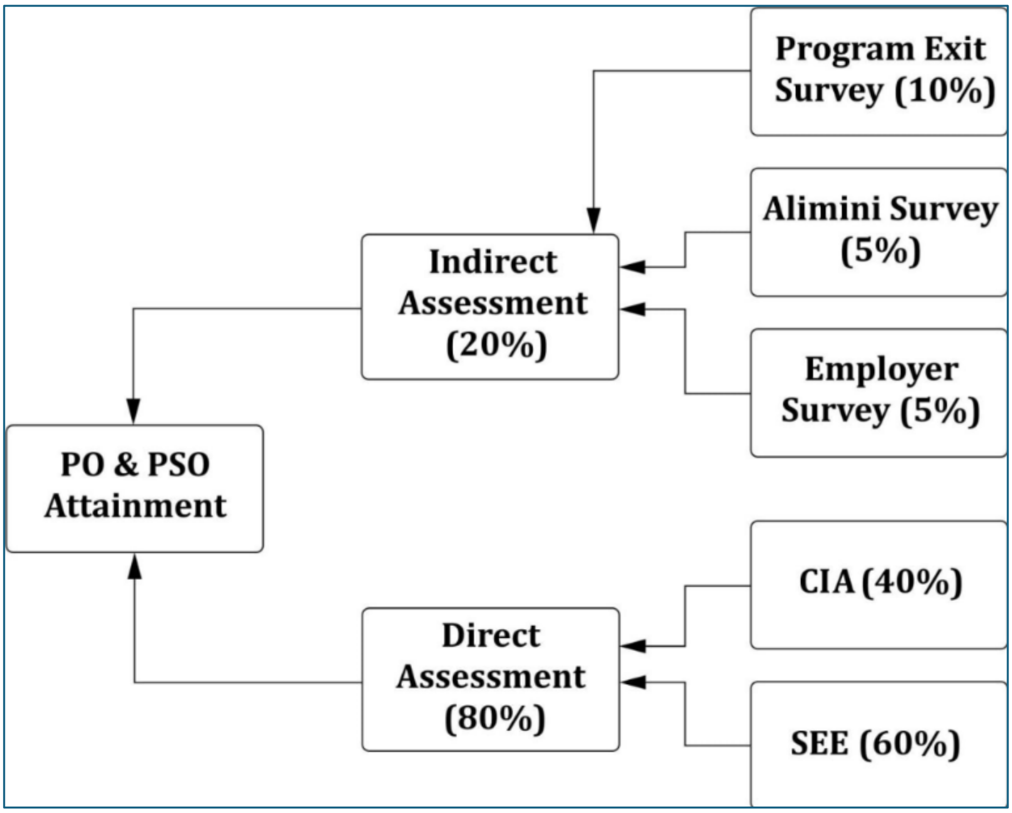

Figure 5: Evaluation Process of POs and PSOs Attainment

20. PROGRAM OUTCOMES (POs) AND PROGRAM SPECIFIC OUTCOMES (PSOs) ATTAINMENT THROUGH COURSE MODULES

Code	Course(s)	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
	B.Tech - I Semester														
AHSE01	Matrices and Calculus	✓	✓										✓		
AHSE02	Engineering Physics	✓			✓			✓	✓					✓	
AHSE04	Professional Communication	✓			✓			✓	✓					✓	
AMEE01	Engineering Mechanics	✓	✓					✓	✓			✓		✓	✓
ACSE01	Object Oriented Programming	✓	✓	✓		✓					✓		✓		
AHSE07	English Language and Communication Skills Laboratory	✓						✓			✓	✓			✓
ACSD03	Object Oriented Programming Laboratory	✓	✓	✓		✓				✓				✓	
AHSE05	Engineering Physics Laboratory	✓	✓				✓					✓			✓
AMEE02	Engineering Workshop	✓	✓	✓			✓	✓			✓	✓	✓		
	B.Tech - II Semester														
AHSE03	Engineering Chemistry	✓	✓			✓				✓		✓	✓		

