ADITYA ENGINEERING COLLEGE (A)

(Approved by AICTE, New Delhi, permanently affiliated to JNTUK, Kakinada)
(Recognized u/s 2(f) & 12(B) of UGC Act 1956, Accredited by NAAC)
Aditya Nagar, ADB Road, Surampalem - 533 437 Andhra Pradesh, INDIA

ASSESSMENT MANUAL

(AR20 REGULATION)

Version-3

ENLIGHTENS THE NESCIENCE

PREFACE

Outcome Based Education (OBE) Manual is to make the users aware of the OBE process which is being followed in Aditya Engineering College(A), Surampalem since 2017. All the stakeholders of the institute will be made aware of all the phases of OBE process, designed and implemented.

The present manuscript provides all corners of this OBE process i.e., design stage, training stage and implementation stage for the benefits of students and faculty of the institute. All the stakeholders of the institute i.e., students, parents, alumni etc. shall be made aware of the completed process and applications of OBE i.e., curriculum design and development, up gradation of teaching-learning process, design and implementation of assessment procedures.

OBE manual comprises of three (3) sections in which the fundamentals of OBE framework, processes adopted and examples as annexures.

Version History

Assessment manual transforms from Version 1 to Version 3 in phases as shown below.

S.No	Version	Regulation	Year of Release
1	Version-1	AR17	2017
2	Version-2	AR19	2019
3	Version-3	AR20	2020

1. OUTCOME BASED EDUCATION (OBE) FRAMEWORK

1.1 TERMINOLOGY/ DEFINITIONS OF OBE COMPONENTS

Fundamental concepts and terminology of the Outcome Based Education are discussed as under:

VISION

A vision statement is a document that states the current and future objectives of a College/Department. The vision statement is intended as a guide to help the college / department make decisions that align with its philosophy and declared set of goals.

MISSION

The mission statement(s) should define the broad purposes the program /department is aiming to achieve, describe the community the program /department designed to serve, and state the values and guiding principles which define its standards.

COURSE is defined as a theory or a practical or a theory cum practical concepts studied in a semester. Ex: Engineering Mathematics

PROGRAM is defined as the specialization or discipline of a degree. It is the interconnected arrangement of courses, co-curricular and extracurricular activities etc. to accomplish predetermined objectives, thus leading to the awarding of a degree. For example: B.E., MARINE Engineering

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The Program Educational Objectives of a program are the statements that describe the expected achievements of graduates in their career, and also in particular, what the graduates are expected to perform and achieve during the first few years after graduation.

- PEOs of the program seeking accreditation may form 3 to 5 PEOs.
- The PEOs should be consistent with the mission of the institution.
- All the stakeholders should participate in the process of framing PEOs.
- Different surveys are to be conducted from stakeholders and to be analysed for the formation of PEOs at department level.
- The number of PEO's should be manageable.
- The programme shall demonstrate how the PEOs are aligned with the mission of the department/ institution.
- The PEOs are reviewed periodically based on feedback of the programme's various stakeholders
- The department PEOs will be formed by Department BoS &ratified draft will be forwarded to Academic Council and Governing Body for final approval.

COURSE OUTCOMES (COs)

Course outcomes are those which statements that describe significant and essential learning that learners have achieved, and can be reliably demonstrated at the end of a course. Generally 5 or 6 course outcomes are specified for each a course based on its weightage.

PROGRAM OUTCOMES(POs)

Program Outcomes (PO) are to be in line with the graduate attributes as specified in the Washington Accord. POs are to be specific, measurable and achievable. NBA has defined 12 POs and it is common for all the institutions in India. In the syllabus book given to students, there should be clear mention of course outcomes along with CO-PO course articulation matrix for all the courses.

PROGRAM SPECIFIC OUTCOMES (PSOs)

Program Specific Outcomes are what the students should be able to do at the time of graduation with reference to a specific discipline. Usually there are 2-4 PSOs for a program.

GENESIS OF OUTCOME BASED EDUCATION (OBE)

It is a process that involves the restructuring of curriculum, assessment, and reporting practices in education to reflect the achievement of higher order learning and mastery rather than the accumulation of course credits.

WASHINGTON ACCORD

It recognizes the substantial equivalency of programs accredited by those bodies and recommends that graduates of programs accredited by any of the signatory bodies be recognized by the other bodies as having met the academic requirements for entry to the practice of engineering.

The induction of India in the Washington Accord in 2014 with the permanent signatory status of The National Board of Accreditation (NBA) is considered a big leap forward for the higher education system in India. It means that an Engineering graduate from India can be employed in any of the other countries who have signed the accord. For Indian Engineering institutions to get accredited by NBA according to the pacts of the accord, it is compulsory that engineering institutions follow the Outcome Based Education (OBE) model.

Outcome-Based Education (OBE) model is being adopted in engineering colleges now-a-days as per AICTE guidelines. This model is student-centered instruction model that focuses on measuring student performance through outcomes. Outcomes include knowledge, skills, and attitudes. Its focus remains on evaluation of outcomes of the program by stating the knowledge, skill and behaviour, a graduate is expected to attain upon completion of a program after 4 – 5 years of graduation. In the OBE model, the required knowledge and skill sets for a particular engineering degree are predetermined and the students are evaluated for all the required parameters (outcomes) during the course of the program. Accreditation is mandatory for any institution in view of Global recognition. The OBE framework and Outcome Based Accreditation are shown in Fig 1.1 and Fig. 1.2.

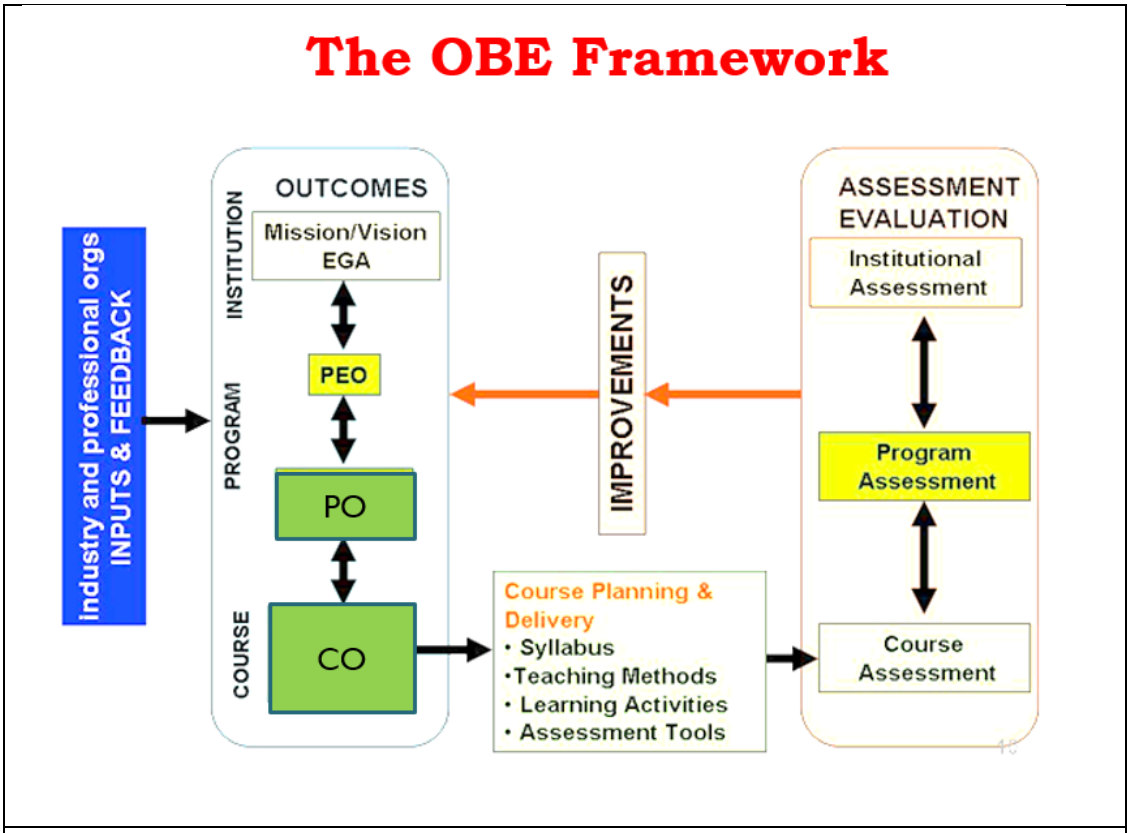


Fig. 1.1: OBE Framework

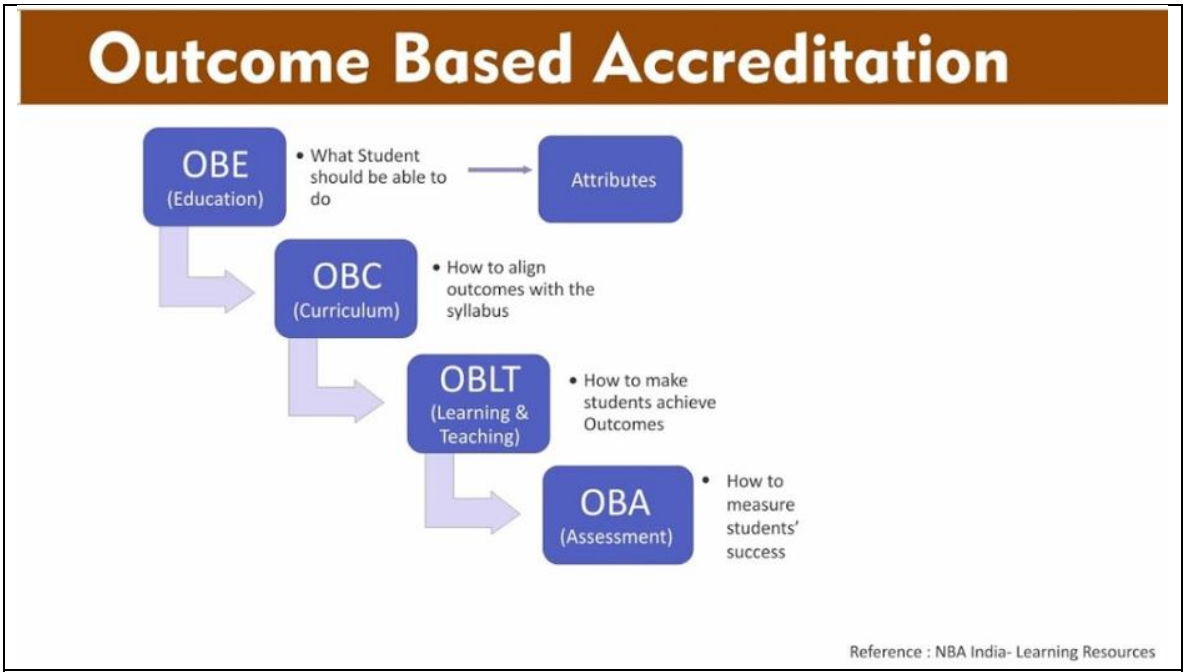


Fig. 1.2: OBE Accreditation

PROCESS OF DEVELOPMENT AND ATTAINMENT OF OBE ELEMEMNTS

There are two important phases in the OBE framework namely Development Phase and Attainment Phase.

In the first phase, OBE elements will be developed and arranged in a systematic manner so that dissemination of vision of the organization will be reach the root level (single course) of the operations.

In the present case of an academic institution, Vision of the organization (time horizon: 10 years) is developed to next level by defining Program Educational Objectives (PEOs). Vision of the organization is transformed into next stage of PEOs through Mission statements. A mapping matrix between Mission statements and PEOs is prepared. By attaining the PEOs, it is assured that the Vision of the organization is fulfilled in real case.

PEOs attainment is to be analyzed after 3-5 years from the graduation of the student. Hence, it is to be transformed to next level i.e., program level by defining Program Outcomes(Pos) and Program Specific Outcomes(PSOs).

PO's and PSO's attainment is to be analyzed at the end of graduating program indicating that the time horizon is equal to duration of the program itself i.e.4 years. After the student is graduated from the organization, immediately PO's and PSO's attainment is to be calculated.

As POs and PSOs are confined to program, it is necessary to develop another level i.e., Course level. In this level, PO's and PSO's are mapped with Courses through their Course Outcomes. A CO-PO-PSO articulation matrix is developed to assess the PO attainment through Course Outcome Attainment of all the courses.

In this way, Vision of the Organization is developed to the root level i.e., Course level.

In the second phase, i.e., Attainment Phase, initially Course Outcomes attainment is calculated for each course. All courses attainments will lead to PO/PSO attainment through CO-PO-PSO articulation matrix. PO/PSO attainment will lead to attainment of PEOs as an analysis of 3 or 4 batches of graduating students.

PEO attainment will lead to attainment of fulfilment of Mission statements through PEO-Mission statements mapping matrix.

Attainment of Mission statements reveals the realization of Vision of the organization.

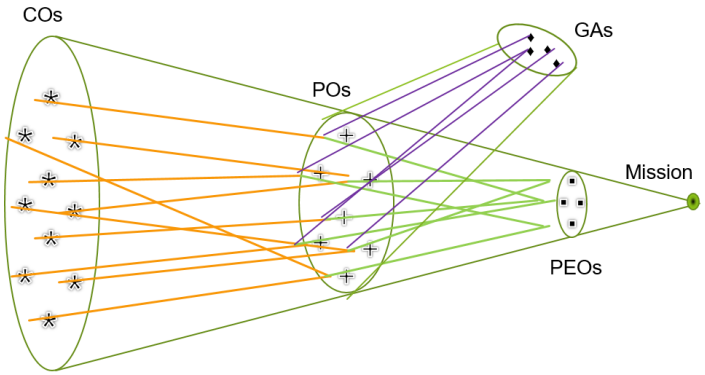


Fig 1. 3 Integration of all the OBE components

TRADITIONAL EDUCATION Vs OUTCOME BASED EDUCATION

The difference between traditional education and outcome-based education lies in the approach through various parameters i.e., role of a teacher, focus on the teaching-learning process, output in measurable terms etc. All the comparative parameters are shown in Fig 1.4 and Table 1.1

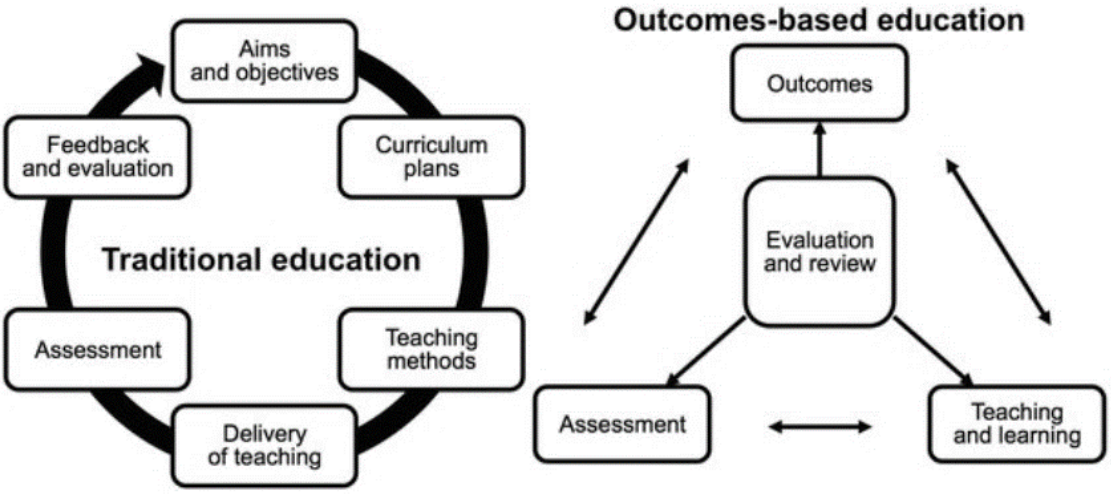


Fig. 1.4: Traditional Education Vs Outcome Based Education

Table 1.1: Traditional Teaching Approach Vs Outcome Based Approach

Traditional Teaching Approach	Outcome Based Approach
Teacher-centered	Learner/Student centered
Teacher's role as instructor	Teacher's role as partner /facilitator
Focus on Teacher's input	Focus on learner's output
Rigid and controlling	Flexible and empowering
Emphasis on products	Emphasis on progress and overall learning
Course objectives / Syllabus is seen rigid and non-negotiable	Learning outcomes / Learning programmes are seen as guides that allows teachers to be innovative and creative in achieving learning outcomes
Norm-referenced assessment	Criterion reference assessment
Content based and content delivery	Ability building and Skills development

Spady, W. D, in his book, "Outcomes Based Education: Critical Issues and Answers" highlighted the following seven beliefs and features as:

1 All students can learn and succeed, but not on the same day in the same way.
2 Success breeds success.
3 Schools control the conditions of success
4 It emphasizes authentic, achievable, and assessable learning outcomes
5 It is primarily concerned with what students' culminating capabilities at graduation time. It centers curriculum and assessment design around higher order exit outcomes
6 It is accountable to the stake holders, the learners, the teachers, the employers, and the public
7 It leads to the change of schooling, including the curriculum, instruction and assessment

The fundamental phase of Outcome based educations starts from identifying the different levels of learning, which is easily identifiable using Blooms' Taxonomy which will be explained in the next section 1.2.

1.2 BLOOM'S TAXONOMY

Bloom's Taxonomy provides an important framework to not only design curriculum and teaching methodologies but also to design appropriate examination questions belonging to various cognitive levels. Bloom's Taxonomy of Educational Objectives developed in 1956 by Benjamin Bloom was widely accepted by educators for curriculum design and assessment. In 2001, Anderson and Krathwohl modified Bloom's Taxonomy to make it relevant to the present-day requirements. It attempts to divide learning into three types of domains (cognitive, affective and behavioural) and then defines the level of performance for each domain. Conscious efforts to map the curriculum and assessment to these levels can help the programs to aim for higher-level abilities which go beyond remembering or understanding, and require application, analysis, evaluation or creation.

Revised Bloom's taxonomy in the cognitive domain includes thinking, knowledge, and application of knowledge. It is popular framework in engineering education to structure the assessment as it characterizes complexity and higher-order abilities. It identifies six levels of competencies within the cognitive domain which are appropriate for the purposes of engineering educators. Bloom's Taxonomy is hierarchical, meaning that learning at the higher level requires those skills which are attained at a lower level.

ACTION VERBS FOR ASSESSMENT

Choice of action verbs in constructing assessment questions is important to consider. Quite often, the action verbs are indicators of the complexity (level) of the question. Over the time, educators have come up with taxonomy of measurable verbs corresponding to each of the Bloom's cognitive levels. These verbs help us not only to describe and classify observable knowledge, skills and abilities but also to frame the examination or assignment questions that are appropriate to the level we are trying to assess.

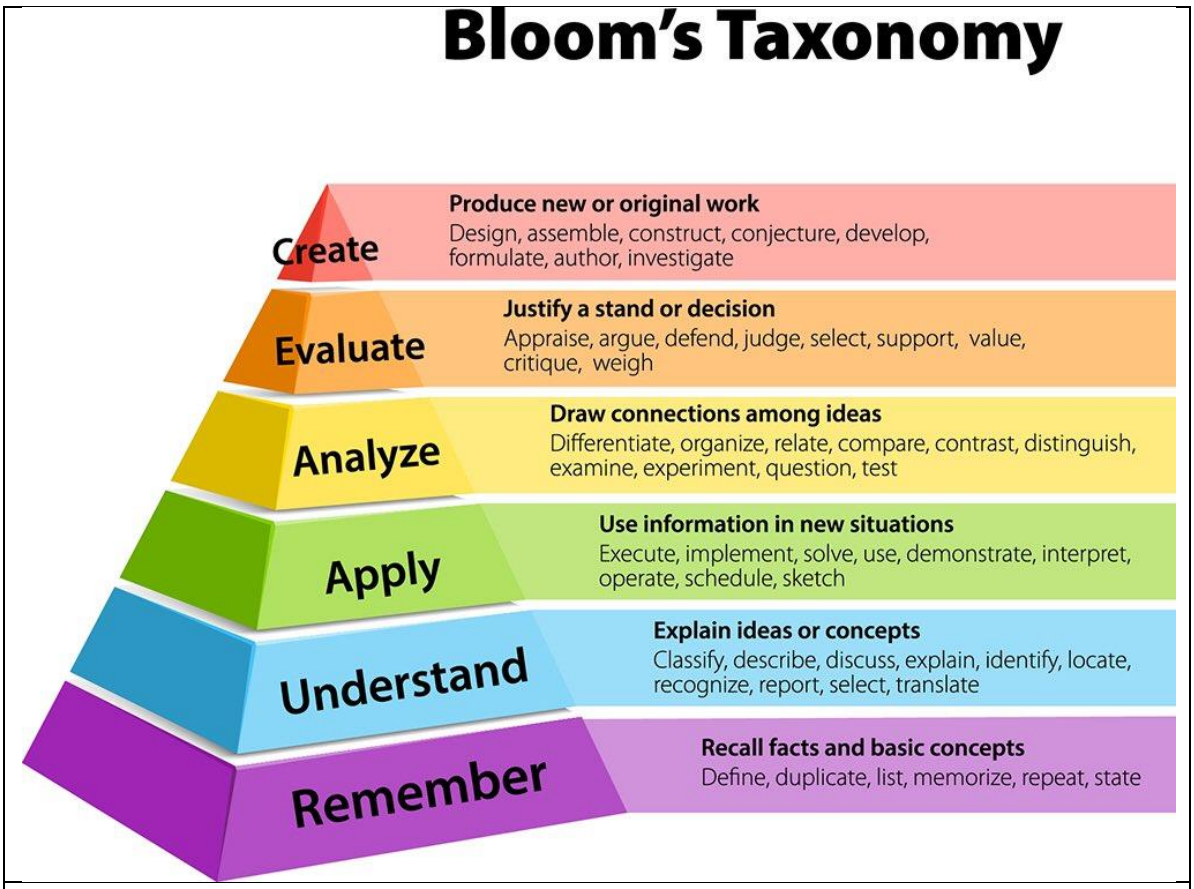


Fig 1.5: Bloom's Taxonomy

A suggestive list of skills/ competencies to be demonstrated at each of the Bloom's level and corresponding cues/ verbs for the examination/ test questions are given in Table 1.2.

Table 1.2: Bloom's Taxonomy – Skills and Verbs

S. No	Level	Skill Demonstrated	Question/Verbs for tests
1	Remember	• Ability to recall of information like facts, conventions, definitions jargon, technical terms, classifications, categories and criteria. • Ability to recall methodology and procedures, abstractions, principles and theories in the field. • Knowledge of dates, events, places • Mastery of subject matter	List, define, tell, describe, recite, recall, identify, show, label, tabulate, quote, name, who, when, where etc.
2	Understand	• Understanding information • Grasp meaning • Translate knowledge into new context. • Interpret facts, compare, contrast. • Order, group infer causes. • Predict consequences	Describe, explain, paraphrase, restate, associate, contrast, summarize, differentiate, interpret, discuss
3	Apply	• Use information. • Use methods, concepts, laws, theories in new situations. • Solve problems using required skills or knowledge. • Demonstrating correct usage of a method or procedure	Calculate, predict, apply, solve, illustrate, use, demonstrate, determine, model, experiment, show, examine, modify
4	Analyse	• Break down a complex problem into parts. • Identify the relationship and interaction between the different parts of complex problem. • Identify the missing information, sometimes the redundant information and the contradictory information, if any.	Classify, outline, break down, categorize, analyze, diagram, illustrate, infer, select
5	Evaluate	• Compare and discriminate between ideas. • Assess value of theories, presentations make. • Choices based on reasoned argument verify value evidence recognize subjectivity use of definite criteria for judgements	Assess, decide, choose, rank, grade, test, measure, defend, recommend, convince, select, judge, support, conclude, argue, justify, compare, summarize, evaluate
6	Create	• Use old ideas to create new ones. • Combine parts to make(new) whole. • Generalize from given facts relate knowledge from several areas predict, draw conclusions	Design, formulate, build, invent, create, compose, generate, derive, modify, develop, integrate

It may be noted that some of the verbs in the above table are associated with multiple Bloom's Taxonomy level. These verbs are actions that could apply to different activities.

1.3 PROCESS CYCLES

In Outcome based education(OBE), CO,PO,PEO process cycles are to be defined /framed cautiously. The various inputs and process changes are shown in the figure below.

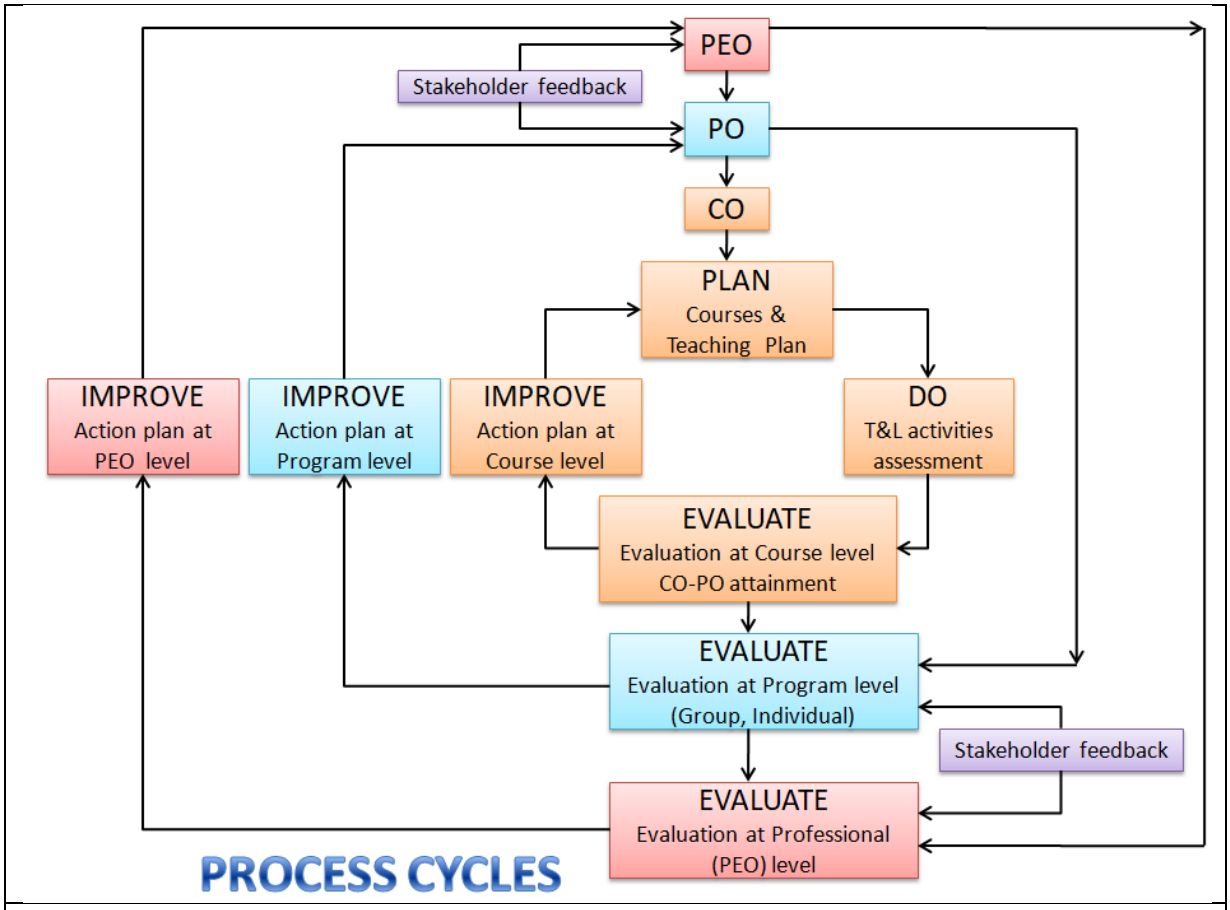


Fig 1.6: Process cycles of CO, PO and PEO

COURSE OUTCOME PROCESS CYCLE

The process cycle of Course Outcomes originates from the initial stage of defining the course outcomes, preparation of syllabus in tune with course outcomes, preparation of teaching plan or lecture plan and associated teaching-learning methodologies. This stage is primarily termed as Planning stage.

After planning stage, it is necessary to execute the methodologies and assess their actual achievement i.e., CO & PO direct and indirect assessment through various activities, both curricular and co-curricular activities. Direct assessment always deals with the teaching activities with the involvement of instructor and learner in the same place either in the classroom or in a laboratory or a project area.

After execution, it is important to evaluate the assessment results i.e., Compare CO-PO attainment values against the targets set. This CO attainment analysis has to be at a course level not program level.

After the comparison of CO attainment against the set targets, gap analysis is to be prepared, by which the action plan either to improve the Teaching-learning methodologies (if not achieved) or to modify the Teaching-learning methodologies(if achieved).

After the modification or improvement of the teaching –learning methodologies, the process becomes cyclic, i.e. again planning is to be carried out for modified methodologies in the next program cycle.

PROGRAM OUTCOME PROCESS CYCLE

The process cycle of Program Outcomes originates from the initial step of defining/ adopting the PO statements. Initially PO statements are given by NBA in India. The program outcomes will be active through Course outcomes only. CO statements are to be written in the light of PO statements only through CO-PO mapping. The PO assessment (Direct) will be purely extracted from CO assessment only.

After the Course outcome attainment calculation, PO attainment (Direct) will be calculated initially for each single course. A single course contribution towards attainment of Program Outcomes(1 to 12) will be calculated as weighted average of Course outcome attainments and mapping levels. Consolidated PO attainment (Direct) will be the arithmetic average of PO attainments of all the Mapped courses.

For example, out of 50 courses, if 5 courses are mapped to PO8, and their attainments in PO8 are 1.20, 1.34, 2.45, 2.56 and 2.67 respectively. Then the PO attainment for PO8 will be arithmetic average of 1.20, 1.34, 2.45, 2.56 and 2.67 which results 2.044. Similarly, all the PO attainments will be calculated.

After evaluating PO attainments, it is necessary to analyze the academic gap i.e., difference between the Target level for each PO and attainment for each PO (both at Course level and Group/batch level). After analysis, action plan needs to be initiated to improve the PO attainment in the next academic period by considering the feedback from the existing analysis. At this juncture, the feedback from the stakeholders also to be considered in the improvement of Curriculum for the next academic period.

PROGRAM EDUCATION OBJECTIVES PROCESS CYCLE

We all know that the educational objectives of an engineering degree program are the statements that describe the expected achievements of graduates in their career, and what the graduates are expected to perform and achieve during the first few years after graduation. The PEOs, may be guided by global and local needs, vision of the Institution, long term goals etc. For defining the PEOs the faculty members of the program must continuously work with all stakeholders: Employers, Industry, Students, Parents and the Alumni. PEOs can be written in different frameworks or perspectives i.e. Career, Technical competency and behavior.

PEO attainment calculation is a difficult task in the Indian context. PEO attainment calculation is the measurement of realization of the efforts of the institution in making the vision and mission statements in real terms of measurement. Depending on the context, we need to calculate the PEO attainment. It can also be designed in line with Program Outcomes i.e., Direct assessment through PO-PEO mapping and Indirect assessment through the Feedback from various stakeholders i.e., Alumni, Parents, Employers and Industry.

After the evaluation of PEOs, it is necessary for the Institution to initiate an action plan to improve/update the Curriculum and Teaching-learning processes from the next academic period.

1.4. COURSE OUTCOMES(COs) ASSESSMENT

Course outcomes attainment is to be calculated after teaching learning process is completed through various pedagogical elements of assessment i.e., Class, Seminar, Workshop etc. CO attainment is to be calculated based on the evaluation results obtained from different assessment criteria i.e., Sessional Examinations, Semester End Examinations, Assignments, Quiz etc. by the faculty.

Attainment of course outcome will be the ratio of actual result obtained to the expected result based on the targets set for that course. Complete process of CO attainment will be discussed in the next section.

1.5. PROGRAM OUTCOME (PO) & PROGRAM SPECIFIC OUTCOME (PSO) ASSESSMENT

Program Outcomes (PO) and Program Specific Outcomes (PSOs) assessment is having two parts i.e., Direct assessment and Indirect assessment. Direct assessment will be through CO-PO mapping matrix. Every course will have contribution towards Program outcomes through the CO-PO mapping matrix. Indirect assessment of PO will be done through various surveys and activities.

PO attainment is dependent on the attainment of Course outcomes only. Initially, we need to ascertain the correlation of a course outcome with each PO/PSO at different levels, which is denoted as CO-PO-PSO mapping. After CO-PO-PSO mapping is completed, CO attainment will be the input for PO/PSO attainment calculation, which will be discussed in detail in the next section.

CO-PO-PSO MAPPING

- The process of attainment of COs, POs starts from writing appropriate COs for each course of the program.
- Then, a correlation is established between COs and POs in the scale of 1 to 3, 1 being the slight (low), 2 being moderate (medium) and 3 being substantial (high).
- A mapping matrix is prepared in this regard for every course in the program including the elective courses.

Example:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	-	-	-	-	-	-	2	1	2
CO2	2	3	-	-	-	-	-	-	-	-	-	1	1	1
CO3	2	1	1	-	-	1	-	2	-	-	-	-	2	-
CO4	-	1	1	1	-	-	-	-	-	-	1	-	1	-
CO5	1	1	-	-	1	-	-	1	-	-	-	-	1	3

BRIDGING THE GAP for CO

In the outcome-based education, it is mandatory to upgrade or modify the Teaching-Learning Process (TLP) from time to time according to the course outcome attainment. Starting from definition of course outcome to attainment of course outcome, teaching learning process includes many stages. Initially Course instructor will set a target or threshold percentage i.e., 1.8 in present case.

After the CO attainment is calculated, the activities to be completed are

- Gap analysis
- Action plan

Both of the above need to be made ready in order to bridge the attainment gap.

BRIDGING THE GAP for PO/PSO

Similar to the academic learning gap in case of course outcome, program outcome gap will be also be calculated based on the fact that Graduate Attributes Gaps need to be identified and remedial action need to be initialized.

As Program outcome attainment also has Direct and Indirect Components, Final PO/PSO attainment will be calculated as a Weighted Average. The weightages for Direct PO/PSO and Indirect PO/PSO components will be 80% and 20% respectively.

Consolidated gaps will go into the academic calendar as various activities.

2. PROCESSES ADOPTED

2.1. FRAMING VISION, MISSION, PROGRAM EDUCATIONAL OBJECTIVES, PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

The various processes to formulate Vision and Mission of the Institute and Department, Program Educational Objectives, Program Outcomes and Program Specific Outcomes will be explained below.

PROCESS OF FRAMING VISION AND MISSION

- Collect the basic inputs i.e., Vision and Mission of Affiliating University and other premier institutes.
- Involve all stakeholders to get inputs.
- Gap analysis or SWOC analysis
- Graduate Attributes
- Discussion, Brainstorming by College Academic Committee (CAC) to prepare Draft copy.
- After the final draft copy is ready it is to be reviewed by Academic Council
- After reviewed by Academic council, it is to be approved by Governing body.
- If the Governing body approves, the College will publish and disseminate Vision and Mission statements to all the stakeholders. Else, it is to be sent to the Academic council to review again and make modifications.

The entire process of framing Vision and Mission is shown in Fig. 2.1.

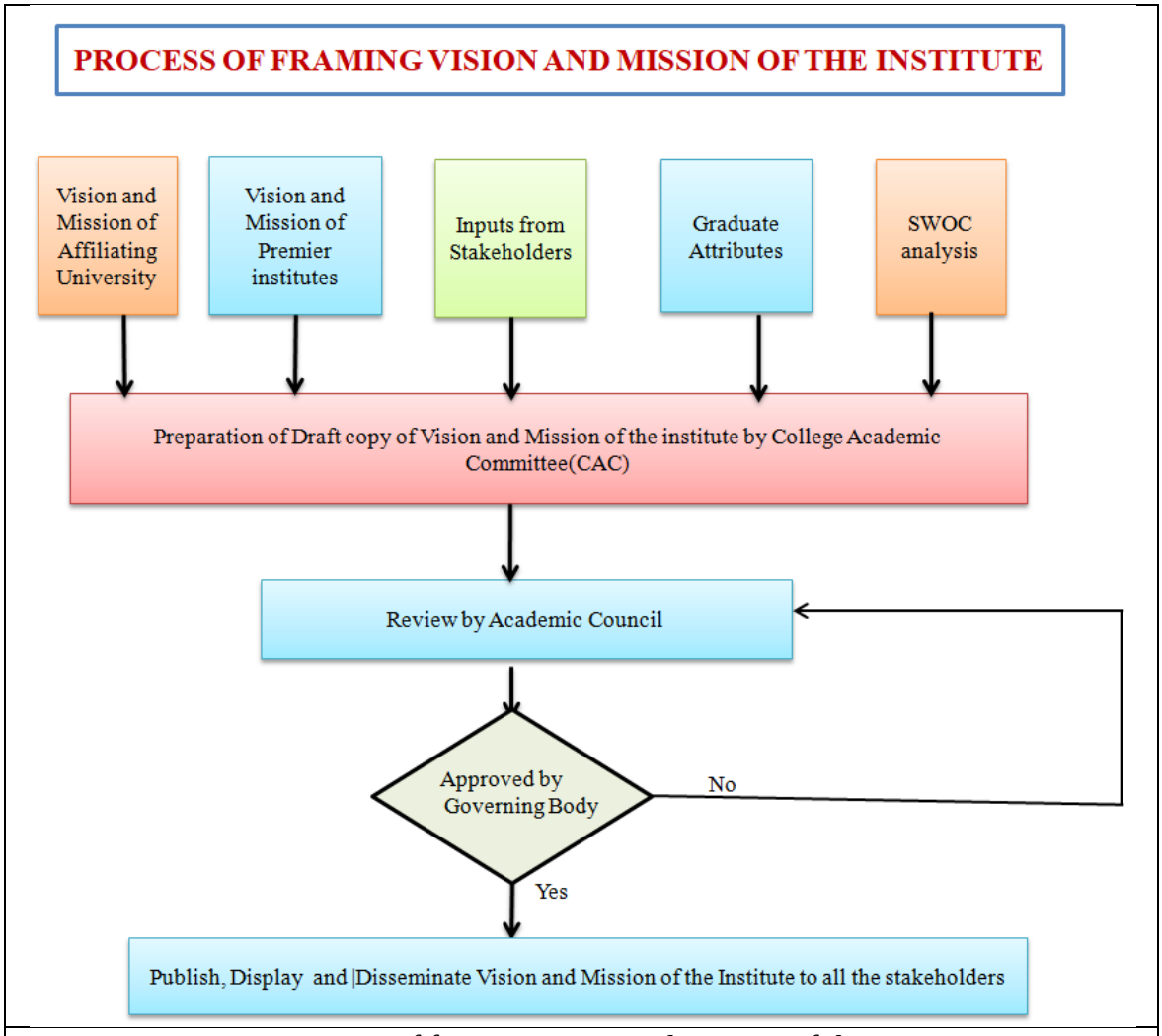


Fig.2.1: Process of framing Vision and Mission of the Institute

PROCESS FOR FRAMING VISION &MISSION OF THE DEPARTMENT

Vision and Mission of the department are to be framed by taking various inputs i.e., Vision and Mission of the Institute, Department SWOC Analysis and opinions of the stakeholders (internal and external) and executing various phases as under.

1. Collect the various inputs for Brainstorming sessions by the departments' faculty members.
2. After Brainstorming sessions, department committee will prepare Draft copy of Vision and Mission,
3. The draft copy is to be verified and modified by Department Advisory Committee (DAC).
4. The draft copy after modification from DAC has to be approved by Principal.
5. If Principal approve the draft copy, it is to be ratified by Academic Council and Governing Body. Else, it is to be sent to DAC to review and refine the draft copy.
6. After the final ratification by the Academic Council and Governing body, college will display, publish and disseminate Vision and Mission of the department to all the stakeholders.

All the above steps are clearly shown in Fig. 2.2.1.

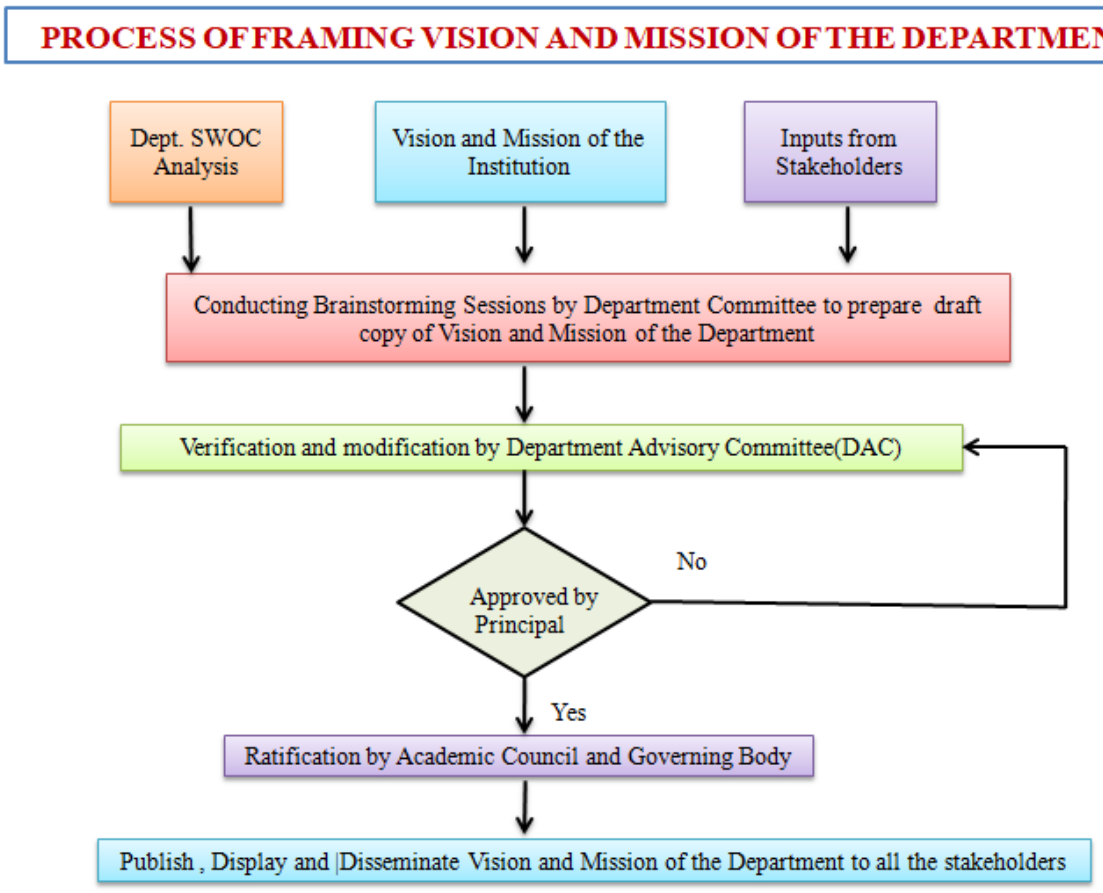


Fig. 2.2.1 : Process of framing Vision and Mission of the Department

Before disseminating the Vision and Mission statements to the stakeholders, we need to crosscheck important points which are presented here .

VISION STATEMENT

- Is the statement addressing "What the department would like to become?" such as best, leader, recongised state/nation level for etc.
- Is the statement addressing "What the department is striving for?" such as reputation, excellence in … etc.
- Does it indicate what the programs will look like in future?
- Is inspirational word present?
- is it giving desired direction?
- Is it aligned to the Institute vision?

MISSION STATEMENT(S)

- Is the statement indicates the primary functions or activities of the department? (providing good infrastructure)
- Is the statement indicates the primary functions or activities of the department? (providing good education or T-L-E)

- Is the statement indicates the primary functions or activities of the department? (providing co-curricular & extra-curricular activities)
- Is the statement indicates the primary functions or activities of the department? (providing good resources, collaborations etc)
- Is the statement has mention about the identified stakeholders or their expectations?
- Is it distinctive having speciifics? Or generic statements?
- Does it states what is the pursose of the programs?
- is it easily memorable?
- Is it aligned to the Institute mission?

PROCESS FOR FRAMING PROGRAM EDUCATIONAL OBJECTIVES(PEOs)

Program Educational Objectives(PEOs) are to be framed by taking various inputs i.e., Vision and Mission of the Institution & Department, Department SWOC Analysis, Graduate Attributes and opinions of the stakeholders (internal and external) and executing various phases as under.

1. Collect the various inputs for brainstorming sessions in the department committee to prepare draft copy of PEOs
2. The draft copy is to be verified and modified by Program Assessment Committee (PAC)
3. The modified draft copy of PEOs is then sent to Principal for approval.
4. If the draft copy is approved by Principal, it is to be ratified by Academic council and governing body. Else, document is to be sent to PAC to update the draft copy.
5. The draft copy, after Principal's approval is to be ratified by Academic council and Governing body.
6. After the ratification by Academic council and governing body, college will display, publish and disseminate the PEOs to all the stakeholders.

All the above steps are clearly shown in Fig. 2.2.2.