AHSE08	Ordinary Differential Equations and Vector Calculus	✓	✓				✓				✓		✓	✓	
AMEE04	Thermodynamics	✓	✓			✓									✓
ACSE05	Data Structures	✓	✓						✓			✓	✓		✓
AEEE01	Basic Electrical and Electronics Engineering	✓	✓			✓						✓		✓	
AHSE06	Engineering Chemistry Laboratory	✓	✓				✓					✓	✓		
AEEE03	Basic Electrical and Electronics Engineering Laboratory	✓	✓			✓				✓		✓			✓
ACSE07	Programming for Problem Solving Laboratory	✓	✓	✓		✓				✓				✓	
ACSE08	Data Structures Laboratory	✓	✓					✓	✓			✓			✓
AMEE03	Computer Aided Engineering Graphics	✓	✓			✓			✓			✓	✓		

21. COURSE OUTLINE DESCRIPTION

Annexure - 1

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

COURSE OUTLINE DESCRIPTION

SECTION 1: General Information about the Course	
Course Title	**ENGINEERING MECHANICS**
Course Code	AMEE01
Course Start	First Semester
Course Type	Foundation
Regulation	IARE - BT 25
Prerequisite Courses	Linear Algebra and Calculus
Department	Mechanical Engineering
Number of Credits	3 Credit hours
Academic Year	2025-26
Method(s) of Instruction	Theory
Course Administrator	**Dr. C Labesh Kumar** Assistant Professor of Mechanical Engineering IARE10100 **c.labeshkumar@iare.ac.in**
Course Coordinator	**Dr. D.Govardhan** Professor of Mechanical Engineering IARE10086 **d.govardhan@iare.ac.in**
Prior Learning Assessment and Recognition (PLAR)	No
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=33
Course Description	Engineering Mechanics is a branch of Physics that deals with the study of the system of forces acting on a particle which is at rest or in motion. The course emphasizes thorough understanding of theories and principles related to static and dynamic equilibrium of rigid bodies to acquire the analytical capability required for solving engineering problems and is one of the foundation courses that forms the basis of many of the traditional branches of engineering such as aerospace, civil and mechanical engineering.
Course Objectives	**The students will try to learn:** a. The application of mathematics and science principles to represent the free body diagrams in the area of rigid body mechanics b. The conditions of static and dynamic equilibrium of bodies subjected to a particular force system for solving the field problems. c. The effects of force and motion while carrying out the innovative design functions of engineering
Text and Reference Books	**Text Books** 1. Irving H. Shames (2006), “Engineering Mechanics”, Prentice Hall, 4th Edition, 2013 2. S. Bhavikatti, “A Text Book of Engineering Mechanics”, New Age International, 1st Edition, 2012

	3. R. C. Hibbler (2006), "Engineering Mechanics: Principles of Statics and Dynamics", Pearson Press, 5^{th} Edition, 2021 **Reference Books** 1. F. P. Beer and E. R. Johnston (2011), "Vector Mechanics for Engineers", Vol I - Statics, Vol II, – Dynamics, Tata McGraw Hill , 9^{th} Edition,2013 2. A.K. Tayal, "Engineering Mechanics", Uma Publications, 14^{th} Edition, 2013 3. R. K. Bansal "Engineering Mechanics", Laxmi Publication, 8^{th} Edition, 2013 4. Basudeb Bhattacharya, "Engineering Mechanics", Oxford University Press, 2^{nd} Edition, 2014
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/playlist?list=PLzkMouYverAKB0aKoYKi6LZqdSKCV2KSB • https://www.youtube.com/playlist?list=PLzkMouYverAIS2u_lXRZex1L2m8EySjmQ
Supplemental Materials	**Readings, Videos, and Links** 1. https://ocw.mit.edu/courses/1-050-engineering-mechanics-i-fall-2007/
Learning and 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
TLA 1	Lectures	48	01	48
TLA 2	Tutorials			
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			
TLA 10	Homework assignments / Programming assignments			10
TLA 11	Placement / work based learning or Specific practical training			

TLA 12	Presentation / Seminar Preparation			
TLA 13	Course Project / Preparation for Complex Problem Solving			15
TLA 14	Technical visit			
TLA 15	Field activities			
			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	**Determine** the unknown forces by free body diagrams to a given equilibrium force system through laws of mechanics.	Apply
CO2	**Calculate** the system of forces acting on wedge and screw jack by using the laws of static and dynamic frictions.	Apply
CO3	**Use** the concepts of centroid in stability problems for evaluation of area moment of inertia.	Apply
CO4	**Identify** the mass moment of inertia of symmetrical and non-symmetrical section by using the concepts of centre of gravity.	Understand
CO5	**Solve** the position, velocity, acceleration and the characteristics of a body in dynamic equilibrium for various types of motion using appropriate mathematical tools.	Apply
CO6	**Develop** governing equation from first principles by using work - energy and impulse - momentum in dynamic equilibrium condition.	Analyze

SECTION 3B: Cognitive Levels	
Blooms Taxonomy Level	**Cognitive Level in Percentage (%)**
Remember	0
Understand	16
Apply	64
Analyse	16
Evaluate	0
Create	0

SECTION 4: Content and Context of Data Structures	
CO1	**Deduce the unknown forces by free body diagrams to a given equilibrium force system through mechanics laws and derived laws.**
	The students will develop the ability to analyze and solve problems related to forces acting on objects or systems in equilibrium. By employing the principles of engineering mechanics, they will learn to deduce unknown forces using free body diagrams (FBDs). A free body diagram is a powerful tool that visually represents all external forces, moments, and reactions acting on a body, simplifying the analysis of complex systems. Students will apply fundamental mechanics laws, such as Newton's laws of motion, and derived principles, including equilibrium equations and the conditions for static and dynamic stability. Through systematic approaches, they will identify and isolate individual components or systems, represent the acting forces accurately, and solve for unknown quantities using mathematical techniques. This outcome emphasizes critical problem-solving skills, including decomposing forces into components, resolving concurrent and non-concurrent force systems, and applying the conditions of equilibrium to achieve practical solutions. Mastery of these skills will enable students to tackle real-