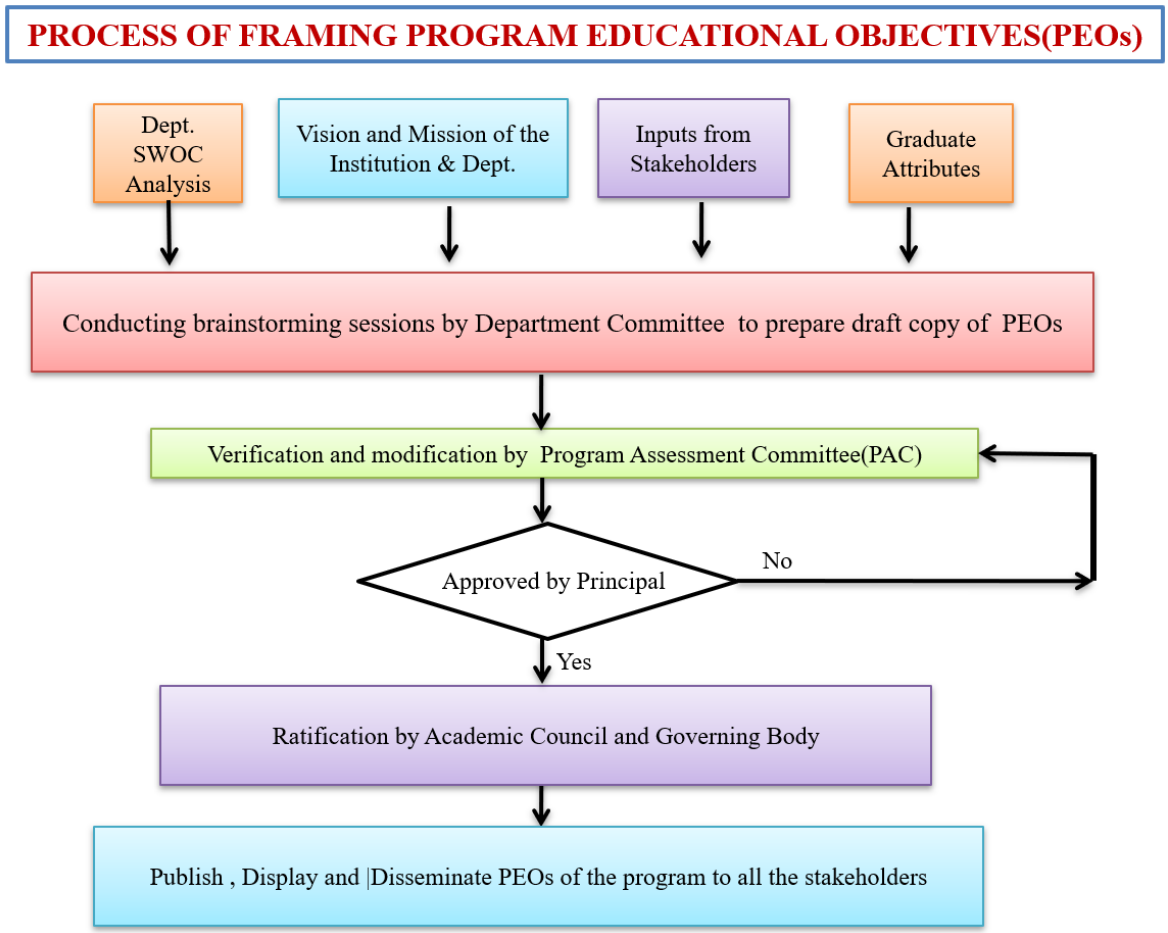


Fig. 2.2.2: Process of framing PEO's of the programme

Before disseminating the PEO statements to the stakeholders, we need to crosscheck important points which are presented here.

- Is the statement indicates the accomplishments of GRADUATES only?
- Is any PEO addressing Preparation (Employment/Higher Studies)?
- Is any PEO addressing Core Competence (Discipline knowledge)?
- Is any PEO addressing Breadth / Interdisciplinary aspect ('T' Shaped Engineer)?
- Is any PEO addressing Professionalism - 3Ps (Professional value, professional knowledge, professional development)?
- Is any PEO addressing Life long learning (Environment)?

Similarly, before finalizing PSO statements, we need to crosscheck important points which are presented here.

- Is the statement indicate the skill, knowledge, values, attitude?
- Is PSO addressing specific outcomes the given generic PO?
- Is PSO addressing the specific accomplishments of the students?
- Is PSO addressing the specific facilities required by the students?
- Is PSO addressing the specific facuty/expert support required by the students?

2.2 GUIDELINES FOR WRITING COURSE OUTCOMES

Course Outcomes (COs) will be formed for each course in all the programs. All the instructors dealing a particular course will formulate the Course Outcomes.

- COs will be formed by the instructors dealing the same course and authority for approving COs will be department BoS.
- 5-6 COs can be framed per course, and COs are formed by considering the learning levels of Bloom's Taxonomy.

Structure of Course Outcomes:

A Course Outcome must have the following characteristics.

1. Specific
2. Measurable
3. Attainable

A well written Course Outcome will have the following 3 components as.

1. Condition
2. Performance
3. Criterion

We can map the characteristics and components as > Specific –Condition , Measurable-Performance and Attainable –Criterion.

In view of the above characteristics and components , instructor(s) have to prepare the Course outcomes.

Course Outcome statement may be broken down into two main components:

- **An action word** that identifies the performance to be demonstrated.
- **Learning statement** that specifies what type of learning will be demonstrated in the performance;

Examples of good action words to include in course outcome statements:

- Compile, identify, create, plan, revise, analyze, design, select, utilize, apply, demonstrate, prepare, use, compute, discuss, predict, assess, compare, rate, critique, outline, evaluate,

Examples:

A well-written course outcome will be as explained under.

At the end of the course, student is able to:

1. **Apply** laws of physics (e.g...Hooke's law, etc.,) to compute different types of response (stress and deformation) in the given materials. (PO 1)
2. **Analyze** structural elements for different force systems to compute design parameters (BM and SF) (PO2)
3. **Design** compression elements using engineering principles to resist any given loads. (PO3)
4. **Conduct** experiments to validate physical behavior of materials/ components.(PO4)
5. **Prepare** laboratory reports on interpretation of experimental results (P10)

ROLE OF COMPETENCIES AND PERFORMANCE INDICATORS

Program Outcomes give useful guidance at program level for the curriculum design, delivery and assessment of student learning. However, they represent fairly high-level generic goals that are not directly measurable. A real observability and measurability of the POs at course level is very difficult. To connect high-level learning outcomes (POs) with course content, course outcomes and assessment, there is a necessity to bring further clarity and specificity to the program outcomes . This can be achieved through the following two-step process of identifying Competencies and Performance Indicators (PI).

(1) Identify Competencies to be attained:

For each PO define competencies –different abilities implied by program outcome statement that would generally require different assessment measures. This helps us to create a shared understanding of the competencies we want our students to achieve. They serve as an intermediate step to the creation of measurable indicators.

Example: Program Outcome (Attribute 3) Design: PO 3: Design/Development of Solutions:
Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.

Competencies
1. Demonstrate an ability to define a complex open-ended problem in engineering terms.
2. Demonstrate an ability to generate a diverse set of alternative design solutions
3. Demonstrate an ability to select the optimal design scheme for further development
4. Demonstrate an ability to advance an engineering design to defined end state

(2) Define Performance Indicators

For each of the competencies identified, define Performance Indicators (PIs) that are explicit statements of expectations of the student learning. They can act as measuring tools in assessment to understand the extent of attainment of outcomes. They can also be designed to determine the appropriate achievement level or competency of each indicator so that instructors can target and students can achieve the acceptable level of proficiency.

Example: For the Competency -2

Demonstrate an ability to generate a diverse set of alternative design solutions
Performance Indicators:
1. Apply formal idea generation tools to develop multiple engineering design solutions
2. Build models, prototypes, algorithms to develop a diverse set of design solutions
3. Identify the functional and non-functional criteria for evaluation of alternative design solutions.

It should be noted that, when we consider the program outcome, it looks like, it can be achieved only in the Capstone project. But if we consider the competencies and performance indicators, we start seeing the opportunities of addressing them (and hence PO) in various courses of the program. Once the above process is completed for the program, the assessment of COs for all the courses are designed by connecting assessment questions (used in various assessment tools) to the Performance Indicators. By following this process, where examination questions map with Performance Indicators, we get clarity and better resolution for the assessment of COs and POs.
The process is clearly shown in Fig. 2.2.3.

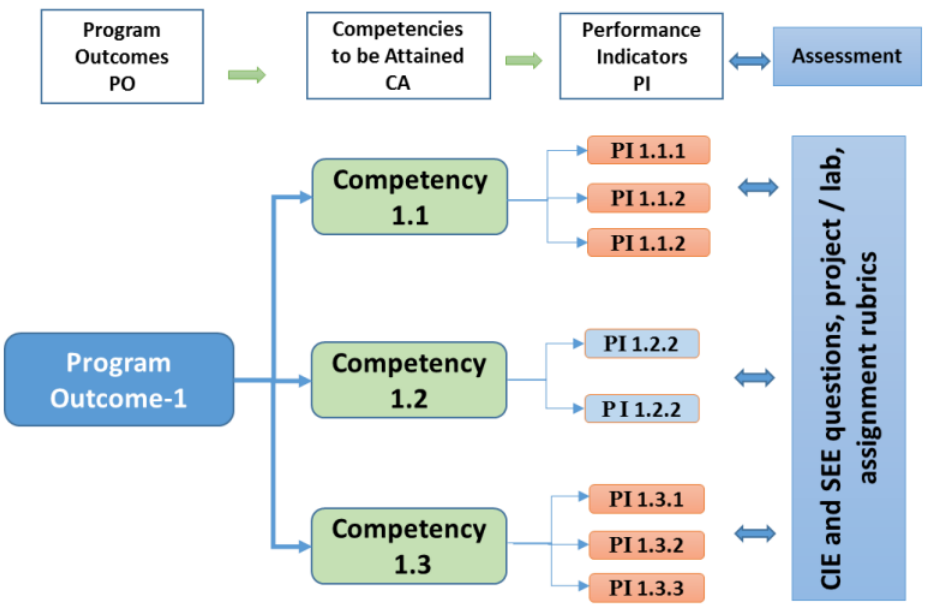


Fig. 2.2.3: Competencies and Performance Indicators

The following table gives a suggestive list of competencies and associated performance indicators for each of the PO.

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals,and an engineering specialisation for the solution of complex engineering problems.		
Competency	**PI #**	**PI Description**
1.2 Demonstrate competence in mathematical modelling	1.2.1	Apply the knowledge of discrete structures, linear algebra, statistics and numerical techniques to solveproblems
	1.2.2	Apply the concepts of probability, statistics and queuingtheory in modeling of computer based system, data andnetwork protocols.
1.5 Demonstrate competence inbasic sciences	1.5.1	Apply laws of natural science to an engineeringproblem
1.6 Demonstrate competence in engineering fundamentals	1.6.1	Apply engineering fundamentals
1.7 Demonstrate competence in specialized engineering knowledge to the program	1.7.1	Apply theory and principles of computer scienceengineering to solve an engineering problem
PO 2: Problem analysis: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences,and engineering sciences.		
Competency	**PI #**	**PI Description**
2.5 Demonstrate an ability to identify an formulate complex engineering problem	2.5.1	Evaluate problem statements and identifies objectives
	2.5.2	Identifies processes/modules/algorithms of a computer based system and parameters to solve a problem
	2.5.3	Identifies mathematical algorithmic knowledge thatapplies to a given problem
2.6 Demonstrate an ability toformulate a solution planand methodology for an engineering problem	2.6.1	Reframe the computer based system intointerconnected subsystems
	2.6.2	Identifies functionalities and computing resources.
	2.6.3	Identify existing solution/methods to solve the problem, including forming justified approximationsand assumptions
	2.6.4	Compare and contrast alternative solution/methods toselect the best methods
	2.6.5	Compare and contrast alternative solution processes to select the best process.
2.7 Demonstrate an ability toformulate and interpret amodel	2.7.1	Able to apply computer engineering principles to formulate modules of a system with required applicability and performance.
	2.7.2	Identify design constraints for required performancecriteria.
2.8 Demonstrate an ability to execute a solution processand analyze results	2.8.1	Applies engineering mathematics to implement thesolution.
	2.8.2	Analyze and interpret the results using contemporary tools
	2.8.3	Identify the limitations of the solution andsources/causes.
	2.8.4	Arrive at conclusions with respect to the objectives.
PO 3: Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate considerationfor public health and safety, and cultural, societal, and environmental considerations.		
3.5 Demonstrate an ability todefine a complex / open-ended problem in engineering terms	3.5.1	Able to define a precise problem statement withobjectives and scope.
	3.5.2	Able to identify and document system requirementsfrom stake holders.
	3.5.3	Ability to review state of the art literature to synthesizesystem requirements.
	3.5.4	Ability to choose appropriate quality attributes asdefined by ISO/IEC/IEEE standard.
	3.5.5	Explore and synthesize system requirements from larger social and professional concerns.
	3.5.6	Ability to develop software requirement specifications (SRS).
3.6 Demonstrate an ability to generate a diverse set of alternative design solutions	3.6.1	Ability to explore design alternatives.
	3.6.2	Ability to produce a variety of potential design solutions suited to meet functional requirements.
	3.6.3	Identify suitable non functional requirements for evaluation of alternate design solutions.
3.7 Demonstrate an ability toselect optimal design scheme for further development	3.7.1	Ability to perform systematic evaluation of the degreeto which several design concepts meet the criteria.
	3.72	Consult with domain experts and stakeholders toselect candidate engineering design solution for further development

3.8 Demonstrate an ability to advance an engineering design to defined end state	3.8.1	Ability to refine architecture design into a detaileddesign within the existing constraints.
	3.8.2	Ability to implement and integrate the modules.
	3.8.3	Ability to verify the functionalities and validate thedesign.
PO 4: Conduct investigations of complex problems: Use research-based knowledge and researchmethods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.		
4.4 Demonstrate an ability to conduct investigations oftechnical issues consistent with their levelof knowledge and understanding	4.4.1	Define a problem for purposes of investigation, itsscope and importance
	4.4.2	Ability to choose appropriate procedure/algorithm,data set and test cases.
	4.4.3	Ability to choose appropriate hardware/software toolsto conduct the experiment.
4.5 Demonstrate an ability todesign experiments to solve open ended problems	4.5.1	Design and develop appropriate procedures / methodologies based on the studyobjectives
4.6 Demonstrate an ability to analyze data and reach avalid conclusion	4.6.1	Use appropriate procedures, tools and techniquesto collect and analyze data
	4.6.2	Critically analyze data for trends and correlations,stating possible errors and limitations
	4.6.3	Represent data (in tabular and/or graphical forms)so as to facilitate analysis and explanation of the data, and drawing of conclusions
	4.6.4	Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions
PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modernengineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.		
Competency	**PI #**	**PI Description**
5.4 Demonstrate an ability to identify / create modern engineering tools, techniques and resources	5.4.1	Identify modern engineering tools, techniques andresources for engineering activities
	5.4.2	Create/adapt/modify/extend tools and techniques tosolve engineering problems
5.5 Demonstrate an ability to select and apply disciplinespecific tools, techniques and resources	5.5.1	Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii)monitoring system performance, and (iv) creating engineering designs.
	5.5.2	Demonstrate proficiency in using discipline specific tools
5.6 Demonstrate an ability to evaluate the suitability and limitations of tools used to solve anengineering problem	5.6.1	Discuss limitations and validate tools, techniques andresources
	5.6.2	Verify the credibility of results from tool use with reference to the accuracy and limitations, and theassumptions inherent in their use.
PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.		
6.3 Demonstrate an ability to describe engineering roles ina broader context, e.g. pertaining to the environment, health, safety, legal and public welfare	6.3.1	Identify and describe various engineering roles; particularly as pertains to protection of the public andpublic interest at global, regional and local level
6.4 Demonstrate an understanding of professional engineering regulations, legislation andstandards	6.4.1	Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution tothe protection of the public
PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions insocietal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.		
7.3 Demonstrate an understanding of the impactof engineering and	7.3.1	Identify risks/impacts in the life-cycle of an engineeringproduct or activity

industrialpractices on social, environmental and in economic contexts	7.3.2	Understand the relationship between the technical,socio economic and environmental dimensions of sustainability
7.4 Demonstrate an ability toapply principles of sustainable design and development	7.4.1	Describe management techniques for sustainabledevelopment
	7.4.2	Apply principles of preventive engineering and sustainable development to an engineering activity orproduct relevant to the discipline
PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms ofthe engineering practice.		
Competency	**PI #**	**PI Description**
8.3 Demonstrate an ability to recognize ethical dilemmas	8.3.1	Identify situations of unethical professional conduct andpropose ethical alternatives
8.4 Demonstrate an ability toapply the Code of Ethics	8.4.1	Identify tenets of the ASME professional code of ethics
	8.4.2	Examine and apply moral & ethical principles to knowncase studies
PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverseteams, and in multidisciplinary settings.		
9.4 Demonstrate an ability toform a team and define arole for each member	9.4.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
	9.4.2	Implement the norms of practice (e.g. rules, roles,charters, agendas, etc.) of effective team work, to accomplish a goal.
9.5 Demonstrate effective individual and team operations--communication,problem solving, conflict resolution and leadership skills	9.5.1	Demonstrate effective communication, problem solving,conflict resolution and leadership skills
	9.5.2	Treat other team members respectfully
	9.5.3	Listen to other members ure in difficult Maintain ituation scompos
9.6 Demonstrate success in a teambased project	9.6.1	Present results as a team, with smooth integration ofcontributions from all individual efforts
PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions		
Competency	**PI #**	**PI Description**
10.4 Demonstrate an ability to comprehend technical literature and document project work	10.4.1	Read, understand and interpret technical and non-technical information
	10.4.2	Produce clear, well-constructed, and well-supportedwritten engineering documents
	10.4.3	Create flow in a document or presentation - a logicalprogression of ideas so that the main point is clear
10.5 Demonstrate competencein listening, speaking, andpresentation	10.5.1	Listen to and comprehend information, instructions, andviewpoints of others
	10.5.2	Deliver effective oral presentations to technical and non-technical audiences
10.6 Demonstrate the ability to integrate different modes of communication	10.6.1	Create engineering-standard figures, reports and drawings to complement writing and presentations
	10.6.2	Use a variety of media effectively to convey a messagein a document or a presentation
PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manageprojects and in multidisciplinary environments.		
Competency	**PI #**	**PI Description**
11.4 Demonstrate an ability to evaluate the economic and financial performance of anengineering activity	11.4.1	Describe various economic and financial costs/benefitsof an engineering activity
	11.4.2	Analyze different forms of financial statements to evaluate the financial status of an engineering project
11.5 Demonstrate an ability to compare and contrast the costs/benefits of alternate proposals for an engineeringactivity	11.5.1	Analyze and select the most appropriate proposalbased on economic and financial considerations.

11.6 Demonstrate an ability to plan/manage an engineeringactivity within time and budget constraints	11.6.1	Identify the tasks required to complete an Engineering activity, and the resources required to complete thetasks
	11.6.2	Use project management tools to schedule an engineering project so it is completed on time and onbudget.
PO 12: Life-long learning: Recognise the need for, and have the preparation and ability to engage inindependent and life-long learning in the broadest context of technological change.		
Competency	**PI #**	**PI Description**
12.4 Demonstrate an ability to identify gaps in knowledgeand a strategy to close these gaps	12.4.1	Describe the rationale for requirement for continuing professional development
	12.4.2	Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to closethis gap
12.5 Demonstrate an ability to identify changing trends in engineering knowledge andpractice	12.5.1	Identify historic points of technological advance inengineering that required practitioners to seek education in order to stay current
	12.5.2	Recognize the need and be able to clearly explain whyit is vitally important to keep current regarding new developments in your field
12.6 Demonstrate an ability to identify and access sourcesfor new information	12.6.1	Source and comprehend technical literature and othercredible sources of information
	12.6.2	Analyze sourced technical and popular information forfeasibility, viability, sustainability, etc.

DO's AND DON'Ts IN WRITING COURSE OUTCOMES

- Avoid using the words which increases the scope or create ambiguity in understanding the theme of the Course outcome i.e., 'all the types of', 'good', 'best way', 'various types of', 'etc', 'like', 'such as'.
- Ensure that all the Course outcome are written with reference to 'learner' not 'instructor'.
- All course outcomes must be Action oriented.
- If the Course outcome contains two action verbs, higher knowledge level verb is to be highlighted in the Course Outcome statement.
- Course outcome statement should be in such a way that it should reflect the scope or limitations of the study under consideration.
- Number of course outcome should be restricted to 6.

CHECKLIST FOR VERIFICATION BY COURSE COORDINATOR

After all the course outcomes are written, Course coordinator has to verify different components. After verification, coordinator has to take a decision whether any component needs improvement or not. For this, Boolean checklist i.e., Yes /No, True/False, Update required / not required etc., Some of them are as follows.

1. Number of course outcomes
2. Is the Course outcome statement reflect learning and activity ?
3. Is the Bloom's Taxonomy followed in framing the Course outcome statement?
4. Is the CO statement has Performance component or not?
5. Is the CO statement has Condition component or not ?
6. Is the CO statement has Criteria component or not?
7. Is the action part of CO is Specific?
8. Is the action part of CO is Measurable ?
9. Is the action part of CO has attainable criterion?
10. Is the syllabus framed is in line with the Course outcomes statements ?

11. Is the Semester end examination question paper is set as per Course outcomes and Bloom's taxonomy?

GUIDELINES FOR CO-PO MAPPING

CO-PO mapping process is a critical part in the OBE process. It is the key process by which root level attainment of OBE process will be transformed to higher levels i.e., POs,PSOs and PEOs. All higher level processes' attainments will be based on CO-PO mapping only. Hence, CO-PO mapping is to be done with utmost care.
CO-PO mapping process is to be carried out by the Course instructors in discussion with Course coordinator and Head of the Department(HoD).

The various factors/points to be considered in CO-PO mapping process are as under.

- Check whether CO reflects the intended measurement related to any of the Program outcomes or not. Each CO has to address a subset of Program outcomes. Else, it becomes worthless in the curriculum, as it directly indicating that it is not contributing anything towards any of the Graduate attributes. In that case, it is better to redefine that Course outcome, or discard it from the syllabus.
- The number of hours allocated for each Course outcome as a percentage of total allocated hours for that Course, Bloom's taxonomy level associated primarily guides the mapping level or correlation to be 1,2 or 3.
  (1-low,2-moderate and 3-substantial or high).
- CO-PO mapping should reflect the ambitions of all the stakeholders.
- Quantitative methods can be developed to decide the mapping level 1,2 or 3. At times, we may take fractional values also i.e., 2.45, 2.56 etc.,
- CO-PO mapping process should reflect the Teaching-Learning processes followed in the content delivery of that Course.
- If there is any change in the curriculum or TLP, CO-PO mapping matrix need to be modified.
- CO-PO mapping matrix is to be supported by the justification statements, why mapping level is 1, 2 or 3 for that combination of CO and PO.
- If more number of faculty are dealing the same course, CO-PO matrix is to be prepared by every faculty.

CHECKLLIST FOR CO-PO MAPPING

After CO-PO mapping is completed, Course coordinators has to check the reliability of mapping process under various parameters. Some of them are as follows.

1. Does each CO mapped to at least one PO at Level 3 or HIGH?
2. Does the CO verb is aligned to the highest mapped PO?
3. Does each Course Outcome (CO) mapped to ≤ 5 POs?
4. Does the entire Course mapped to ≤ 5 POs?
5. Does each CO-PO mapping justification sentence written using syllabus topics?
6. Does the CO-PO mapping table with justification available in Course file?
7. Does the Course wise PO mapping has appropriate level of mapping?
8. Is there any Course outcome left behind without being mapped to any of the PO or PSO?