	world engineering problems, such as designing stable structures, ensuring the safety of mechanical systems, and analyzing force interactions in machinery. By the end of this course, students will be equipped to confidently deduce unknown forces and contribute to engineering design and analysis effectively.
CO2	**Interpret the static and dynamic friction laws for the equilibrium state of a wedge, ladder and screw jack.**
	Learner will focus on understanding and applying the principles of static and dynamic friction to analyze equilibrium state in various mechanical systems, including wedges, ladders, and screw jacks. Friction plays a critical role in maintaining equilibrium, and students will explore the laws governing frictional forces to interpret their effects on different systems. Students will first learn the foundational concepts of static and dynamic friction, such as the coefficient of friction, angle of repose, and limiting friction. They will then apply these concepts to real-world applications, examining how friction influences the stability and motion of engineering systems. For example, they will analyze the equilibrium of wedges used in lifting or splitting tasks, evaluate the safety and stability of ladders under various loading conditions, and determine the mechanical advantage and frictional losses in screw jacks. Through theoretical learning and practical problem-solving, students will gain insights into how friction can be harnessed or mitigated in engineering designs. By the end of this course, they will be able to interpret the frictional forces acting on different systems, calculate equilibrium conditions accurately, and propose solutions to optimize performance and safety in mechanical and structural applications.
CO3	**Identify the centroid and centre of gravity for the simple and composite plane sections from the first principles.**
	Students will develop a foundational understanding of centroids and centers of gravity for various plane sections, both simple and composite. These concepts are fundamental in engineering mechanics as they describe the geometric center of an area or the balance point of a body, which is essential in structural and mechanical designs. Students will begin by learning the first principles, including the definition and mathematical formulation of centroids and center of gravity. They will explore the methods for locating the centroid of simple shapes such as rectangles, triangles, and circles, and extend their knowledge to composite plane sections composed of multiple shapes. By applying the principle of moments and integrating over an area, students will deduce the exact location of the centroid. In addition, they will analyze the concept of the center of gravity, emphasizing its role in determining the stability and balance of objects under gravitational forces. Students will solve problems involving real-world scenarios, such as calculating centroids for structural beams and machine components or determining the center of gravity for irregular objects. By the end of this course, students will be proficient in identifying centroids and centers of gravity, equipping them with analytical skills essential for designing safe and efficient engineering systems.
CO4	**Calculate moment of inertia and mass moment of inertia of a circular plate, cylinder, cone and sphere from the first principles.**
	Students will be equipped with the ability to calculate the moment of inertia and mass moment of inertia of fundamental geometric shapes, such as circular plates, cylinders, cones, and spheres, using first principles. The moment of inertia is a critical property in mechanics, representing an object's resistance to angular motion about a specific axis, while the mass moment of inertia relates to its rotational dynamics. They will begin by understanding the fundamental definitions and mathematical formulations of moment of inertia and mass moment of inertia. They will apply integral calculus to derive expressions for these quantities, starting from basic principles. Through systematic problem-solving, they will calculate the moment of inertia of a circular plate and extend the analysis to three-dimensional objects like cylinders, cones, and spheres, considering uniform mass distributions. This emphasizes the practical application of the calculations in engineering scenarios, such as analyzing the rotational behavior of machine components, designing structural elements, and optimizing systems for stability and efficiency. By mastering these concepts, students will gain a deeper understanding of the physical significance of inertia and its role in dynamic and static systems. This knowledge forms the foundation for more advanced studies in mechanics, machine design, and

	structural analysis.
CO5	**Apply D'Alembert's principle to a dynamic equilibrium system by introducing the inertia force for knowing the acceleration and forces involved in the system.**
	Learner will focus on the application of D'Alembert's principle to analyze dynamic systems in equilibrium. D'Alembert's principle is a powerful tool in engineering mechanics that simplifies the study of dynamic systems by introducing an inertia force, allowing dynamic problems to be treated as equivalent static equilibrium problems. Students will begin by understanding the fundamentals of D'Alembert's principle, which states that the sum of all external forces and the inertia force acting on a body in motion is zero. By incorporating the inertia force, students will transform complex dynamic systems into simpler equilibrium systems, enabling easier analysis of accelerations and forces. Through practical examples, students will apply the principle to solve problems involving linear and angular motion, such as analyzing the dynamics of moving vehicles, rotating machinery, and oscillatory systems. They will calculate unknown forces and accelerations by systematically applying the equations of motion in conjunction with the inertia force. By mastering this concept, students will gain valuable skills in understanding and solving real-world engineering problems involving dynamic forces and accelerations. This knowledge is crucial for designing and analyzing systems like engines, mechanisms, and structures subjected to dynamic loading, ensuring optimal performance and safety.
CO6	**Determine the governing equation for momentum and vibrational phenomenon of mechanical system by using energy principles for obtaining co efficient and circular frequency.**
	Learner will emphasize the application of energy principles to derive governing equations for momentum and vibrational phenomena in mechanical systems. Understanding these principles is essential for analyzing and designing systems subjected to dynamic forces and oscillatory motions. They will explore the concepts of work, energy, and power, with a focus on their relationships in mechanical systems. They will learn to apply energy conservation and virtual work principles to formulate the governing equations for momentum and vibration. Through systematic derivations, students will calculate key parameters such as coefficients (e.g., damping or stiffness constants) and circular frequency, which describe the system's dynamic behavior. The course will involve analyzing practical systems, such as oscillating masses, springs, and dampers, to determine their vibrational characteristics. Students will gain insights into free and forced vibrations, resonance conditions, and energy dissipation in damping systems. Additionally, they will study the momentum principles to address impact forces and motion changes in dynamic systems. By mastering these concepts, students will acquire the analytical skills needed to solve complex problems in mechanical vibrations and dynamics. This knowledge is essential for the design, optimization, and performance analysis of engineering systems such as machinery, vehicles, and structures subjected to dynamic loading.