2.3. PROCESS OF CURRICULUM DESIGN

To realize the Vision and Mission statements of an institution, it is necessary to design the curriculum to be inline. After finalizing the Vision and Mission of the Institute and the department, Program Educational Objectives, Program Outcomes and Program Specific Outcomes, it is necessary to frame Course Outcomes (CO) which are the root level learning objectives in the Outcome Based Education. The process of Course outcomes preparation and mapping with Program Outcomes and Program Specific Outcomes is as follows.

1. By taking the inputs from Vision and Mission of the Institute and Department, PEOs, POs, PSOs, Feedback on the curriculum by stakeholders, brainstorming sessions will be organized by Department Committee to prepare draft copy of course outcomes.
2. After preparing the Course outcomes, mapping with POs and PSOs is done.
3. After mapping process is completed, it is necessary to design the Course content i.e., syllabus which suits to attain the desired Course Outcomes.
4. The draft copy of the Course outcomes and mapping is verified and modified by Department Advisory Committee(DAC).
5. After the approval from DAC, it is submitted to Board of Studies(BoS) for approval.
6. If BoS approves, it is forwarded to Academic council and Governing body. If not, it is sent to DAC for updation of the document.
7. After being approved from Board of Studies, it is to be ratified by Academic Council and Governing Body.
8. After ratification from Academic Council and Governing Body, college will publish the curriculum to all the stakeholders.

The entire Curriculum Design Process is shown in the Fig. 2.3.

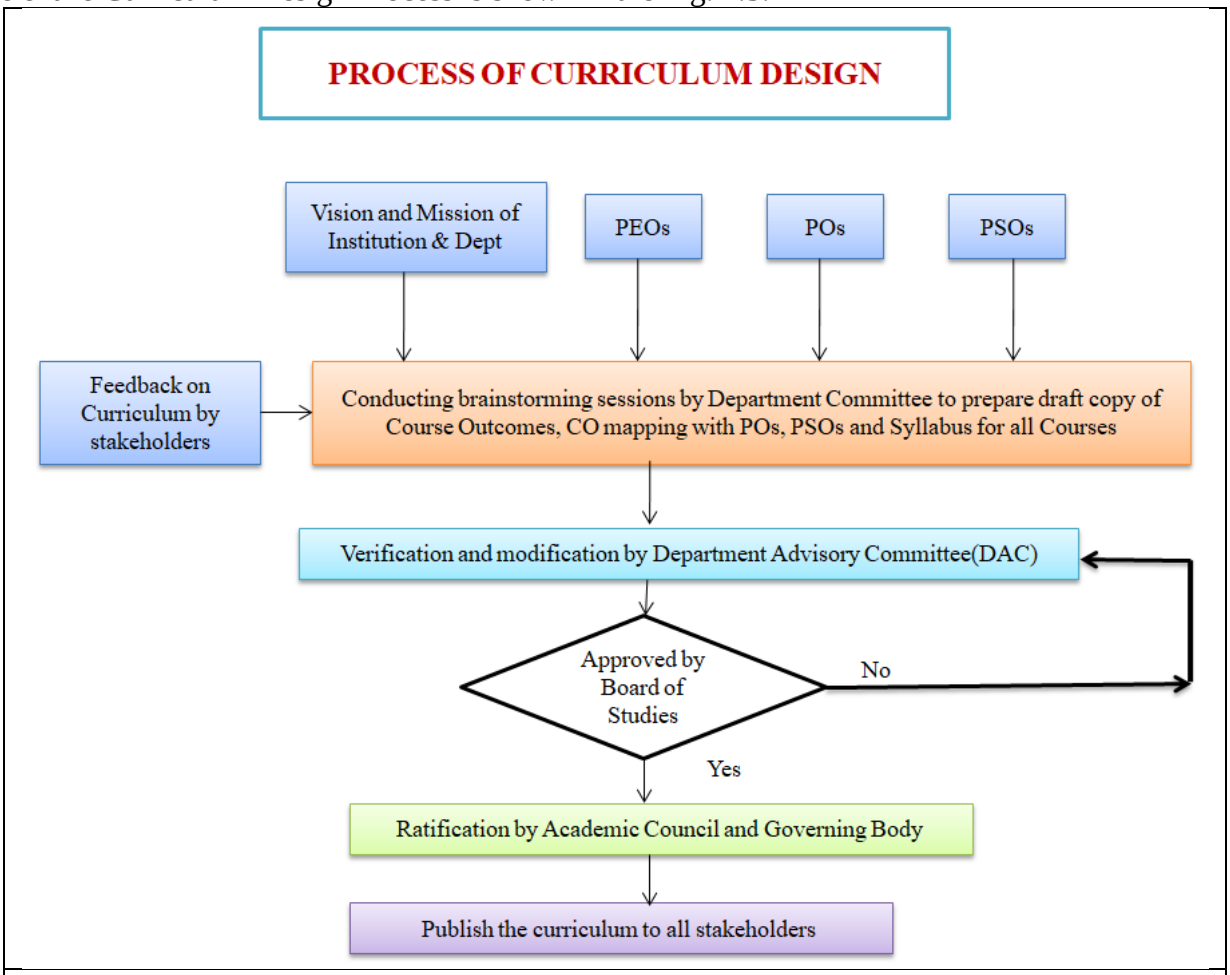


Fig. 2.3: Process of Curriculum Design

ROLE OF OBE PROCESS IN THE EVOLUTION OF PROGRAM CURRICULUM

Outcome based education concepts are mainly helpful in designing the curriculum for the B. Tech Programme in an effective way. Various phases of OBE process in designing the curriculum are shown in Fig. 2.4.

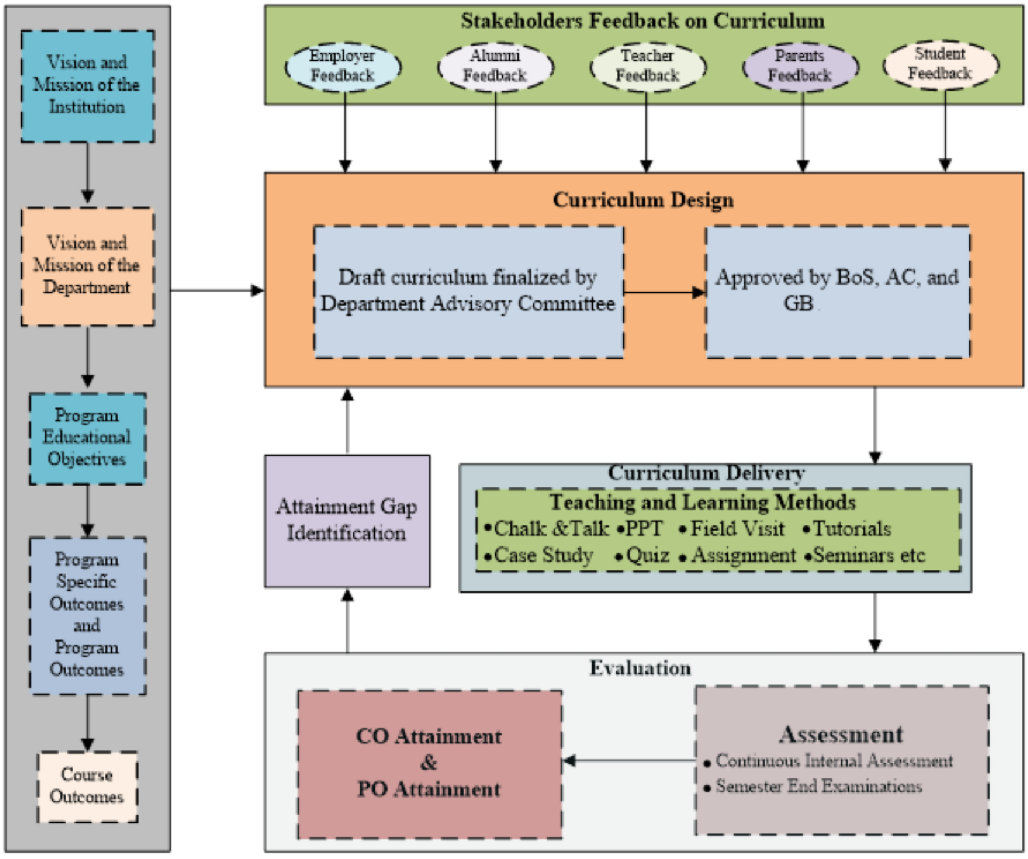


Fig.2.4: **Role of OBE process in the Evolution of Program Curriculum**

2.4 TEACHING-LEARNING PROCESS & ACTION PLAN

In Outcome based education, it is necessary to design teaching-learning process and its components in accordance with the desired course outcomes, program outcome and program specific outcomes. For a single course, course instructor(s) will plan different teaching-learning process methodologies as per the subject experience and number of times dealt that course. Initially, course instructor makes ready the action plan to be followed lecture by lecture in a single semester. In general, we call this action plan as a part of teaching learning process as 'lesson plan'. After the content delivery is completed, all assessment tests /activities are completed, CO attainment and PO/PSO attainment will be calculated. After analysis of CO and PO/PSO attainments, it is the responsibility of the course instructor to update the teaching learning process in the next semester as per the outcome of the present academic semester. Course instructor has to decide whether present teaching learning methodologies to be followed or modified or new methodology is to be introduced.

In addition to Chalk & talk, the various teaching-learning methodologies to encourage Participative, Problem solving and Experiential learning are as under :

1. Hackathons	2. MOOCs
3. Workshops	4. Google Classroom
5. Seminars	6. Project- based learning
7. Virtual Lab	8. Real-time case studies
9. Simulation	10. Worksheets
11. Role play	12. PPT
13. Review web literature	14. Kahoot
15. Video	16. Mind map
17. Demonstration	18. Journal Review
19. Activity-based learning	20. Pogil
21. Jigsaw	22. Open book test
23. Think-Pair-Share	24. Proto-type model
25. Flipped Classroom	26. Cross words
27. Plicker	28. Research projects
29. Guest lecture	30. Language games
31. Professional practice school	32. Viva
33. Group Discussion/ debate	34. Poster presentation
35. Peer learning groups	36. Public Speaking

ACTION PLAN

Every course instructor prepares a group of teaching methodologies to deliver the content in the classroom. The type of methodology depends on the content, complexity of the topic and interest of the instructor. Every class content is planned well in advance with information about the textbooks and reference books to be studied. All these activities are referred to as action plan' for conducting the course in the given semester period of 16 weeks.

2.5. CALCULATION OF CO-PO-PSO ATTAINMENT

- The process of attainment of Cos, POs starts from writing appropriate Cos for each course of the program.
- Then, a correlation is established between Cos and POs in the scale of 1 to 3, 1 being the slight (low), 2 being moderate (medium) and 3 being substantial (high).
- A mapping matrix is prepared in this regard for every course in the program including the elective courses.
- The course outcomes written and their mapping with POs are reviewed frequently by a BoS before they are finalized.

2.5.1. COURSE OUTCOME ASSESSMENT:

CO Attainment is calculated under two components.

- **Direct assessment**

  Direct Assessment refers to the assessment of the activities which are directly connected with an Examination or Test or Quiz where an Instructor will assess the level of attainment of the concepts by all the students of a particular section, by conducting an Examination.

- **Indirect Assessment.**

  Indirect Assessment refers to the assessment of level of agreement of the learner about the skills he derived from the Teaching-Learning process. Learner opinions will be collected through various surveys.

2.5.1 a) CO-DIRECT ASSESSMENT

In general, Direct Assessment will have two components

1. Continuous Evaluation Component
2. Semester End Examination Component

In Continuous Evaluation component, instructor will have direct interaction with all the students during the Semester period. During the course time, Instructor will conduct Sessional Examination or Assignment or Quiz or Slip Test or Flash Test etc. to assess the students' attainment in getting the concepts defined in Course outcomes. After the course instruction period is completed, Semester End Examination will be conducted.

The composition of Continuous Evaluation and Semester End Examination for a Theory course is proposed as follows.

Continuous Evaluation	Semester End Examination	Total
30	70	100

DIVISION OF SUB-COMPONENTS OF CONTINUOUS EVALUATION PROCESS

Theory Course :

In Aditya Engineering College (A), the proposed Sub-Components of Continuous Evaluation Process for a theory course are :

- Sessional -1 Examination – Descriptive Test
- Sessional -1 Examination – Objective Test
- Sessional -1 Examination - Assignment
- Sessional -2 Examination – Descriptive Test
- Sessional -2 Examination – Objective Test
- Sessional -2 Examination - Assignment
- Sessional Examination 1 and 2 will be conducted according to the dates mentioned in the Academic Calendar.

- The composition and award of marks or grades in various assessment tools i.e., Descriptive test, Objective test and Assignment test will be as per the resolutions of the Academic Council. It is recommended by the Academic Council that the division of marks for Sessionals and Externals has to be 30% + 70%.
- The marks composition of Descriptive Test, Objective Test and Assignment in different academic regulations is as follows:

Descriptive	Objective	Assignment	Total
15	10	5	30

- The test composition of Descriptive Test, Objective Test and Assignment in different academic regulations is proposed as follows:

Descriptive	Objective	Assignment	Total
3 Questions of 5 marks each	20 questions of ½ mark each	3 questions set for 5 marks	30

- The time duration for Descriptive Test and Objective Test is 90 minutes and 20 minutes respectively.
- In the Descriptive Test , each question is appended with its concerned Course Outcome and Bloom’s taxonomy level as shown in the specimen below.

Q.No	Question	CO	BTL
1a	<Question 1a>	CO1	L2
1b	<Question 1b>	CO2	L3

Laboratory Course :

In Aditya Engineering College (A), the proposed Sub-Components of Continuous Evaluation Process for a laboratory course are:

- The composition and award of marks or grades in various assessment tools i.e., Day-to-day evaluation, Observation and Record, Internal Test and Semester End Examination will be as per the resolutions of the Academic Council. It is recommended by the Academic Council that the division of marks for Sessional and Semester End Examination has to be 30% + 70%.
- The marks composition of Day-to-day evaluation, Observation and Record, Internal Test and Semester End Examination in different academic regulations is as follows:

Day-to-day evaluation	Observation & Record	Internal Test	Total
10	10	10	30

PROCESS TO SET TARGET PERCENTAGE ATTAINMENT FOR COURSE OUTCOMES

In Outcome based education (OBE) process, it is essential to set a primary target to be set by the Course Instructor prior to the starting of the academic sessions i.e., before the Semester instruction begins. The target setting process necessitates discussion among Course Instructors, Course Coordinator and HOD of the Department.

After discussion, committee will decide the primary targets for each Course Outcome of all the Courses in that Semester. Various factors to be considered in setting the targets are :

a. Complexity of the Concepts included in that Course Outcome(CO)
b. Number of hours to be engaged for that CO
c. Feedback Report or Opinion from instructors who dealt that Course earlier.
d. Performance levels of the Learners based on Academic record(s).
e. Feasibility of the particular Course to have Demonstration or Equipment Exposure inside a Laboratory

PRIMARY TARGETS FOR COURSE OUTCOMES

After the OBE process to set the targets for the Course Outcomes, it is decided to set 60% (i.e. 1.8 out of 3) as primary target for each Course Outcome. The motto behind this fixation of 1.8 out of 3 is that if we set a target at low level i.e., 1.0, attainment gaps in Teaching-Learning Process(TLP) may not be identified as we will get the Attainment in most of the cases i.e., Courses. So, to extract the inherent difficulties in TLP, it is suggested to set a target of 60% (1.8 out of 3) for each Course.

Levels associated with CO Attainment

For any Course Outcome, if less than 60% of the students got more than Threshold percentage (1.8 or 60%) the associated level will be 1. If 60-80 % of the students got more than Threshold percentage (1.8 or 60%) the associated level will be 2. If 80% of the students got more than Threshold percentage (1.8 or 60%) the associated level will be 3.

The interpretations of levels can be taken as 1-Needs improvement, 2-Satisfactory and 3-Excellent.

First level	**1**	<60% students attained more than target %
Second level	**2**	60- 80% students attained more than target %
Third level	**3**	≥80% students attained more than target %

CALCULATION OF CO ATTAINMENT IN SESSIONAL EXAMINATION

After the Sessional Examination scripts of all the students are validated by the Course Instructor(s), Marks data will be stored in an Excel file enabling data retrieval to be easy enough.

In every sessional examination, there will be 3 components as mentioned earlier, namely Descriptive, Objective and Assignment. In the sessional paper, three (3) questions will be given for Descriptive Examination. Course Outcome (CO) for each question or section of a question i.e., a or b etc., will be indicated.

CO ATTAINMENT CALCULATION FOR SEMESTER END EXAMINATION

After the Sessional Examination attainment calculation, we need to calculate the attainment for Course Outcomes from the Semester End Examination. It is necessary to collect the question wise data for each student from the Examination Cell. The targets for the Course outcomes are same as of Sessional examinations.

In the Semester End Examination, as the learner will have choice of answering the questions, internal choice will be given. Question paper consists of 10 questions having internal choice i.e., learner can answer 1 or 2, 3 or 4, 5 or 6, 7 or 8 and 9 or 10. Proper care should be taken by the Paper setter to have equal contribution to all the Course outcomes in the Question paper.

Course Outcome attainment calculation for the Semester End Examination will also be in the similar lines of Sessional Examination Attainment calculation. The only difference is that there will be not be any choice in the sessional examination, whereas in Semester End Examination, it will be. If any Course outcome appears many times in the Question paper the final attainment value of that Course outcome will be the average of all the individual components.

2.5.1 b) CO- INDIRECT ASSESSMENT

Indirect assessment for a Course will be done by means of Course Exit Survey. At the end of the Semester, every student must fill a form in which he /she has to mention the level of their ability to perform the activity defined in a Course Outcome.

The level varies from 1 to 5 based on his/her agreement of student in getting the skills mentioned in Course Outcome definition. Students' agreement level for any course outcome will be as follows.

Level	Description	Numerical value assigned
1	Strongly Agree	5
2	Agree	4
3	Neutral	3
4	Disagree	2
5	Strongly Disagree	1

CALCULATION OF COURSE OUTCOME ATTAINMENT

Course outcome attainment calculation from Sessional Examinations, Semester End Examination and Indirect Survey is consolidated as weighted average of the individual components' contribution.

The Sessional Examinations contribute to 30% of Direct Assessment and Semester End Examination contributes to remaining 70% of Direct Assessment.

The Total Course Outcome Attainment comprises of Direct CO Attainment which is obtained through Assessment i.e., Examinations and Indirect CO Attainment which is obtained through Course Exit Survey. The composition of Direct CO Attainment and Indirect CO Attainment will be 80% and 20% respectively.

CO-Direct Attainment

= (30%) CO-Sessional Attainment + (70%) CO-Semester End Examination Attainment

CO- Indirect Attainment will be directly obtained from the Course Exit Survey on a scale of '3'.

Consolidated CO Attainment

= 80% of CO-Direct Attainment + 20% of CO-Indirect Attainment

The entire process of CO Assessment for a Theory course, Laboratory course and Project course is shown in Fig. 2.4(a) , Fig. 2.4(b) and Fig. 2.4(c) respectively.

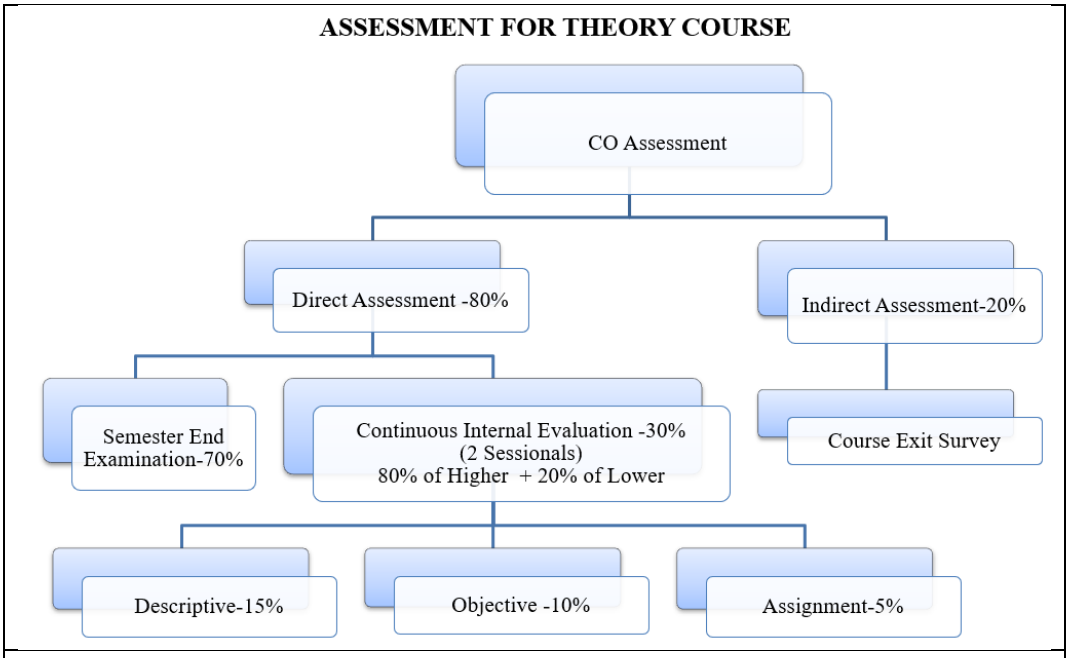


Fig. 2.4(a)

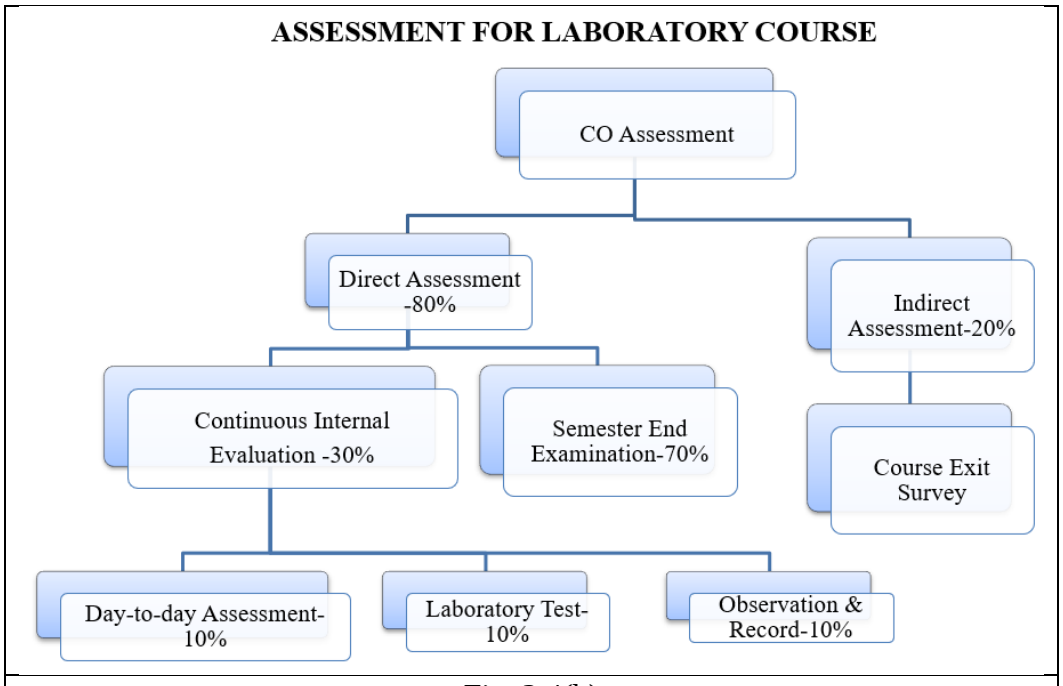


Fig. 2.4(b)

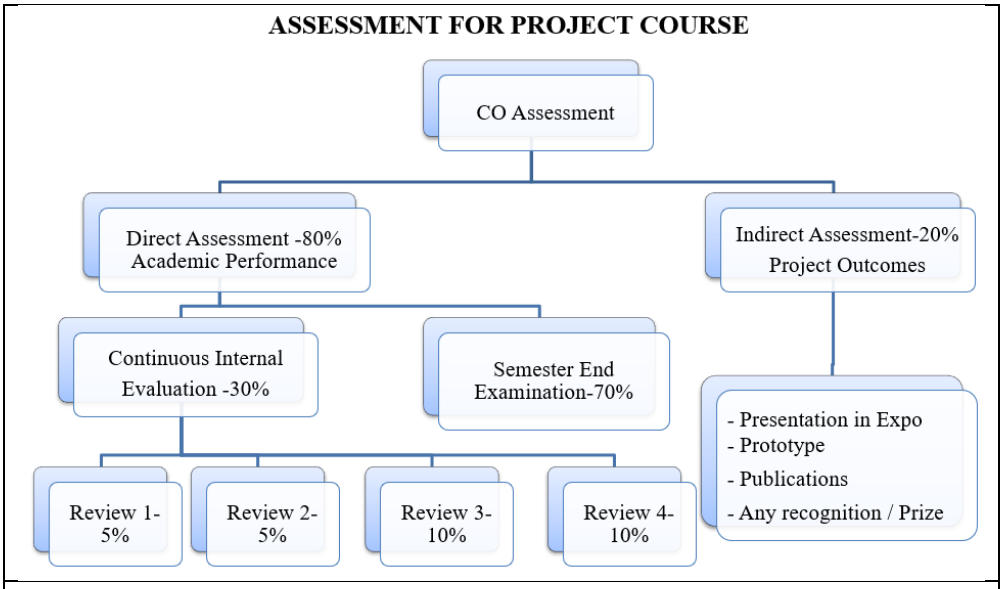


Fig. 2.4(c)

2.5.2. CALCULATION OF PO & PSO ATTAINMENT

The attainment of Program Outcome as well as Program Specific Outcome will be based on the relative mapping of Course Outcomes with PO and PSO. For this, primarily, CO_PO_PSO mapping has to be done properly.

Every Course Outcome by virtue of its content will induce some qualities or skills in the learners. Course instructor must disclose the skills to be induced by a particular Course Outcome in relation to PO1 to PO12.

There will be some correlation or synchronization of the skills expected from Graduate Engineer (PO) and skills induced through Instruction process (CO). We must assign some numerical values to have a measurement for comparison. It is suggested by OBE community that levels 1,2 and 3 can be assigned based on CO_PO_PSO mapping. If the synchronization is substantial or high, CO-PO mapping level is '3'.

Example:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	-	-	-	-	-	-	2	1	2
CO2	2	3	-	-	-	-	-	-	-	-	-	1	1	1
CO3	2	1	1	-	-	1	-	2	-	-	-	-	2	-
CO4	-	1	1	1	-	-	-	-	-	-	1	-	1	-
CO5	1	1	-	-	1	-	-	1	-	-	-	-	1	3

MAPPING STRENGTH:

It is the numerical measure of the extent of correlation of a particular Program outcome with the Course as a total.

It is calculated as an average of mapping values of a particular Program outcome with all the Course outcomes of a course

For example, the Mapping Strength of PO1 taking CO-PO-PSO mapping table above will be calculated as.

Mapping strength of PO1 = Average of {3, 2, 2,-, 1} = (3+2+2+1)/4 = 2

Similarly mapping strengths of PO2 to PO12 and PSOs also can be calculated.

CALCULATION OF PO & PSO ATTAINMENT

Program Outcome Attainment and Program Specific Outcome Attainment of a Course is having two components namely, Direct Attainment and Indirect Attainment in the similar lines of Course Outcome Attainment.

- Direct Attainment refers to the attainment of PO/PSO through CO Attainment
- Indirect Attainment refers to the attainment of PO/PSO through Surveys i.e., Program Exit Survey, Alumni Survey, Parents Survey &Employer Survey and cocurricular & extra-curricular activities.

CALCULATION OF PO-DIRECT ATTAINMENT

Direct Program Outcome Attainment and Program Specific Outcome Attainment will be calculated directly from the Course Outcome Attainment through a formula taking inputs from CO-PO-PSO mapping table.

PO/PSO Attainment

= Weighted Average of Mapped Course Outcomes

Example:

In the earlier section, for PO1. Here PO1 is mapped with CO1, CO2, CO3 and CO5 at 3, 2, 2 and 1 levels respectively.

Let the CO attainments of CO1, CO2, CO3, CO4 and CO5 be 2.12, 2.34, 1.56, 1,23 and 2.56 respectively. Now the PO1 Direct Attainment

= Weighted Average of Mapped Course Outcomes

= Weighted Average of (2.12, 2.34, 1.56, 1.23,2.56),(3,2,2,0,1)
=(2.12*3+2.34*2+1.56*2+1.23*0+2.56*1)/(3+2+2+0+1)= 2.09

It is declared that PO1-Direct Attainment for a Course 1 is 2.09

In the same way, PO2-Direct Attainment for the Course 1 is 2.08

Similarly, attainments for other POs are also calculated.

CALCULATION OF CONSOLIDATED PO/PSO DIRECT ATTAINMENT

The consolidated PO-Direct Attainment of all the program outcomes is calculated as an Average of (PO-Direct Attainments) of all the Courses which are mapped with those Program Outcomes.

To sum up easily, all the values are to be entered in a matrix. The final value of a Program Outcome for a list of courses will be the Arithmetic Average of all the Direct PO Attainments of the Individual Courses listed together.

Example:

Let PO1, Direct Attainment values for the Courses C201, C202,C304 and C403 are 1.43,2.41,1.22 and 2.67 respectively. Then Consolidated Direct PO Attainment for PO1 will be Arithmetic Average of (1.43,2.41,1,22 and 2.67) = **1.933**

CALCULATION OF PO-INDIRECT ATTAINMENT

Indirect PO attainment calculation will be done through Survey Reports and Attainment reports from various Co-curricular and Extra curricular activities. The various surveys are

- Program Exit Survey
- Alumni Survey
- Employer Survey
- Parents' Survey

CO-CURRICULAR AND EXTRA-CURRICULAR ACTIVITIES

As the program outcomes PO6 to PO12 are not related to technical domain, they will be achievement to the full extent or satisfactory level skill development through academic courses. In view of this, other activities i.e., co-curricular and extra-curricular activities are conducted to enhance the skills related to PO6 to PO12. All these activities enhance the team working skills, individual decision making skills, societal involvement, environmental concern and professional ethics in the societal and industrial operations, communication skills in dealing with the group and outsiders, project and finance management in executing the activities in a better way. In the process of participating and executing the activities automatically enhance the lifelong learning skills, which is PO12.

Various committees are framed to involve students in the activities. They are

- Alumni Coordination Committee
- Career guidance, training and placement committee
- Committee for Co- Curricular Activities
- Committee for Extension activities –NSS,LEO,YRCU,ECO
- Committee for Extra- Curricular Activities
- Committee for industry institute coordination and entrepreneurship development
- Professional Societies Coordination Committee
- Sports and games committee
- Photography and Video club

The operations of any such committee can be explained briefly as:

1. Functions/objectives of committee are defined.
2. Functions mapping with Program Outcomes (PO) articulation matrix is to be prepared.
3. Tools / rubrics to assess the levels of attainment are to be prepared.
4. After completion of the activities, attainment is to be calculated.

As an example, the operations of Cultural committee is presented.

1. Functions/objectives of Cultural Committee

F1. Organize Extra-curricular activities

F2. Inculcate human values through fine arts.

F3. Plan and schedule cultural events for the academic year.

F4. Train the students to ensure the best performance in cultural events.

F5. Provide a supportive environment for the students interested in photography so as to share their creativity, knowledge, and passion for photography.

F6. Encourage students to participate in various inter-col1ege cultural events.

2. Functions-POs Mapping

The correlation levels of the functions of committee with the POs is shown below.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
F1	-	-	-	-	-	3	-	-	-	-	-	1
F2	-	-	-	-	-	-	-	-	2	-	-	2
F3	-	-	-	-	-	-	-	-	-	-	2	2
F4	-	-	-	-	-	-	-	-	-	-	3	2
F5	-	-	-	-	-	2	-	2	-	-	-	1
F6	-	-	-	-	-	2	-	-	-	2	-	2

3. Procedure for PO attainment through Cultural Activities :

Program outcome(PO) attainment as its indirect component will be attained through Cultural activities. As the cultural activities are conducted involving students having different number of participants in different events, rubrics will be developed to quantify the activities data. The various parameters for rubrics are as under :

1. Number of events conducted
2. Number of students participated in the events
3. Number of awards received.

Rubrics developed to assess cultural activities :

Based on the available data of cultural activities conducted, rubrics will be applied to calculate the level of attainment for each parameter . The levels based on parameters are shown in the table below.

S. No	Parameter	Level-1	Level-2	Level-3
1	No. of events conducted	5	6-10	>10
2	No. of Students Participated	≤30	31-79	80-120
3	No. of Awards received	2	3-5	>5

4. PO Attainment Calculation process

All these activities will involve students such a way that Professional Program Outcomes (PO6 to PO12) is attained successfully through these activities. An articulation matrix mapping the rubric parameter and Program Outcome is prepared. The level of attainment is shown in the table.

	Attainment	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
T1	No. of events conducted						3			2	2		
T2	No. of Students Participated									3	2		2
T3	No. of Awards received									2	2		2
Avg. Attainment							**3**			**2.3**	**2**		**2**

Based on the number of events conducted, students participated, awards received, the attainment levels for the tools and corresponding POs are identified. The attainments level for T1 with PO6 is 3 (the number of events conducted is 13) for PO6, T1 with PO9 is 2, T1 with PO10 is 2, T2 with PO9 is 3 etc. The Average attainment for each PO is calculated. i.e2.3 for PO9, 2 for PO10 and 2 for PO12.

In the same way all other committees' attainments are to be calculated and entered in a consolidated table along with Survey reports attainments.

All the survey reports and other activities will calculate the PO attainment in '3' scale. The process is similar to the Indirect Survey attainment calculation in the case of Course Outcome Indirect Survey. Consolidated Indirect PO Attainment will be the Arithmetic Average of all the survey reports mentioned above.

CALCULATION OF OVERALL PO ATTAINMENT

Final Consolidated Program Outcome Attainment will be Weighted Sum of Consolidated Direct Attainment and Consolidated Indirect Attainment of individual Program Outcome. The weightages for Direct and Indirect components are 80% and 20% respectively.

OVERALL PO ATTAINMENT

= 80 % of Direct PO Attainment + 20% Indirect PO Attainment

In the example discussed above, for PO1, Direct Attainment is 1.933 and Indirect Attainment is 0.793.

Now, OVERALL PO ATTAINMENT = 0.8* 1.933 + 0.2 * 0.793 =1.705.

In the same way, Final PO/PSO Attainment values will be calculated for all other Program Outcomes.

The entire process of PO/PSO attainment process is shown in Fig. 2.5(a)

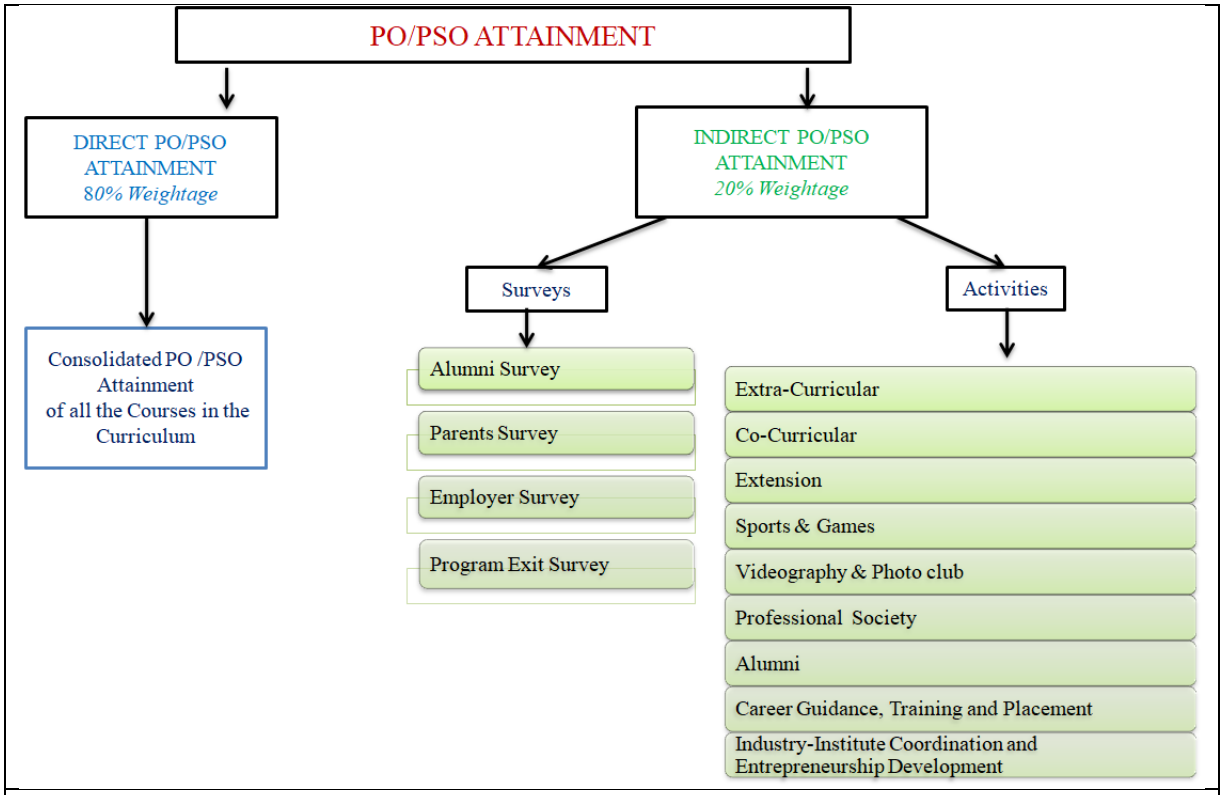


Fig. 2.5(a)

BRIDGING THE CO ATTAINMENT GAP

In the Outcome Based Education, it is mandatory to upgrade or modify the Teaching-Learning Process (TLP) from time to time according to the Course Outcome Attainment. Starting from Definition of Course outcome to Attainment of Course outcome, Teaching Learning process includes many stages. Initially Course instructor will set a target or threshold percentage i.e., 1.8 in present case.

- After the valuation process is completed, a consolidated statement is prepared comparing the Threshold CO attainment and Actual CO Attainment. The difference between Threshold CO attainment and Actual CO Attainment will be called as 'Attainment Gap'.
- If the 'Attainment Gap' is positive, it indicates that the Teaching Learning Process (TLP) being followed for that Course is resulting well in improving the skills of the learners as desired in the definition of Course outcome. In this case, target value or threshold value of CO attainment can be improved.
- For the analysis purpose, it is recommended to continue the same target to compare two academic batch students.
- If the 'Attainment Gap' is negative, it indicates that the Teaching Learning Process (TLP) needs some corrections or modifications which will be suggested primarily by the Course Instructor who dealt that Course recently.
- Whether the attainment gap is positive or negative, the instructor has to identify the component of TLP which corresponds to that gap either positive or negative. This should be posted in the column 'Observations'.
- As a part of improvement in TLP, Course Instructor being fully aware of the Present Instruction process, Paper setting process and Paper valuation process, has to recommend or suggest the Action proposed to bridge the gap. After the results are announced, Course instructors have to

get the data and analyse it for Course Outcome Gaps. Instructor has to find the gaps in the Teaching learning process of his course. The gaps in the TLP are to be filled by taking remedial action for the next batch of students for the same course. The 'action proposed to bridge the gap' needs to be dynamic in filling the earlier CO Gaps. The proposed changes in TLP should be posted in the column 'improvements'.

- The suggestions of the present Course Instructor to bridge the gap between Threshold CO Attainment and Actual CO Attainment are to be carried to the Course Instructor(s) who are going to deal with that Course in the next semester(s) by the Department OBE coordinator or HOD of the Department.
- Based on the earlier suggestions to improve the TLP, next level Course Instructors will decide the modifications in their TLP so that CO attainment gap can be reduced or made positive.

BRIDGING THE PO/PSO ATTAINMENT GAP

Similar to the Attainment Gap in the case of Course Outcome, Program Outcome Gap will also be calculated and remedial action needs to be initialized. Final PO /PSO Outcome Attainment is to be compared with the Mapping Strength of the CO-PO-PSO to find the PROGRAM OUTCOME GAP. Program Outcome Gap enables us to find solutions to fill the gap through academic activities.

In the earlier section discussed, for PO1, Final Attainment value is 1.819 whereas Mapping strength is 2.00.

Now the PO gap for PO1 will be 2.00 – 1.819 = 0.181

Similarly, PO attainment gaps will be calculated for all the other program outcomes.

ANNEXURE I: OBE COMPONENTS

After implementing all the processes discussed in the earlier section, the output of the processes will be evolved as follows.

VISION –MISSION OF THE INSTITUTE AND DEPARTMENTS

The vision and mission of the College and various departments are presented as below.

VISION AND MISSION OF THE INSTITUTE

VISION

To emerge as a premier institute for quality technical education and innovation.

MISSION

M1: Provide learner centric technical education towards academic excellence.
M2: Train on technology through collaborations
M3: Promote innovative research & development.
M4: Involve industry institute interaction for societal needs.

DEPARTMENT OF CIVIL ENGINEERING

VISION

To be a recognized center in Civil Engineering with values and innovation.

MISSION

M1: Practice learner-centric quality teaching-learning process abreast with changing industry needs and societal challenges
M2: Provide Quality infrastructure towards academics, research, and innovation
M3: Establish effective industry and institutional collaboration.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION

To excel in electrical education, research and technology in tune with societal needs.

MISSION

M1: Impart quality education and entrepreneur skills.
M2: Provide cutting edge technologies for research and sustainability in collaboration with industry.
M3: Nurture Professional ethics and lifelong learning in tune with societal needs.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To be a preferred knowledge hub in Mechanical Engineering towards critical thinking, quality research and innovation.

MISSION

M1: Provide infrastructure for design and development of modern-day solutions.

M2: Impart leadership & interpersonal skills towards critical thinking and innovation.

M3: Collaborate with industry, academia, & R&D organizations for excellence in teaching, research, and consultancy services.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

VISION

To become a center of excellence in the field of Electronics and Communication Engineering with technological capability, professional commitment and social responsibility.

MISSION

M1: Provide quality education, well-equipped laboratory facilities and industry collaboration.

M2: Promote cutting edge technologies to serve the needs of the society and industry through innovative research.

M3: Inculcate professional ethics and personality development skills.

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

VISION

To emerge as a competent Centre of excellence in the field of Computer Science and Engineering for the industry and societal needs.

MISSION

M1: Impart quality and value-based education.

M2: Inculcate the interpersonal skills and professional ethics.

M3: Enable research through state-of-the-art infrastructure.

M4: Collaborate with industries, government, and professional societies.

DEPARTMENT OF INFORMATION TECHNOLOGY

VISION

To emerge as a premier department with quality of education, technical competency and innovations.

MISSION

M1: Provide an academic environment with quality infrastructure for solving real world problems and work in multi-disciplinary teams.

M2: Impart value-based education in innovative research and leadership aspects.

M3: Collaborate with the industry and academia towards addressing the evolving changes in Information Technology and related areas.

DEPARTMENT OF PETROLEUM TECHNOLOGY

VISION

To attain recognition in research and equip students for meeting the challenging needs of petroleum, allied industries and society.

MISSION

M1: To provide excellent instruction and design experience essential for Petroleum Engineers.
M2: To develop research that communicates, and applies new knowledge for the betterment of society.
M3: To assist the public in addressing issues concerning the use of resources, protection of the environment, through service and leadership.

DEPARTMENT OF MINING ENGINEERING

VISION

To prepare the graduates in the major fields of mining engineering at par with international standards.

MISSION

M1: By upgrading mining engineering education through training of faculties regularly.
M2: By providing state of the art laboratory facilities & constantly updating it.
M3: By exposing the real time technologies practiced in mining industries.

DEPARTMENT OF AGRICULTURAL ENGINEERING

VISION

To make the Agricultural Engineering education known for its contribution to agriculture and allied fields in making agriculture more sustainable and profitable.

MISSION

M1: Implementation of new technologies for the farmers on sustainable food production through precision agriculture and mechanized food processing.
M2: Educating the students to integrate knowledge of agricultural engineering fundamentals and design of systems involved in food production, processing, storage, handling, distribution, and use of food.
M3: Developing the good atmosphere/ foundation between the students and faculty to perform and lead engineering projects and make significant contributions for the benefit farming community.

DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

VISION

To achieve excellence in the field of AIML and nurture the professionals, to build sustainable and intellectual solutions with natural intelligence that meets the beneficiary of industry and society.

MISSION

M1: Impact the knowledge through states-of-the-art concepts, tools and techniques in Artificial Intelligence and Machine Learning.
M2: To promote technical competence in AIML graduates that satisfies the needs of the industry and societal challenges.
M3: Inculcate ethical and environmental consciousness, leadership qualities and life-long learning that ensures the holistic development of students.
M4: Establish centers of excellence in leading areas of computing with Artificial Intelligence and Machine Learning

PROGRAM OUTCOMES (PO's)

The 12 Program Outcomes are described as below.

After successful completion of the program, the graduates will be able to

PO1 **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

PO3 **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

PO4 **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

PO5 **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

PO6 **The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and

the consequent responsibilities relevant to the professional engineering practice

PO7 **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

PO8 **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

PO9 **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

PO10 **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

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

PROGRAM SPECIFIC OUTCOMES (PSO's)

The Program Specific Outcomes of all the departments are presented as below.

Department of Civil Engineering

PSO 1 Capable of planning, designing, and constructing sustainable structures based on functional requirements.

PSO 2 Apply standard practices in identifying quality of material for sturdy construction

Department of Electrical Engineering

PSO 1 Provide effective solutions in the fields of Power Electronics and Power Systems using modern computational tools.

PSO 2 Apply knowledge to solve industrial and societal needs using innovation and development in electrical engineering.