SECTION 5: Complex Engineering Problem Solving

Engineering Mechanics: Principles, Problem Solving, and Applications

There is one piece of assessed coursework, involving a mixture of theoretical analysis and applied problem-solving. Students are encouraged to apply fundamental principles across different engineering contexts—although they may focus on specific problem domains, depending on their level of understanding.

Problem-solving assignments are a mandatory part of the course. Homework problems will focus on applying key mechanics concepts and analytical techniques. Projects will involve large-scale problem-solving exercises, incorporating topics such as force equilibrium, kinematics and dynamics. Engineering projects will be worth significantly more points than homework problems. All work must be completed individually.

Examinations and in-class problem-solving sessions will also be conducted. Students are required to complete these tasks during the class period with no external assistance.

SECTION 6A: Assessment Methods – Direct

Item	Evaluation Components	Week in / out	Marks

AAT: 1 - 1	Tech-Talk	Week – 2 / 5	05
AAT: 1 - 2	Definition & Terminology	Week – 4 / 7	05
AAT: 2 - 1	Complex Engineering Problem Solving	Week – 9 / 12	05
AAT: 2 - 2	Definition & Terminology	Week – 12 / 15	05
CIE - 1	2 hours - Answer 4 out of 5 questions	Week - 9	10
CIE - 2	2 hours - Answer 4 out of 5 questions	Week - 17	10
SEE	3 hours - Answer 1 from each module	Week - 18	60
		Total Marks	**100**

Department's Late Submission Policy:
1. 1 – 24 hours: 25% of the mark will be deducted
2. > 24 hours: Not accepted

SECTION 6B: Assessment Methods –Indirect	
Course End Survey (End Semester OBE Feedback)	✓

SECTION 7: Engineering Competencies (ECs) Focused
Please tick (✓) relevant engineering competency profile covered

EC Number	Attributes	Profiles	(✓)
EC1	Depth of knowledge required (CP)	Ensures that all aspects of an engineering activity are soundly based on fundamental principles - by diagnosing, and taking appropriate action with data, calculations, results, proposals, processes, practices, and documented information that may be ill-founded, illogical, erroneous, unreliable or unrealistic requirements applicable to the engineering discipline	✓
EC2	Depth of analysis required (CP)	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.	✓
EC3	Design and development of solutions (CA)	Support sustainable development solutions by ensuring functional requirements, minimize environmental impact and optimize resource utilization throughout the life cycle, while balancing performance and cost effectiveness.	✓
EC4	Range of conflicting requirements (CP)	Competently addresses complex engineering problems which involve uncertainty, ambiguity, imprecise information and wide-ranging or conflicting technical, engineering and other issues.	-
EC5	Infrequently encountered issues (CP)	Conceptualizes alternative engineering approaches and evaluates potential outcomes against appropriate criteria to justify an optimal solution choice.	-
EC6	Protection of society (CA)	Identifies, quantifies, mitigates and manages technical, health, environmental, safety, economic and other contextual risks associated to seek achievable sustainable outcomes with engineering application in the designated engineering discipline.	-
EC7	Range of resources (CA)	Involve the coordination of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies) in the timely delivery of outcomes	✓
EC8	Extent of stakeholder involvement (CP)	Design and develop solution to complex engineering problem considering a very perspective and taking account of stakeholder views with widely varying needs.	-
EC9	Extent of applicable codes, legal and regulatory (CP)	Meet all level, legal, regulatory, relevant standards and codes of practice, protect public health and safety in the course of all engineering activities.	-
EC10	Interdependence (CP)	High level problems including many component parts or sub-problems, partitions problems, processes or systems into manageable elements for the purposes of analysis, modelling or	-