Department of Mechanical Engineering

PSO 1 Apply techniques in design, analysis, and fabrication of high end automotive solutions

PSO 2 Demonstrate essential skills to analyze the thermal, fluid systems and processes

Department of Electronics and Communication Engineering

PSO 1 Provide sustainable solutions in the field of Communication and Signal Processing.

PSO 2 Apply current technologies in the field of VLSI and embedded systems for professional growth.

Department of Computer Science and Engineering

PSO 1	Develop efficient solutions to real world problems using the domains of Algorithms, Networks, database management and latest programming tools and techniques.
PSO 2	Provide data centric business solutions through emerging areas like IoT, AI , data analytics and Block Chain technologies.

Department of Information Technology

PSO 1	Develop IT Solutions to mitigate business challenges using AIML and IOT technologies.
PSO 2	Learn and employ future technologies in research application

Department of Petroleum Technology

PSO 1	Develop IT solutions to mitigate business challenges using AIML and IOT technologies.
PSO 2	Use acquired foundational skills and knowledge to learn future technologies and employ them in research applications.

Department of Mining Engineering

PSO 1	Identify, formulate, and solve Mining & Mineral engineering problems.
PSO 2	Use the techniques, skills, and modern engineering tools, like mine planning and blast optimization software necessary for Mining engineering practice.
PSO 3	Pursue broad education necessary to understand the impact of Mining engineering solutions in a global and societal context.

Department of Agricultural Engineering

PSO 1	Develop skills necessary to design the process and evaluate and come out with problem solutions of farm implements through adequate farm power for sustainable agriculture and to gain better employment in various industries of agricultural engineering.
PSO 2	Develop expertise in planning and management of natural resources through advanced soil and water conservation techniques and various irrigation and drainage methods with the skill of data interpretation.
PSO 3	Contribute towards enhancing farmer income & play a dynamic role in the circular economy through technology intervention in promoting sustainable food supply chain & processing of agro-food produce.

Department of Artificial Intelligence and Machine Learning

PSO 1	Apply the core concepts of computational and optimized algorithms to produce efficient and effective solutions.
PSO 2	Apply the technical and research capability skills in AIML using innovative tools and techniques to provide solutions in the areas of engineering, industry and society to become successful graduate/entrepreneur.

PROGRAM EDUCATIONAL OBJECTIVES (PEO's)

Department of Civil Engineering

PEO 1 Apply technical knowledge to excel in the industry and higher education
PEO 2 Analyze, design, and build safe, sustainable and economical structures
PEO 3 Exhibit good leadership qualities in a multidisciplinary environment to meet societal needs

Department of Electrical Engineering

PEO 1 Create multidisciplinary project works in teams.
PEO 2 Design and develop innovative products and services in the field of Electrical and Electronics engineering.
PEO 3 Engage in lifelong learning, career enhancement and adapt to changing professional and societal needs.

Department of Mechanical Engineering

PEO 1 Model and analyze complex engineering systems
PEO 2 Use professional Knowledge to solve real-time engineering challenges for societal development
PEO 3 Demonstrate interpersonal skills in the chosen area of profession for lifelong learning

Department of Electronics and Communication Engineering

PEO 1 Adapt the learning culture needed for a successful professional career and pursue research.
PEO 2 Build modern electronic systems by considering technical, environmental, and social contexts.
PEO 3 Communicate effectively and demonstrate leadership qualities with professional ethics.

Department of Computer Science and Engineering

PEO 1 Adopt new technologies and provide innovative solutions.
PEO 2 Be employable, become an entrepreneur or researcher for a successful career.
PEO 3 Demonstrate interpersonal, multi-disciplinary skills and professional ethics to serve society.

Department of Information Technology

PEO 1 Develop solutions for real world problems and adapt to the ever-evolving challenges in Information Technology (IT) and related inter disciplinary areas.
PEO 2 Communicate effectively with multi-disciplinary teams to develop quality computing systems with an orientation towards research and development for lifelong learning
PEO 3 Use emerging technologies in ethical & professional manner to fulfil industrial and societal needs.

Department of Petroleum Technology

PEO 1 Be successful in diverse career paths of the petroleum and allied industries.
PEO 2 Enhance problem-solving skills that involve designing and interpretation of data
PEO 3 Continue professional development and lifelong learning

Department of Mining Engineering

PEO 1 Advanceintheircareers,adaptingtonewsituationsandemergingproblems, in a variety of professional roles such as mine planner, designer, production manager, mineral processing engineer, consultant, technical support representative and regulatory specialist.
PEO 2 Pursue advanced degrees in mineral-related fields.

PEO 3 Display professional skills such as effective communication, teamwork, and leadership.

PEO 4 Play critical role as a mining engineer in society with respect to health, safety, and the environment in tangible ways such as achieving professional licensure.

Department of Agricultural Engineering

PEO 1 Develop diverse capability to work with tractor industries, seed processing industries, irrigation companies and also to run self-entrepreneurship like dairy farming and custom hiring centers.

PEO 2 Solve real time engineering problems using professional knowledge and skills resulting in significant societal development.

PEO 3 Demonstrate multidisciplinary skills to analyze engineering issues in a broader perspective with ethical responsibility towards sustainable development.

Department of Artificial Intelligence and Machine Learning

PEO 1 Apply core concepts, software engineering and AIML principles to solve complex computing problems and produce optimized solutions.

PEO 2 Pursue higher education and research activities through innovative ideas and latest technology-driven projects in the domain of AIML.

PEO 3 Work in a collaborative environment and also lead the team by understanding the ethical, societal, and financial impact of their work.

ANNEXURE II : COURSE OUTCOMES ATTAINMENT-EXAMPLE

CALCULATION OF CO ATTAINMENT FOR A THEORY COURSE

The sample data and calculations for a Descriptive Examination, Objective and Assignment is given below in Fig.3.1, Fig. 3.2, Fig. 3.3 and Fig. 3.4.

ADITYA ENGINEERING COLLEGE(A)								
SESSIONAL -1 DATA								
ACADEMIC YEAR				**SEMESTER**				
BRANCH				**REGULATION**				
COURSE NAME				**COURSE CODE**				
DATE OF THE EXAMINATION				**SESSIONAL**				
COURSE INSTRUCTOR								
	Descriptive-I						**Assignment-I**	**Objective-I**
	Q1		**Q2**		**Q3**			
	A	**B**	**A**	**B**	**A**	**B**		
Max.Marks	**3**	**2**	**3**	**2**	**3**	**2**	**5**	**10**
COURSE OUTCOME	**CO1**	**CO1**	**CO2**	**CO2**	**CO3**	**CO3**	**ALL**	**ALL**
Student 1	2	0	3	1	3	2	5	4
Student 2	3	1	3	2	2	2	5	6
Student 3	3	2	2	1	0	2	5	7
Student 4	3	2	2	2	1	2	2	7
Student 5	3	2	3	2	1	2	3	6
Student 6	3	2	2	2	2	1	3	7
Student 7	2	2	3	0	3	2	4	7
Student 8	1	1	3	2	3	1	2	7
Student 9	3	1	2	2	3	2	5	8
Student 10	1	1	3	2	3	0	5	7

Fig. 3.1: Sessional-1 Data for a Course

MARKS SATISFYING TARGET PERCENTAGE	**2**	**1**	**2**	**1**	**2**	**1**	**3**	**6**
NO. OF STUDENTS ≥TARGET PERCENTAGE	**8**	**5**	**10**	**7**	**7**	**7**	**8**	**9**
COURSE OUTCOME	**CO2**	**CO2**	**CO3**	**CO3**	**CO1**	**CO1**	**ALL**	**ALL**
CO ATTAINMENT %	**80%**	**50%**	**100%**	**70%**	**70%**	**70%**	**80%**	**90%**
ATTAINMENT LEVELS RESULTS	**CO1**	**CO1**	**CO2**	**CO2**	**CO3**	**CO3**	**ALL**	**ALL**
CO ATTAINMENT LEVEL	**3**	**1**	**3**	**2**	**2**	**2**	**3**	**3**

Fig. 3.2: Sessional-I CO Attainment Calculations

The various steps involved in CO Attainment Calculation for one question are as follows.

- Question 1 (a)is given for 3 marks and associated with CO1.
- As the threshold percentage is set as 1.8 i.e., 60%, for this question, the marks satisfying threshold percentage will be 60% of 3 i.e., 1.8 rounded 2.
- Now, the number of students who got 2 or above marks for the Question No. 1(a) is 8 out of 10, who attempted CO1.
- The CO Attainment for the CO1 through Question No. 1a will be 8/10 i.e., 80% From the levels associated with CO attainment as mentioned earlier, 80% attainment for CO1 results the level 3.
- In the same way, all other CO attainment levels are calculated.
- In the case of Objective Test and Assignment, it is followed to link all the Course outcomes in the particular Sessional Examination to have equal linkage with total marks of Objective test and Assignment Test i.e., Objective Test is for 10 marks and Assignment is for 6 marks. The threshold is same for both Objective Test and Assignment i.e., 60%. As the CO1,CO2 and CO3 are part of Sessional-1, these two will have equal weightage in the CO Attainment Calculation.
- In the specimen sheet above shown, the number of students who got more than 3 marks (60% of 5) for Assignment test is 8 out of 10 which results 80% which results attainment level ‘3’. This attainment level ‘3’ is attached to Course outcomes CO1, CO2 and CO3 which are part of Sessional-1.
- Similarly, the CO attainment calculation for Objective test also. The number of students who got more than 6 marks(60% of 10) for Objective Test is 9 out of 10 which results 90% i.e., attainment level ‘3’.

- If any Course outcome is contributing to more questions or question sections, the final attainment of that CO will be the average of all the attainment values which will be the Net attainment value of that CO from Descriptive Test.
- The FINAL ATTAINMENT VALUE for a Course Outcome is calculated as Average of Descriptive Test, Assignment and Objective Test.

CO attainment values through Sessional-I examinations are shown in Fig. 3.3.

CO Attainment values from Sessional-I Examinations

ANALYSIS OF ATTAINMENTS	CO1	CO1	CO2	CO2	CO3	CO3	FINAL ATTAINMENT VALUE(average of all individual CO's and combined Assignment &Objective)
CO1	3	1					2.67
CO2			3	2			2.83
CO3					2	2	2.67
CO4							0.00
CO5							0.00
CO6							0.00

Fig. 3.3: CO Attainment values for Sessional-I

In the same process, CO attainment values in Sessional-II examination also found, shown in Fig. 3.4

CO Attainment values from Sessional –II Examinations

ANALYSIS OF ATTAINMENTS	CO3	CO4	CO4	CO5	CO6	CO6	FINAL ATTAINMENT VALUE (average of all individual CO's and combined Assignment &Objective)
CO1							0.00
CO2							0.00
CO3	2						2.67
CO4		3	3				3.00
CO5				3			3.00
CO6					3	3	3.00

Fig. 3.4: CO Attainment values for Sessional-II

The Final attainment calculations of CO1, CO2, CO3, CO4 and CO5 from Sessional examinations are shown in Table 3.1.

Table 3.1: CO ATTAINMENT FROM SESSIONALS

CO	CO1	CO2	CO3	CO4	CO5	CO6
Attainment Value	2.67	2.83	2.67	3.00	3.00	3.00

INDIRECT ASSESSMENT OF COURSE OUTCOME

Based on the number of responses for each level, Weighted Average will be calculated for the Scale of 5. Next, this value obtained is converted to '3' scale, as we will have to analyze all the attainments in the scale of 3 only. The specimen for an indirect survey report is shown in Fig. 3.5

ADITYA ENGINEERING COLLEGE(A)								
INDIRECT CO ATTAINMENT(SURVEY)								
ACADEMIC YEAR		**SEMESTER**						
BRANCH		**REGULATION**						
COURSE		**COURSE CODE**						
COURSE INSTRUCTOR								
	COURSE OUTCOMES	**Strongly Agree (5)**	**Agree (4)**	**Neither Agree nor Disagree (Neutral) (3)**	**Disagree (2)**	**Strongly Disagree (1)**	**Weighted Average (5)**	**CO ATTAINED THROUGH SURVEY**
CO1	CO1 statement	4	3	2	1	0	4.00	2.40
CO2	CO2 statement	5	3	2	0	0	4.30	2.58
CO3	CO3 statement	4	4	1	1	0	4.10	2.46
CO4	CO4 statement	4	4	1	1	0	4.10	2.46
CO5	CO5 statement	5	3	1	1	0	4.20	2.52
CO6	CO6 statement	4	3	3	0	0	4.10	2.46

Fig. 3.5: CO attainment- Indirect

Sample Calculation:

- In the Fig. 3, for CO1, Number of responses for different levels Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree are 4,3,2,1 and 0 respectively.
- The Weighted Average will be [5*4 + 4*3 + 3*2 + 5*1+ 1*0]/ [4+3+2+1+0] = 4.00
- The Weighted Average 4.00, when converted to '3' scale becomes 2.4.
- Similarly, other CO's CO2, CO3, CO4 ,CO5 and CO6 will have Attainments as 2.58, 2.46, 2.46, 2.52 and 2.46 respectively.

CO ATTAINMENT CALCULATION FOR SEMESTER END EXAMINATION

All the data received from Examination cell will be entered in the Excel form as shown in the Specimen (Fig. 3.6)

- The CO attainment calculation process for a Course Outcome from the Semester End Examination is like the calculation process from the Sessional Examination.
- The fixation of Threshold percentage to be attained, calculation of number of students who got more than threshold percentage, calculation of attainment by dividing the earlier number with number of students who attempted that particular Course Outcome etc. will be the same as they are in Sessional Examination Excel Tab.

ADITYA ENGINEERING COLLEGE(A)

SEMESTER END EXAM

BRANCH											**REGULATION**									
COURSE NAME											**COURSE CODE**									
COURSE INSTRUCTOR																				
	Q1		**Q2**		**Q3**		**Q4**		**Q5**		**Q6**		**Q7**		**Q8**		**Q9**		**Q10**	
	A	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
Max.Marks	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**
COURSE OUTCOME==> *Script Reference Number*	**CO1**	**CO1**	**CO2**	**CO1**	**CO3**	**CO2**	**CO5**	**CO2**	**CO1**	**CO5**	**CO6**	**CO5**	**CO1**	**CO4**	**CO1**	**CO3**	**CO3**	**CO4**	**CO5**	**CO6**
Student 1			5	7	6	6					4	2	4	2			5	4		
Student 2	6	6			4	5			5		7	6	6	5	4	7	7	6		
Student 3	3	3		5	4				5		6	4	5	3				6		
Student 4	6		5	5	6				4				6	5						
Student 5	6		7	6	6	5			4	2			5	5					4	6
Student 6	6	6	5	6	4		6	6			4	2	6	3					2	7
Student 7			7	6			7	5	7	6			6	6	5				3	5
Student 8	2	1	5	6	5				2	6			6	5					2	6
Student 9	5		2	6				5	2			6	1	5	2	0			5	5
Student 10			5	6							7	6	7	6	6	5		6	6	6

Fig. 3.6: CO Attainment – Semester End Examination

- In the Fig. 3.6, CO1 contributes for 6 question parts, CO2 contributes for 3 question parts, CO3 contributes for 3 parts, CO4 contributes for 2 parts, CO5 contributes for 4 parts and CO6 contributes for 2 parts.

- The final Course Outcome calculation for CO1 to CO6 will be the average of all the CO attainment values from the Individual Question parts, like the process in the Sessional Examination.

The specimen calculation is shown in Fig 3.7 below.

ANALYSIS OF ATTAINMENT	CO 1	CO 1	CO 2	CO 1	CO 3	CO 2	CO 5	CO 2	CO 1	CO 5	CO 6	CO 5	CO 1	CO 4	CO 1	CO 3	CO 3	CO 4	CO 5	CO 6	FINAL ATTAINMENT VALUE
CO1	2	1		3					1				3		1						1.83
CO2			3			3		3													3.00
CO3					1											2	3				2.00
CO4														2				2			2.00
CO5							3			2		1							1		1.75
CO6											2									3	2.50

Fig. 3.7: CO attainment (SEE) Calculation and Results

- From the above calculation data in Fig. 3.7, Final Attainment values of CO1 to CO5 are as under.
  CO1: Average of 2,1,3,1,3 and 1 = 1.83
  CO2: Average of 3,3 and 3 = 3.00
  CO3: Average of 1,2 and 3 = 2.00
  CO4: Average of 2 and 2 = 2.00
  CO5: Average of 3,2,2 and 1 = 1.75
  CO6: Average of 2 and 3 =2.50

CONSOLIDATED COURSE OUTCOME ATTAINMENT CALCULATION

The calculations of various components of CO Attainment will be as under:

Sessional CO Attainment

= Maximum (CO Attainment in Sessional 1, CO Attainment in Sessional 2)

(If a particular CO appears either of Sessional 1 or Sessional 2)

= Average(CO Attainment in Sessional 1, CO Attainment in Sessional 2)

(If a particular CO appears in both Sessional 1 and Sessional 2)

Direct CO Attainment = 30% (Sessional Examinations) + 70% (Semester End Examination)

Total CO Attainment = 80% (Direct CO Attainment) + 20% (Indirect CO Attainment)

Sample calculation for a course is shown as specimen below.

ADITYA ENGINEERING COLLEGE(A)

COURSE OUTCOME(CO) ATTAINMENT

ACADEMIC YEAR		**SEMESTER**	
BRANCH		**REGULATION**	
COURSE		**COURSE CODE**	
COURSE INSTRUCTOR			

ANALYSIS OF ATTAINMENTS	**S1**	**S2**	**CO ATTAINMENT Sessionals**	**CO ATTAINMENT Semester End Exams**	**DIRECT CO ATTAINMENT**	**INDIRECT CO ATTAINMENT**	**FINAL CO ATTAINMENT**
CO1	2.67	0.00	2.67	1.83	2.08	2.40	2.15
CO2	2.83	0.00	2.83	3.00	2.95	2.58	2.88
CO3	2.67	2.67	2.67	2.00	2.20	2.46	2.25
CO4	0.00	3.00	3.00	2.00	2.30	2.46	2.33
CO5	0.00	3.00	3.00	1.75	2.13	2.52	2.20
CO6	0.00	3.00	3.00	2.50	2.65	2.46	2.61
					Course CO attainment		2.36

Fig. 3.8: Total CO Attainment

Course CO attainment will be the average of CO attainments of all the Course outcomes i.e., 2.36 in the above example.

CALCULATION OF DIRECT CO ATTAINMENT FOR A LABORATORY COURSE

According to the academic guidelines for a laboratory course, various assessment tools are practised to get the assessment data about the learners. The various assessment tools are

1. Day to day evaluation
2. Observation and record
3. Internal laboratory test
4. Semester End Examination

For evaluation, instructor has to follow individual assessment rubrics for each division.

Sample input data and calculations about day-to-day evaluation, observation and record, internal test are presented in Fig.3.1(b).

ADITYA ENGINEERING COLLEGE(A)

DIRECT CO ATTAINMENT

ACADEMIC YEAR		**SEMESTER**	
BRANCH		**REGULATION**	
COURSE NAME		**COURSE CODE**	
COURSE INSTRUCTOR			

	LABORATORY EXPERIMENTS DAY-TO-DAY PERFORMANCE										**CONTINUOUS EVALUATION**	**OBSERVATION & RECORD**	**INTERNAL TEST**	**SESSIONAL MARKS**	**SEMESTER END EXAM**
EXPERIMENT NO.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**					
Max. Marks	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**30**	**70**
CO	**CO1**	**CO2**	**CO2**	**CO3**	**CO4**	**CO4**	**CO5**	**CO5**	**CO5**	**CO6**		**all CO's**	**all CO's**	**all CO's**	**all CO's**
Student 1	8	8	8	8	8	8	8	8	8	7	8	8	7	23	57
Student 2	8	8	8	8	8	8	8	8	8	8	8	8	8	24	60
Student 3	9	9	9	9	9	9	9	9	9	9	9	9	9	27	63
Student 4	8	8	8	8	8	8	8	8	8	8	8	10	6	28	63
Student 5	8	8	8	8	8	8	8	8	8	8	8	10	6	28	48
Student 6	9	9	9	9	9	9	9	9	9	9	9	9	9	27	63
Student 7	8	8	8	8	8	8	8	8	8	8	8	8	9	25	66
Student 8	7	7	7	7	7	7	7	7	7	7	7	10	9	26	59
Student 9	10	10	10	10	10	10	10	10	10	10	10	10	9	29	63
Student 10	8	8	8	8	8	8	8	8	8	8	8	10	8	26	65

CO TARGET %	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**		**70**	**70**		**70**
MARKS SATISFYING TARGET	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**		**7.00**	**7.00**		**49.00**
NO. OF STUDENTS ≥TARGET	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**		**10**	**8**		**9**
COURSE OUTCOME	**CO1**	**CO2**	**CO2**	**CO3**	**CO4**	**CO4**	**CO5**	**CO5**	**CO5**	**CO6**		**all CO's**	**all CO's**		**all CO's**
CO ATTAINMENT	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**		**100 %**	**80%**		**90%**
CO ATTAINMENT	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**		**3**	**2**		**3**

ANALYSIS OF ATTAINMENTS											**Continuous Evaluation**	**Record**	**Internal Test**	**External**	**TOTAL CO ATTAINMENT**
CO1	3										3	3	2.00	3.00	**2.90**
CO2		3	3								3	3	2.00	3.00	**2.90**
CO3				3							3	3	2.00	3.00	**2.90**
CO4					3	3					3	3	2.00	3.00	**2.90**
CO5							3	3	3		3	3	2.00	3.00	**2.90**
CO6										3	3	3	2.00	3.00	**2.90**

Fig. 3.1(b): Sessional Data for a Laboratory Course

The various steps involved in CO Attainment Calculation for one laboratory experiment are as follows.

- Experiment is given for 10 marks and associated with CO1.
- As the threshold percentage is set as 2.1 i.e., 70%, for this experiment, the marks satisfying threshold percentage will be 70% of 10 i.e. 7 .
- Now, the number of students who got 7 or above marks for the Experiment No. 1 is 10out of 10, who attempted CO1.
- The CO Attainment for the CO1 through Experiment No. 1 will be 10/10 i.e., 100%
- From the levels associated with CO attainment as mentioned earlier, 100% attainment for CO1 results the level 3.
- In the same way, for all other experiments, CO attainment levels are calculated.
- In the case of Observation & record, separate rubrics are followed to award marks for each learner. Sample marks are shown in the table.
- In the specimen sheet above shown, the number of students who got more than 70% marks for Observation & Record are 10 out 10 which results 100% which is *more than 80%* which results attainment level '3'. This attainment level '3' is attached to all the Course outcomes CO1 to CO6.
- In the similar way, Course outcome attainment for Internal test is also attached to all the Course outcomes CO1 to CO6.
- From the Semester End Examination marks awarded, CO attainment is calculated for threshold percentage of 70%. The CO Attainment obtained is equally attached to all the Course outcomes i.e., CO1 to CO6. This corresponds to 70% in direct attainment calculation.
- The Sessional component of Direct CO Attainment is calculated as a Weighted Average of Day-to-day performance average(10), Observation & Record(10) and Internal Test (10). This contributes to 30% in direct attainment calculation.
- The direct attainment is calculated as summation of 30% of Sessional attainment and 70% of Sessional End Examination.
- Direct CO Attainment = 0.3*(
  Average of Day-to-day performance *(10/30)
  +(Observation & record*(10/30)
  + Internal Test*(10/30)
)

  +0.7 * Semester End Examination

INDIRECT ASSESSMENT OF COURSE OUTCOME

Based on the number of responses for each level, Weighted Average will be calculated for the Scale of 5. Next, this value obtained is converted to '3' scale, as we will have to analyze all the attainments in the scale of 3 only. The specimen for an indirect survey report is shown in Fig. 3.2(b)

ADITYA ENGINEERING COLLEGE(A)								
INDIRECT CO ATTAINMENT(SURVEY)								
ACADEMIC YEAR		**SEMESTER**						
BRANCH		**REGULATION**						
COURSE		**COURSE CODE**						
COURSE INSTRUCTOR	0							
	COURSE OUTCOMES	**Strongly Agree (5)**	**Agree (4)**	**Neither Agree nor Disagree (Neutral) (3)**	**Disagree (2)**	**Strongly Disagree (1)**	**Weighted Average (5)**	**CO ATTAINED THROUGH SURVEY**
CO1	CO1 statement	4	3	2	1	0	4.00	2.40
CO2	CO2 statement	5	4	1	0	0	4.40	2.64
CO3	CO3 statement	3	3	3	1	0	3.80	2.28
CO4	CO4 statement	4	1	1	2	2	3.30	1.98
CO5	CO5 statement	5	5	0	0	0	4.50	2.70
CO6	CO6 statement	5	3	2	0	0	4.30	2.58

Fig. 3.2(b): CO attainment- Indirect

Sample Calculation:

- In the Fig. 3.2(b), for CO1, Number of responses for different levels Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree are 4,3,2,1 and 0 respectively.
- The Weighted Average will be [5*4 + 4*3 + 3*2 + 2*1+ 1*0]/ [4+3+2+1+0] = 4.00
- The Weighted Average 4.43, when converted to '3' scale becomes 2.40.
- Similarly, other CO's CO2, CO3, CO4, CO5 and CO6 will have Attainments as 2.64, 2.28, 1.98, 2.70 and 2.58respectively.

CONSOLIDATED COURSE OUTCOME ATTAINMENT CALCULATION

The calculations of various components of CO Attainment will be as under:

Direct CO Attainment = 30% (Sessional Examinations) + 70% (Semester End Examination)

Total CO Attainment = 80% (Direct CO Attainment) + 20% (Indirect CO Attainment)

For the above sample data, Total CO Attainment is calculated as shown in Fig. 3.3(b)

.

CO	CO ATTAINMENT = 80% (Direct Attainment)+ 20% (Indirect attainment)
CO1	2.80
CO2	2.85
CO3	2.78
CO4	2.72
CO5	2.84
CO6	2.32

Fig. 3.3(b): Total CO Attainment

BRIDGING THE CO ATTAINMENT GAP

The specimen for CO attainment gap analysis is shown in Fig. 3.9.

ADITYA ENGINEERING COLLEGE(A)					
BRIDGING THE ATTAINMENT GAP					
ACADEMIC YEAR			**SEMESTER**		
BRANCH			**REGULATION**		
COURSE			**COURSE CODE**		
COURSE INSTRUCTOR					
ANALYSIS OF ATTAINMENTS	**CO TARGET**	**CO ATTAINMENT= 80% (Direct Attainment)+ 20% (Indirect Attainment)**	**CO ATTAINMENT GAP (Attainment-Target)**	**Observation**	**Improvements**
CO1	2.10	2.80	**0.70**		
CO2	2.10	2.85	**0.75**		
CO3	2.10	2.78	**0.68**		
CO4	2.10	2.72	**0.62**		
CO5	2.10	2.84	**0.74**		
CO6	2.10	2.32	**0.22**		
Signature of the Course Instructor					
Name & Signature of Course Coordinator					
Name & Signature of HOD					

Fig. 3.9 : CO Attainment – Gap Analysis

ANNEXURE III: PO/PSO ATTAINMENT –EXAMPLE

CALCULATION OF PO/PSO ATTAINMENT

Program Outcomes (POs) and Program Specific Outcomes(PSOs) attainment is to be extracted from Course Outcome attainment through CO-PO matrix. Initially mapping strength is calculated from CO-PO matrix and it is taken as target for that PO in that particular course.

MAPPING STRENGTH :

A sample CO-PO-PSO articulation matrix is shown in Table 3.2.

Table 3.2: CO-PO-PSO ARTICULATION MATRIX

COURSE OUTCOME	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3						1	1	2	1	2	
CO2	3	1		2					1	1	1	1		2
CO3	3	1			3				1	1	1	1	3	
CO4	3	2				2			1	1	1	1		3
CO5	3	2					1	2	1	1	1	1	2	3
CO6	3	2							1	1	1	1		1
MAPPING STRENGTH	**3.00**	**1.67**	**3.00**	**2.00**	**3.00**	**2.00**	**1.00**	**2.00**	**1.00**	**1.00**	**1.17**	**1.00**	**2.33**	**2.25**

DIRECT PO/PSO ATTAINMENT FOR A LEARNING BATCH CALCULATION

A sample PO/PSO Attainment is shown as Table 3.3 below.

Table 3.3: PO/PSO Attainment Calculation

CO	CO ATTAINMENT	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	**2.80**	**3**	**2**	**3**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**2**	**1**	**2**	**0**
CO2	**2.85**	**3**	**1**	**0**	**2**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**0**	**2**
CO3	**2.78**	**3**	**1**	**0**	**0**	**3**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**3**	**0**
CO4	**2.72**	**3**	**2**	**0**	**0**	**0**	**2**	**0**	**0**	**1**	**1**	**1**	**1**	**0**	**3**
CO5	**2.84**	**3**	**2**	**0**	**0**	**0**	**0**	**1**	**2**	**1**	**1**	**1**	**1**	**2**	**3**
CO6	**2.32**	**3**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**0**	**1**
COURSE ATTAINMENT	**2.72**														
MAPPING STRENGTH		**3.00**	**1.67**	**3.00**	**2.00**	**3.00**	**2.00**	**1.00**	**2.00**	**1.00**	**1.00**	**1.17**	**1.00**	**2.33**	**2.25**
DIRECT PO ATTAINMENT		**2.72**	**2.70**	**2.80**	**2.85**	**2.78**	**2.72**	**2.84**	**2.84**	**2.72**	**2.72**	**2.73**	**2.72**	**2.80**	**2.74**

CALCULATION OF INDIRECT PO/PSO ATTAINMENT

Indirect PO attainment calculation will be done through Survey Reports and other activities by taking arithmetic average of all the attainment values for PO1 to PO12 and PSO's.

A sample report is shown in Fig. 3.10.

INDIRECT PO ATTAINMENT -														
SURVEY REPORTS														
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO 1**	**PSO 2**
ALUMNI SURVEY	2.1	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
EMPLOYER SURVEY	3	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
PARENTS' SURVEY	2.6	2.6	2.6	2.6	2.6	2.6	2.8	2.8	2.6	2.8	2.6	2.6	2.6	2.4
PROGRAM EXIT SURVEY	2.61	2.48	2.42	2.48	2.46	2.42	2.44	2.46	2.46	2.52	2.44	2.48	2.52	2.5
OTHER ACTIVIITIES														
ALUMNI COORDINATION COMMITTEE	3					2.5	1		3		1			
CAREER GUIDANCE, TRAINING AND PLACEMENT COMMITTEE	2	2	2	2	2	2.2	2	2.5	2.17	2.2	2.5	2.14		
COMMITTEE FOR CO-CURRICULAR ACTIVITIES									2	2		1.66		
COMMITTEE FOR EXTENSION ACTIVITIES-NSS,LEO,YRCU,ECO						2				3				
COMMITTEE FOR INDUSTRY INSTITUTE COORDINATION AND ENTREPRENEURSHIP DEVELOPMENT	3	2	3	2					2.5		3	3		
PROFESSIONAL SOCIETIES COORDINATION COMMITTEE						3		1	2	2	1.5	1.25		
COMMITTEE FOR EXTRA CURRICULAR ACTIVITIES						2.17			2.07	2.10		1.83		
SPORTS AND GAMES COMMITTEE						2			2.16	2.16	2.66	1		
PHOTOGRAPHY AND VIDEO CLUB						3	1		3					

Fig. 3.10 :Survey Reports& Other activities

COMPLETE PO/PSO ATTAINMENT CALCULATION

The specimen calculation process for final PO/PSO attainment is shown in Fig. 3.11 below.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
DIRECT PO ATTAINMENT (Assessment Reports)	1.94	1.92	1.90	1.94	1.90	1.71	2.02	2.41	2.22	2.14	2.24	1.91	1.85	2.07
INDIRECT PO ATTAINMENT (Survey Reports & Other Activities)	2.62	2.36	2.52	2.36	2.43	2.45	2.05	2.31	2.42	2.39	2.31	2.11	2.56	2.50
FINAL PROGRAM OUTCOME ATTAINMENT (80% of Direct Attainment + 20% of Indirect Attainment)	**2.07**	**2.01**	**2.03**	**2.03**	**2.00**	**1.86**	**2.03**	**2.39**	**2.26**	**2.19**	**2.26**	**1.95**	**1.99**	**2.16**

Fig. 3.11: Overall PO attainment

BRIDGING THE PO/PSO ATTAINMENT GAP

Similar to the academic learning gap in the case of Course Outcome, Program Outcome/ Program Specific Outcome Gap will also be calculated based on the fact that Graduate Attributes Gaps need to be identified and remedial action need to be initialized.

A specimen report of PO/PSO attainment Gap is shown in Fig. 3.12.

DIRECT PO ATTAINMENT (Assessment Reports)	1.94	1.92	1.90	1.94	1.90	1.71	2.02	2.41	2.22	2.14	2.24	1.91	1.85	2.07
INDIRECT PO ATTAINMENT (Survey Reports & Other Activities)	2.62	2.36	2.52	2.36	2.43	2.45	2.05	2.31	2.42	2.39	2.31	2.11	2.56	2.50
OVERALL PO ATTAINMENT (80% of Direct Attainment + 20% of Indirect Attainment)	2.07	2.01	2.03	2.03	2.00	1.86	2.03	2.39	2.26	2.19	2.26	1.95	1.99	2.16
PO MAPPING STRENGTH	2.31	1.78	1.8	1.57	1.86	1.56	1.54	2.33	2.09	2.07	2	1.25	1.65	1.74
PROGRAMME OUTCOME GAP	**0.24**	**-0.23**	**-0.23**	**-0.46**	**-0.14**	**-0.30**	**-0.49**	**-0.06**	**-0.17**	**-0.12**	**-0.26**	**-0.70**	**-0.34**	**-0.42**

Fig. 3.12 :PO/PSO Attainment Gap

***

ANNEXURE IV: QUESTION PAPER ANALYSIS

QUESTION PAPER ANALYSIS-EXAMPLE

H.T.No: | | | | | | | | | | | Course Code:

ADITYA ENGINEERING COLLEGE (A)

OPERATIONS RESEARCH
(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Answer ONE question from each unit
All Questions Carry Equal Marks
All parts of the questions must be answered at one place only

UNIT – I

Q.No		Question	BTL	CO	Marks
1	a	A company manufactures two products, X and Y by using three machines A, B, and C. Machine A has 4 hours of capacity available during the coming week. Similarly, the available capacity of machines B and C during the coming week is 24 hours and 35 hours respectively. One unit of product X requires one hour of Machine A, 3 hours of machine B and 10 hours of machine C. Similarly one unit of product Y requires 1 hour, 8 hour and 7 hours of machine A, B and C respectively. When one unit of X is sold in the market, it yields a profit of Rs. 5/- per product and that of Y is Rs. 7/- per unit. Solve the problem by using graphical method to find the optimal product mix.	L2	CO1	[7]
	b	Explain the linear programming problem. Write the limitations and applications of linear programming problem.	L2	CO1	[7]
		OR			
2		Use two –phase simplex method to solve the following linear programming problem Min z = x+ y Subject to $2x+y \geq 4$ $x+7y \geq 7$ $x, y \geq 0$	L2	CO1	[14]
UNIT – II					
3	a	Solve the transportation problem | | D | E | F | G | Availability | | A | 11 | 13 | 17 | 14 | 250 | | B | 16 | 18 | 14 | 10 | 300 | | C | 21 | 24 | 13 | 10 | 400 | | Requirement | 200 | 225 | 275 | 250 | |	L2	CO2	[7]
	b	Consider the problem of assigning five operators to five machines. The assignment costs are given in following Table:	L2	CO2	[7]

			M1	M2	M3	M4	M5			
			A	7	7	-	4	8			
			B	9	6	4	5	6			
			C	11	5	7	-	5			
			D	9	4	8	9	4			
			E	8	7	9	11	11			
		Operator A cannot be assigned to machine M3 and operator C cannot be assigned to machine M4. Find the optimum assignment schedule								
		OR								
4	a	Find the cost per period of individual replacement policy of an installation of 300 light bulbs, given the following: i) Cost of replacing an individual bulb is Rs.2 ii) Conditional probability of failure is given below:								
			Week No.	0	1	2	3	4			
			Probability of Failure	0	0.1	0.3	0.7	1.0			
		Also calculate the number of light bulbs that would fail during each of the four weeks.								
	b	List out the Replacement situations.								
UNIT – III										
5	a	Explain the factors affecting inventory, and brief about EOQ, ABC, and VED analysis.								
	b	Determine the optimal sequence of jobs that minimizes the total elapsed time based on the following information processing time on machines is given in hours and passing is not allowed:								
			Job	A	B	C	D	E			
			Machine 1	10	12	8	15	16			
			Machine 2	3	2	4	1	5			
			Machine 3	5	6	4	7	3			
			Machine 4	14	7	12	8	10			
		OR								
6	a	The demand for an item is 6000 units per annum and the unit cost is Re.1/-. Inventory carrying charges of 25% of average inventory cost and ordering cost is Rs.11.50 per order. Calculate optimal order quantity, optimal order time, optimal inventory cost and number of orders.								
	b	Write about Johnson's method for N-Jobs 2-Machine Problem								
UNIT – IV										
7	a	Define saddle point and state the rule to determine saddle point								
	b	The arrival rate of customers at a banking counter follows Poisson distribution with a mean of 45 per hour. The service rate of the counter clerk also follows Poisson distribution with a mean of 60 per hour. i). What is the probability of having 0,5and 10 customers in the system? ii). Find the average number of customers waiting in the queue and in the system. iii). Find average waiting time of the customer in the queue and in the system.								

	L3	CO2	[10]
	L1	CO2	[4]
	L2	CO3	[7]
	L2	CO3	[7]
	L2	CO3	[7]
	L2	CO3	[7]
	L1	CO4	[6]
	L3	CO4	[8]

<table>
<tr><td colspan="7">OR</td></tr>
<tr><td>8</td><td>a</td><td>Explain, in brief, the main characteristics of the ‘queuing system’.</td><td>L2</td><td>CO4</td><td>[7]</td></tr>
<tr><td></td><td>b</td><td>Consider the following payoff matrix and solve it optimally using graphical method.
<table>
<tr><td rowspan="2">Player A</td><td colspan="6">Player B</td></tr>
<tr><td></td><td>B1</td><td>B2</td><td>B3</td><td>B4</td><td>B5</td></tr>
<tr><td></td><td>A1</td><td>3</td><td>0</td><td>6</td><td>-1</td><td>7</td></tr>
<tr><td></td><td>A2</td><td>-1</td><td>5</td><td>-2</td><td>2</td><td>1</td></tr>
</table></td><td>L2</td><td>CO4</td><td>[7]</td></tr>
<tr><td colspan="7">UNIT – V</td></tr>
<tr><td>9</td><td>a</td><td>Explain Bellman’s principle of optimality.</td><td>L1</td><td>CO5</td><td>[7]</td></tr>
<tr><td></td><td>b</td><td>Solve the following linear programming problem by dynamic programming approach.
Maximize Z = 2x1 + 5x2
Subject to 2x1 + x2 ≤ 43
2x2 ≤ 46 and x1, x2 ≥ 0</td><td>L2</td><td>CO5</td><td>[7]</td></tr>
<tr><td colspan="7">OR</td></tr>
<tr><td>10</td><td>a</td><td>List out the advantages and limitations of simulation.</td><td>L2</td><td>CO5</td><td>[7]</td></tr>
<tr><td></td><td>b</td><td>With the help of a single server queuing model having inter-arrival and service times constantly 1.4 minutes and 3 minutes respectively, explain discrete simulation technique taking 10 minutes as the simulation period. Find from this average waiting time and percentage of idle time of the facility of a customer. Assume that initially the system is empty and the first customer arrives at time t = 0.</td><td>L2</td><td>CO5</td><td>[7]</td></tr>
</table>

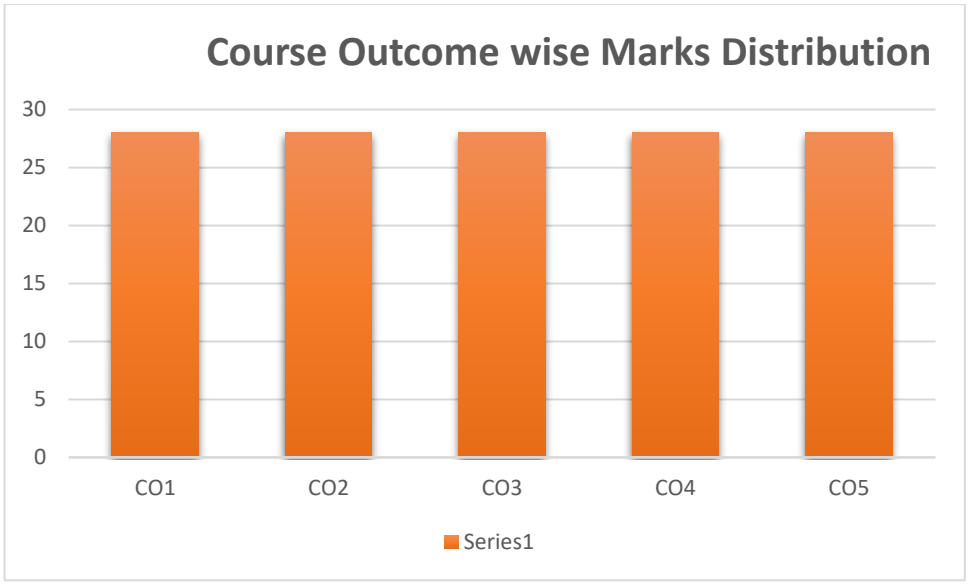
*****

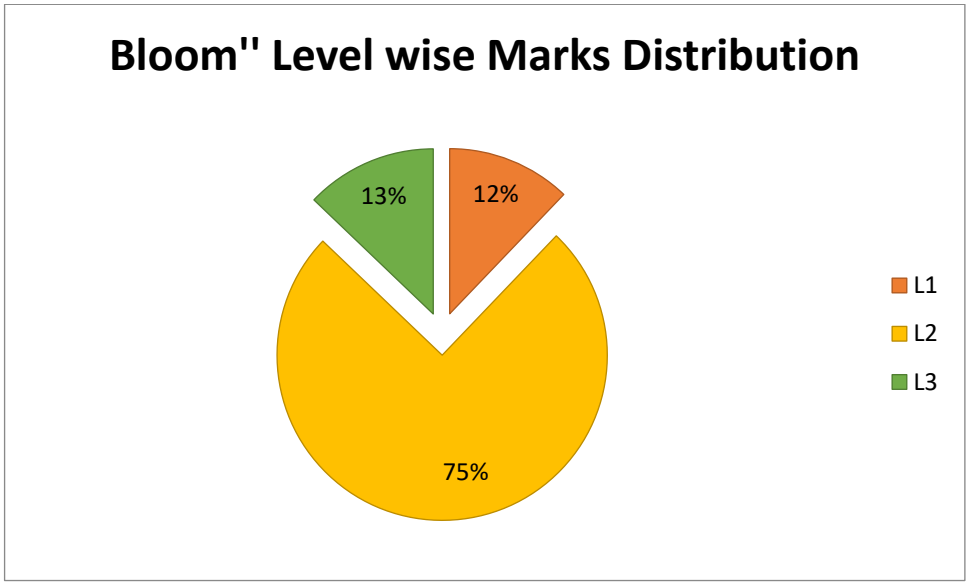
ANALYSIS OF QUESTION PAPER

Data prepared from the Question paper :

CO	MARKS		BL	MARKS
CO1	24		L1	12
CO2	24		L2	90
CO3	24		L3	18
CO4	24		L4	0
CO5	24		L5	0
			L6	0
TOTAL	120		TOTAL	120

GRAPHICAL ANALYSIS OF QUESTION PAPER by PIE CHARTS, BAR CHARTS





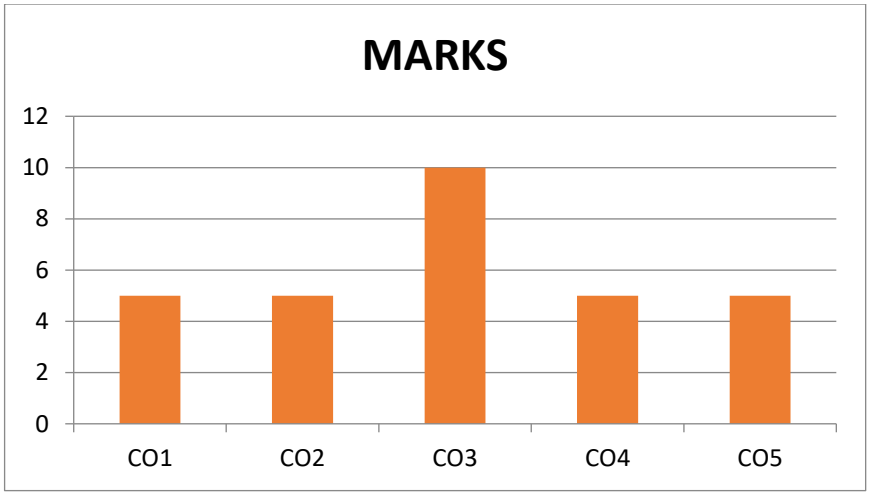
BTL: Bloom's Taxonomy levels (L1: Remember L2: Understand L3: Apply L4: Analyse L5: Evaluate L6: Create)

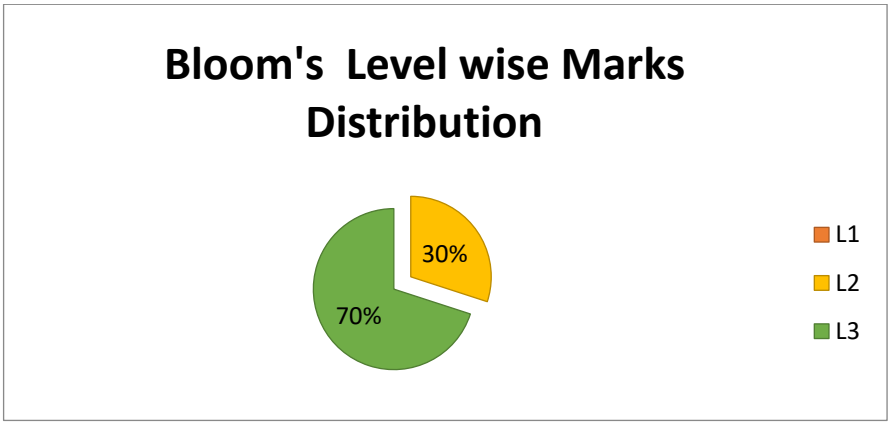
CO: Course Outcome

PO : Program Outcome

QUESTION PAPER ANALYSIS OF SESSIONALS-EXAMPLE

	Q.No.	Sub	CO	Marks	BL
Sessional 1	1	a	CO1	3	L3
	1	b	CO1	2	L3
	2	a	CO2	2	L3
	2	b	CO2	3	L3
	3	a	CO5	5	L2
Sessional 2	1	a	CO3	3	L3
	1	b	CO3	2	L2
	2	b	CO4	2	L2
	2	a	CO4	3	L3
	3	a	CO3	5	L3





ANNEXURE V: PROCESS TO IDENTIFY SLOW AND ADVANCED LEARNERS

In Outcome based education, it is necessary to identify the slow and advanced learners in a class. Course instructor has to identify such people based on different criteria in Teaching learning process. After identifying the slow learners, instructor has to take corrective action to improve the levels of slow learners in the next assessment. The standard operating procedure for the identification of slow and advanced learners and activities is explained as follows.