		design and then re-combines to form a whole, with the integrity and performance of the overall system as the top consideration.	
EC11	Continuing professional development (CPD) and lifelong learning (CA)	Undertake CPD activities to maintain and extend competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work.	-
EC12	Judgement (CA)	Recognize complexity and assess alternatives in light of competing requirements and incomplete knowledge. Require judgement in decision making in the course of all complex engineering activities.	-

SECTION 8: Employability Skills
Example: Communication skills / Programming skills / Project based skills
Employability Skills: • Problem-solving skills for analyzing and designing mechanical systems. • Logical and analytical thinking for evaluating forces, motion, and equilibrium. • Proficiency in engineering tools and simulation software. • Optimization skills for efficient structural and mechanical design. • Knowledge of real-world applications in manufacturing, construction, and automation. • Teamwork and collaboration in multidisciplinary engineering projects. • Adaptability to learn and apply advanced engineering concepts. **Project Management:** • Planning and organizing project timelines and tasks. • Allocating resources efficiently for engineering solutions. • Collaborating and communicating with team members. • Identifying and mitigating structural and mechanical failures. • Testing and validating system performance through simulations and experiments.

SECTION 9: Relevance to Sustainability goals
Brief description about the course and its correlation with Sustainability Development Goal (SDGs).

SDG Goals		**Correlation with SDG**
4		**Quality Education:** An Engineering Mechanics course provides students with a strong foundation in science, mathematics, and problem-solving skills, enhancing their overall educational experience and empowering them to address real-world challenges.
9		**Industry, Innovation, and Infrastructure:** Understanding Engineering Mechanics principles is crucial for developing and maintaining sustainable infrastructure and technological innovations. Students equipped with these skills can contribute to designing safer, more durable, and environmentally friendly infrastructure projects.
11		**Sustainable Cities and Communities:** Engineering Mechanics underpins the construction and maintenance of urban infrastructure. Students learn to design structures that can withstand environmental challenges and contribute to the safety and sustainability of urban spaces.

SECTION 10A: Mapping between COs and POs / PSOs		
Course	**Program Outcomes (POs)**	**Program Specific**

Outcomes											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 Count
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
CO2	PO 2	•	•	•	•	•	•		•			•	•	•																													10
CO3	PO 2	•	•	•	•	•	•		•			•	•	•																													10
	PO 4																													•	•	•			•	•							5
CO4	PO 1	•	•	•	•	•	•		•			•	•	•																													10
CO 5	PO 1	•	•	•	•	•	•		•			•	•	•																													10
CO 6	PO 2	•	•	•	•	•	•		•			•	•	•																													10
	PO 4																													•	•	•			•	•							5
	PSO 1	•	•	•			•		•			•	•	•																													8

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	67	63	-	-	-	-	-		-	-	-	-	-	-	-
CO2	-	63	-	-	-	-	-		-	-	-	-	-	-	-
CO3	-	63	-	71	-	-	-		-	-	-	-	-	-	-
CO4	67	-	-	-	-	-	-		-	-	-	-	-	-	-
CO5	67	-	-	-	-	-	-		-	-	-	-	-	-	-
CO6	-	63	-	71	-	-	-		-	-	-	-	100	-	-

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	3	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	3	-	-	-	-	-	-	-	-	-	-	-	-

CO3	-	3	-	3	-	-	-	-	-	-	-	-	-	-
CO4	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	3	-	3	-	-	-	-	-	-	-	3	-	-
Total	**9**	**12**	**-**	**6**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**-**	**-**
Average	**3**	**3**	**-**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**-**	**-**

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 Definition and Terminologies	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
PSO 1	Focus on Ideation and Research towards **Digital manufacturing in Product development** using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	CIE / SEE / AAT: 1 – 1 Definition and Terminologies	3

SECTION 11: Course Content

MODULE - I	**INTRODUCTION TO ENGINEERING MECHANICS**
	2D Force Systems: Basic concepts, particle equilibrium; rigid body equilibrium; system of forces, coplanar concurrent forces, resultant, moment of forces and its application; couples and resultant of force system, equilibrium of system of forces, free body diagrams, equations of equilibrium of coplanar systems.
MODULE - II	**FRICTION, CENTROID AND CENTRE OF GRAVITY**
	Friction: Types of friction, limiting friction, laws of friction, static and dynamic friction; motion of bodies, wedge friction, screw jack. **Centroid and Centre of Gravity**: Centroid of lines, areas and volumes from first principle, centroid of composite sections; centre of gravity and its implications, theorems of Pappus–Guldinus.
MODULE - III	**AREA MOMENT OF INERTIA AND MASS MOMENT OF INERTIA**
	Area moment of inertia: Definition, moment of inertia of plane sections from first principles, theorems of moment of inertia, moment of inertia of standard sections and composite sections; product of inertia, parallel axis theorem, perpendicular axis theorem. **Mass Moment of Inertia:** Moment of inertia of masses, transfer formula for mass moment of inertia, mass moment of inertia of composite bodies.
MODULE - IV	**KINEMATICS OF RIGID BODIES AND IMPULSE – MOMENTUM METHOD**
	Review of particle dynamics, rectilinear motion; Plane curvilinear motion (rectangular path, and polar coordinates). Relative and constrained motion. Impulse-momentum (linear, angular); impact (Direct and oblique).

MODULE - V	KINETICS OF RIGID BODIES AND WORK – ENERGY PRINCIPLE
	Kinetics of rigid bodies, basic terms, D' Alembert's principle and its applications in plane motion and connected bodies; instantaneous centre of rotation in plane motion and simple problems; work-kinetic energy, power, potential energy. work energy principle and its application in plane motion of connected bodies.

SECTION 12: Tentative Schedule of Instructions		
Week Number	Topics	Duration (Hours)
1	1.1 Introduction to Engineering Mechanics, classification and laws of mechanics 1.2 Force and force characteristics, system of forces 1.3 Resultant, resultant of coplanar concurrent force system	3
2	2.1 Composition and resolution of forces, composition of concurrent forces by method of resolution 2.2 Free body diagram, supports and reactions 2.3 Equilibrium of bodies, equilibrant	3
3	3.1 Conditions of equilibrium 3.2 Moment, Varignon's theorem, couple 3.3 Resolution of force into force and a couple	3
4	4.1 Introduction to friction, laws of friction, important terms in friction, types of friction 4.2 Equilibrium of body due to friction on horizontal plane 4.3 Equilibrium of body due to friction on rough inclined plane	3
5	5.1 Effect of friction in connected bodies 5.2 Friction in wedge applications 5.3 Friction in screw applications	3
6	6.1 Screw jack, efficiency of a screw jack and condition for maximum efficiency 6.2 Over hauling and self-locking screws 6.3 Centre of gravity, centroid, difference between centre of gravity and centroid	3
7	7.1 Determination of centroid for simple sections 7.2 Determination of centroid for composite sections 7.3 Determination of centre of gravity of bodies, lines and arcs	3
8	8.1 Moment of inertia, radius of gyration, polar moment of inertia, theorems of moment of inertia 8.2 Moment of inertia from first principles 8.3 Moment of inertia of standard sections and composite sections	3
CONTINIUOUS INTERNAL EXAMINATION (CIE- I)		
9	9.1 Mass moment of inertia of composite bodies I section 9.2 Mass moment of inertia of composite bodies L section 9.3 Mass moment of inertia of composite bodies T section	3
10	10.1 Mass moment of inertia of composite bodies C section 10.2 Review of particle dynamics, rectilinear motion 10.3 Plane curvilinear motion (polar coordinates)	3
11	11.1 Curvilinear motion 11.2 Relative and constrained motion 11.3 Linear impulse and momentum	3
12	12.1 Conservation of momentum 12.2 Impact of elastic bodies 12.3 Impact and types of impact	3
13	13.1 Coefficient of restitution 13.2 Kinetics – introduction, important terms, Newtons laws of motion 13.3 Relation between force and mass	3
14	14.1 D'Alembert's principle 14.2 Application in plane motion 14.3 Motion of lift	3
15	15.1 Motion of body on inclined plane	3

	15.2 Inertia force and its application for connected bodies 15.3 Work, energy and power, units	
16	16.1 Work, energy equation for translation 16.2 Motion of body on inclined plane problem solving using work energy method 16.3 Work done by spring	3
	Total	**48**

SECTION 14: Specific Goals for the Course	
The following table shows the knowledge and skills covered by the unit outcomes:	
Knowledge	**Skills**
Learners should understand: • fundamental principles of force, equilibrium, and motion. • free-body diagrams and their application in problem-solving. • the concepts of statics and dynamics in mechanical systems. • the analysis of rigid body mechanics, including kinematics and kinetics. • the behavior of structures under different loading conditions. • the application of Newton's laws in engineering mechanics. • methods for solving static equilibrium problems in structures and machines. • the principles of work, energy, and power in mechanical systems. • the use of computational tools for solving engineering mechanics problems. • the importance of dimensional analysis and unit consistency in calculations.	**Learners can:** • analyze and solve problems involving forces, moments, and equilibrium. • construct and interpret free-body diagrams for mechanical systems. • apply Newton's laws to solve static and dynamic problems. • calculate reactions, internal forces, and moments in beams and trusses. • solve kinematics problems related to velocity, acceleration, and displacement. • solve kinetics problems involving work, energy, impulse, and momentum. • analyze motion using equations of motion for particles and rigid bodies. • determine center of mass and centroid for different structures. • apply principles of friction in engineering applications. • use vector analysis for solving force and motion problems. • solve problems involving rotational motion and angular momentum. • apply numerical and computational methods for engineering mechanics solutions. • select appropriate problem-solving methods based on complexity and constraints. • assess mechanical system stability and failure conditions.

Administrative Information

SECTION 15: History of changes		
Regulations	**Description of change**	**BOS Date**
R 16	From R15 JNTUH, Hyderabad to R16 IARE regulations **Module – I, II and III:** The syllabus for these modules are removed and replaced with the topics of dynamics. The course syllabus is prepared for only dynamics topics. **Module – I:** Kinematics of particles - rectilinear motion **Module – II:** Kinetics of particle **Module – III:** Impulse and momentum, virtual work	24.07.2016
R 18	Changes from R16 to R18 regulation • Syllabus topics for static mechanics is reintroduced. • **Module – II:** Truss elements analysis along with beams and its types	16.07.2018

	are introduced • **Module – III:** Virtual work and work energy method are introduced	
UG 20	Changes from R18 to UG 20 regulation • Credits has been reduced to 3 from 4 • **Module – I:** Spatial systems and 3D analysis were removed • **Module – II:** Truss elements analysis along with beams and its types were removed • **Module – IV:** Kinematics part was removed and work – energy method was included • **Module – V:** Impulse momentum method was added	17.11.2020
BT 23	Incorporated the following additions in BT 23 regulations • **Module – II:** Centroid and centre of gravity topics are added that are removed from Module - III • **Module – IV:** Kinematics part was included. Impulse momentum method was included from Module – V • **Module – V:** Kinetics and work – energy method part was included from Module – IV. Vibrations topic was removed	21.08.2023

Course Outline Approvals	
Course Coordinator Name: Signature: Date:	**Head of the Department** Name: 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: Signature: Date:	**Dean of Academics** Name: 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	