1. **Purpose**

- To identify the slow and advanced learners to help them improve their academics and holistic growth.

2. **Scope**

To lay down the procedures for the students

- With low learning capability to attain minimum competency.
- With good learning capacity for their holistic growth.

3. **Responsibilities**

- Head of the Department – Allotment of Course coordinators / Course instructors, Monitoring and conducting activities for different learners.
- Course coordinators / Course instructors – Identify slow and advanced learners and conduct make-up classes for slow learners.
- Mentors – Motivating the slow and advanced learners for their holistic growth.

4. **Procedure**

- The Head of the Department (HoD) appoints one faculty member as a course coordinator for each course to coordinate the other faculty teaching the same course in the aspects of course delivery, assessment and evaluation.
- Slow and advanced learners are identified based on their performance in the first sessional examination.
- The respective course coordinator would identify slow and advanced learners for the respective course.
- Those who got less than 50% marks in the first sessional examination are considered slow learners, and others are considered advanced learners.

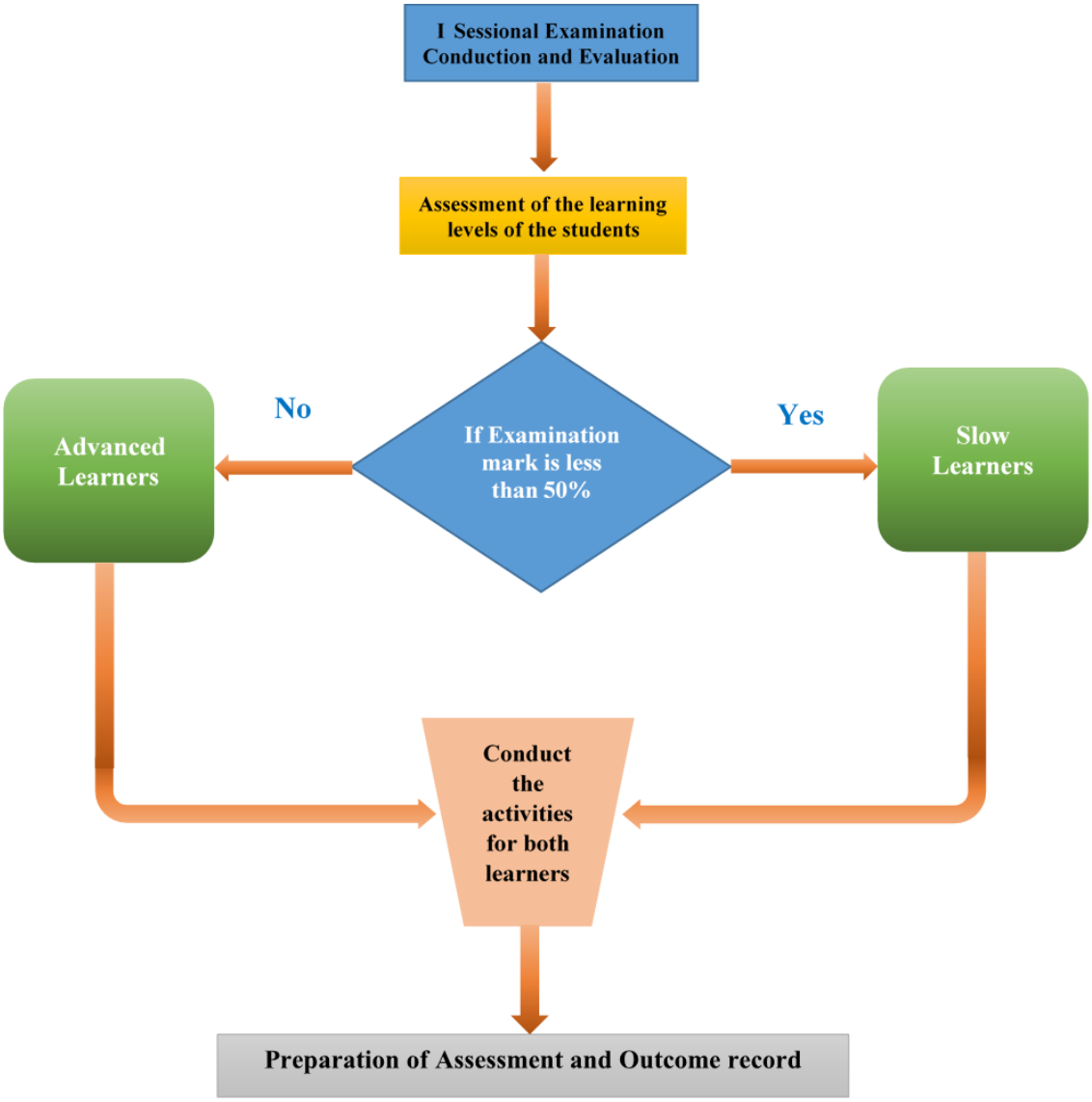


Figure V.1: Procedure for identification of learning levels of students and conduction of activities

Conduction of activities for slow learners:

- Make-up classes are offered for each course after the regular class work to help slow learners perform better.
- The concepts are presented in the native language during make-up classes to facilitate better comprehension.
- The mentor provides the slow learners with academic and psychological counselling.
- Special attention is given to the students in the tutorial classes, who are identified as slow learners.
- Students are given lecture notes and are allowed to practice previous question papers.

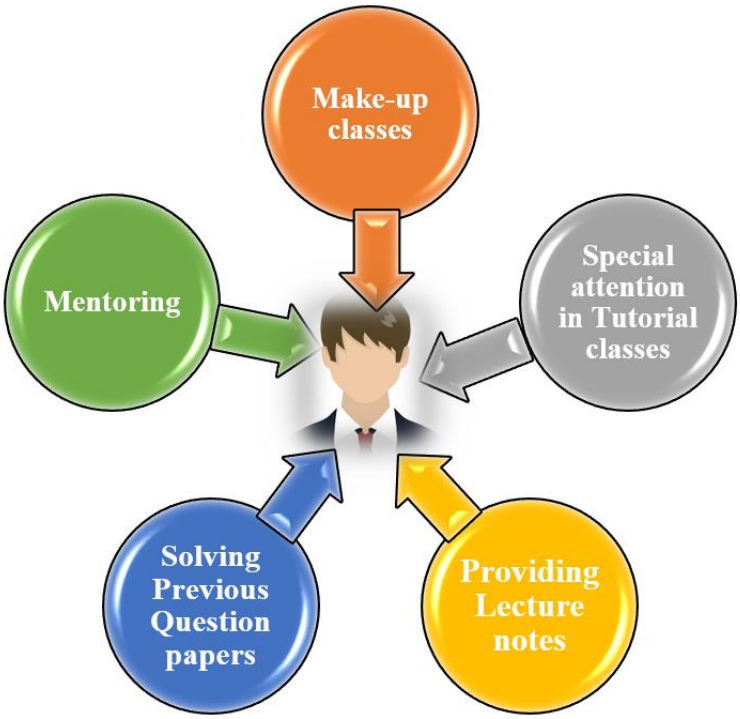


Figure V.2: Activities for the slow learners

Conduction of activities for advanced learners:

- Students are encouraged to learn cutting-edge skills through MOOCs to imbibe self-learning.
- Students are encouraged to do an internship to gain experience with technology, people and projects that may relate to their career goals.
- Students are encouraged to attend GATE coaching to reinforce their fundamental concepts.
- Students are encouraged to do creative and innovative projects to participate in competitions by their respective mentors.
- Students are encouraged to participate in workshops, seminars, paper presentations, etc.
- Students are sponsored to present research articles at different conferences.
- Students are encouraged to pursue higher studies and prepare for the respective competitive examinations.

Figure V.3: Activities for the advanced learners

ANNEXURE VI: RUBRICS

RUBRICS FOR A LABORATORY COURSE EVALUATION

In outcome-based education, rubrics are essential part of the evaluation process, where subjective assessment will be an integral part of the assessment system. In a laboratory course, the experimental results contribute only a part of assessment. There are many performance indicators or parameters are to be considered in overall assessment of a learner. For this purpose, rubrics are developed for each component of laboratory evaluation, i.e., day-to-day performance evaluation, observation & record and internal test. They are explained as under.

S.No.	Performance Indicator
P1	Participation & Regularity (3)
P2	Ability to understand the objectives, setup, conduct, analyze/ implement the experiments and present results (4)
P3	Ability to respond to questions (3)
P4	Background preparation & writing the experiment in Observation book before doing the experiment (3)
P5	Noting the results in Observation book (2)
P6	Preparation of record & Timely submission (5)

DAY TO DAY EVALUATION

Roll No: Academic Year:

Student Name: Semester:

Name of Lab: Regulation: AR20

S. No.	NAME OF THE EXPERIMENT	Continuous Internal Evaluation			Total (10 M)	Observation & Record			Total (10 M)	Faculty Sign
		P1 (3M)	P2 (4M)	P3 (3M)		P4 (3M)	P5 (2M)	P6 (5M)		
1										
2										
3										
		TOTAL (10 M)				TOTAL (10 M)				

SIGNATURE OF THE FACULTY

RUBRICS FOR CONTINUOUS INTERNAL EVALUATION IN LABORATORY COURSE (10 MARKS)

Performance Indicator	Needs improvement	Satisfactory	Good
P1: Participation & Regularity (3)	Most of the times Irregular & Minimum participation (0-1)	Moderately regular with some participation (2)	Regular, Punctual with Maximum participation (3)
P2: Ability to understand the objectives, setup, conduct, analyze/ implement the experiments and present results (4)	Unable to properly setup, conduct, analyze/implement the experiments (1)	Partially able to setup, conduct, analyze/implement the experiments (2-3)	With good background preparation, able to properly setup, conduct, analyze/implement the experiments (3-4)
P3: Ability to respond to questions (3)	Did not answer any of the viva questions (0)	Answered few viva questions (1-2)	Answered all the viva questions (3)

RUBRICS FOR EVALUATION OF LAB OBSERVATION & RECORD (10 MARKS)

Performance Indicator	Needs improvement	Satisfactory	Good
P4: Background preparation & writing the experiment in Observation book before doing the experiment (3)	No background preparation, but have written the experiment in observation book (1)	With Little background preparation, have written the experiment in observation book (2)	With good background preparation, have written the experiment in observation book (3)
P5: Noting the results in Observation book (2)	Couldn't get proper readings/outputs for noting down in the observation book (0)	Noted down the readings but didn't get the proper outputs (1)	Obtained proper readings and evaluated the correct results/outputs (2)
P6: Preparation of record & Timely submission (5)	Lack of organization and/or didn't submit the record in time (0-1)	Organization of record is clear/ not very clear and/or submitted within/ after deadline (2-3)	Proper organization of record & Submitted within the deadline (4-5)

RUBRICS FOR A PROJECT WORK EVALUATION

In Course outcomes and Program Outcomes attainment for a Project related courses, where normal tests or examinations are not useful for assessing the students, we prefer Rubrics. When subjective assessment based on identified performance indicators, rubrics will guide us to award marks for a student based on his performance in that performance indicator. In rubrics, we need to define various levels based on minimum expectation performance as benchmark and maximum possible performance as highest.

Marks awarding scale can be from 3-point scale to 5-point scale. For a project related course i.e., Industry oriented mini project or Major project or Full semester Internship, we need to assess the student based on rubrics developed. Here, various rubrics are presented related to project work. The points related to the rubrics can be altered based on the number of marks allotted in the curriculum.

For Full-semester Internship (Project) in the final semester, the student should mandatorily register and undergo internship and in parallel, he/she should work on a project with well-defined objectives. At the end of the semester, the candidate shall submit an internship completion certificate and a project report. A student shall also be permitted to submit project report on the work carried out during the internship. For Project, 200 marks are awarded, out of which 60 marks shall be for Sessional Evaluation and 140 marks for the Semester End Examination. A group of students or even a single student can take up the Internship for full semester. The supervisor shall assess the student for 30 marks (Report: 15 marks, Seminar: 15 marks). At the end of the semester, all projects shall be showcased at the department for the benefit of all students/staff and the same shall be evaluated by the PRC for 30 marks from four reviews. The Sessional marks for Project are the sum of marks allotted by the Supervisor and the marks allotted by PRC. The Semester End Examination (Viva-Voce) shall be conducted by the committee that consists of an External Examiner appointed by Principal and PRC. The marks awarded by PRC will be scaled for 30 marks. These marks will be added to the marks awarded by Supervisor for 30 marks by means of a Report and a Seminar, which results Sessional marks for 60 marks.

MARKS AWARDED BY PRC

Review #	Agenda	Review Weightage
Review 1	Literature survey and project proposal	10marks
Review 2	Design methodology and demonstration	10marks
Review 3	Implementation of the Project	20marks
Review 4	Results and conclusion of project work	20marks
Total Marks for Internal evaluation		60 marks

Rubrics for Review 1: Literature Survey and Project proposal

Criteria	**Inadequate (0- 40%)**	**Satisfactory (41-70%)**	**Good (>70%)**
Literature Survey and identification of problem area (Max. marks: 2)	Normal explanation of survey conducted and purpose also not completely clearly explained. (0)	Conducted extensive Survey, identified gaps in the existing system with normal communication. (1)	Conducted extensive Survey, identified the gaps in the existing system with clear communication. (2)
Defining the objective of the project work proposed (Max. marks: 2)	Moderately defined objectives but not so clear about methodology. (0)	Clearly defined objectives, but not so clear about the methodology and limitations. (1)	All the objectives of the project work are clearly stated.(2)
Methodology of the proposed work (Max. marks: 3)	Unable to convey properly about the methodology to be followed. (0-1)	Good explanation about the methodology. (2)	Very well explained about the methodology. (3)
Project time estimation (Max. marks: 3)	Prepared network diagram of activities only. (0-1)	Prepared network diagram of activities, but not clear about completion time parameters. (2)	Prepared network diagram of activities and estimation of completion time in a proper defined way. (3)
Total Marks : 10			Marks awarded

Rubrics for Review 2: Design methodology and demonstration

Criteria	**Inadequate (0-40%)**	**Satisfactory (41-70%)**	**Good (>70%)**
Design methodology (Max. marks: 2)	Problem segmentation is not done properly. (0)	Problem segmentation is done. But methodology path is not clearly explained.(1)	Problem segmentation is done properly and methodology path is properly justified.(2)
Building team structure (Max. marks: 2)	Unfair assignment of project tasks to the team members. (0)	Assignment of tasks done in normal manner among team members.(1)	Assignment of tasks done in a good manner among team members. (2)
Usage of modern tools (Max. marks: 3)	Not used relevant modern tools in the project execution. (0-1)	Normal use of modern tools as per requirement in the project execution.(2)	Efficient use of modern tools in the project execution. (3)

Demonstration and presentation (Max. marks: 3)	Progress of the project is not presented properly. (0-1)	Progress of the project is explained in a normal manner with appropriate justification. (2)	Progress of the project is explained in a good manner with appropriate justification of the objectives and tools. (3)
Total Marks : 10			Marks awarded

Rubrics for Review 3: Implementation of the Project

Criteria	**Inadequate (0- 40%)**	**Satisfactory (41-70%)**	**Good (>70%)**
Incorporation of Suggestions (Max. marks: 5)	A few suggestions only implemented. (0-1)	Many suggestions are implemented at a satisfactory level. (2-3)	All suggestions are implemented properly. (4-5)
Achievement of Objectives (Max. marks: 5)	Some objectives only achieved. (0-1)	All objectives are achieved at a satisfactory level. (2-3)	All objectives are achieved more than expected. (4-5)
Project Implementation (Max. marks: 5)	Project modules are not properly aligned or integrated. Demonstrated normally. (0-1)	All project modules are working satisfactory and demonstrated well. (2-3)	All project modules are working in a good condition. Project is demonstrated properly. (4-5)
Presentation (Max. marks: 5)	Presentation of project progress is not fair. Less communicative ability is observed. Eye contact is not maintained. (0-1)	Presentation of project progress is satisfactory. Communication with clear voice and language. Eye contact is maintained. (2-3)	Effective presentation of project progress with good communication skills. Proper gestures with good eye contact is observed. (4-5)
Total Marks : 20			Marks awarded

Rubrics for Review 4: Results and conclusion of project work

Criteria	**Inadequate (0- 40%)**	**Satisfactory (41-70%)**	**Good (>70%)**
Concept explanation and technical details (Max. marks: 5)	Explanation of project concepts is not clear. Lack of communication in explaining technical details. (0-1)	Complete explanation of concepts of the project. Technical details are explained in a normal way. (2-3)	Good explanation of key concepts of the project. Good explanation of technical details of the project.(4-5)
Project Report (Max. marks: 5)	Documentation of the project is not up to the mark as specified in the format. Language is also not proper. (0-1)	Documentation of the project is in line with the format. A few language corrections present. Typographical errors also present. (2-3)	Documentation of project is in line with the format specified. No spelling mistakes or typographical errors. (4-5)
Presentation of results (Max. marks: 5)	Results are presented in an ordinary manner without proper justification or evidence. (0-1)	Results are presented in a satisfactory manner with proper justification or evidence. (2-3)	Results are presented in a good manner with proper justification or evidence. (4-5)
Conclusions and discussion (Max. marks: 5)	Improper conclusions and discussion is not fair. (0-1)	Project conclusions are fair and discussion is normal. (2-3)	Project conclusions are fair and discussion is good. Future scope also discussed. (4-5)
Total Marks : 20			Marks awarded

The specimen of final output of the rubrics and marks awarded is as follows.

	Review 1	**Review 2**	**Review 3**	**Review 4**	**Semester End Exam**
Max. Marks	**10**	**10**	**20**	**20**	**120**
Student 1	9	9	18	18	118
Student 2	8	9	18	18	114
Student 3	7	9	19	20	115
Student 4	8	9	18	18	120
Student 5	7	10	19	19	120

The calculation of Course outcome and Program outcome attainment for a project batch is calculated as follows.

1. Academic Outcomes
2. Project Outcomes

Academic outcomes attainment is calculated from the project reviews internally conducted and semester end examination by the external examiner. By this process of academic outcomes, CO attainment and PO attainment are calculated, which contribute to 70% of total PO attainment.

Project outcomes are purely the attainment of the project through exposure to the outside public or society. Various means of exposure ie., Project display, Project competition and Prizes, Publishing in Journals or Conferences, Prototypes and Awards etc., are analyzed and Outcomes are converted into numerical values or levels of attainment through rubrics.

One example to calculate CO and PO attainment is shown below..

ADITYA ENGINEERING COLLEGE (A)						
Department of _____						
PROJECT ATTAINMENT (COs)						
AY:		**Name of the Guide:**				
NAME OF PROJECT :						
Batch Number						
S.NO.	**Regd. No.**	**Review 1**	**Review 2**	**Review 3**	**Review 4**	**Semester End Examinations**
	Max. Marks	15	15	15	15	140
1	Student 1	12	14	15	14	125
2	Student 2	13	13	14	14	120
3	Student 3	11	12	14	14	130
4	Student 4	14	14	15	15	135
4	Student 5	10	12	14	15	104
Average Mark		***12.00***	***13.00***	***14.40***	***14.40***	***122.80***
% Marks		***80%***	***87%***	***96%***	***96%***	***88%***
Academic Performance Level		***2***	***2***	***3***	***3***	***2***
Review mapping with Course Outcomes (Enter '*' if there is a correlation, else leave it blank)						
		Review 1	**Review 2**	**Review 3**	**Review 4**	**Semester End Examinations**
CO1		*				*
CO2				*		*
CO3			*			*
CO4		*				*
CO5			*			*
CO6				*		*
CO7					*	*
CO8					*	*
CO9				*		*
CO10					*	*

The rubrics for levels of attainment are as follows.

ACADEMIC PERFORMANCE	**PROJECT OUTCOMES**	**LEVEL**
< 80%	Nil	**1**
80 - 89 %	1	**2**
>= 90%	>1	**3**

After rubrics are applied, the attainment of Course outcomes by reviews and semester end exam are follows.

REVIEWS & EXTERNAL						
	Review 1	**Review 2**	**Review 3**	**Review 4**	**Semester End Examinations**	**Average**
CO1	2.00				2.00	2.00
CO2			3.00		2.00	2.50
CO3		2.00			2.00	2.00
CO4	2.00				2.00	2.00
CO5		2.00			2.00	2.00
CO6			3.00		2.00	2.50
CO7				3.00	2.00	2.50
CO8				3.00	2.00	2.50
CO9			3.00		2.00	2.50
CO10				3.00	2.00	2.50
Academic Performance Attainment						**2.30**

The project outcomes as an exposure of the project and its attainment are follows.

PROJECT OUTCOMES	**YES/NO**	**COUNT**
Presentation in Expo		1
Prototypes		0
Publications		0
Any Recognition/Prize		0
	Total	**1**
Project Outcomes Attainment		**2.00**

The Overall Project CO attainment as 60% of Academic performance and 40% of Project outcomes is calculated as follows.

Academic performance (80% Weightage)	2.30	**1.84**
Project Outcomes(Prizes/Prototypes/Publications/Best project) (20%)	2.00	**0.40**
OVERALL PROJECT CO ATTAINMENT		**2.24**

The project attainment obtained above is for a single project batch. Similarly, CO and PO attainment for all project batches will be calculated and it is consolidated as an arithmetic average for the entire class.

. This is shown as follows.

PROJECT ATTAINMENTS

AY: 2021-22 SECTION-A

BATCH	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
A1	2.77	2.76	2.76	2.80	2.76	2.73	2.76	2.72	2.82	2.84	0.00	2.85	2.76	2.76
A2	2.77	2.76	2.76	2.80	2.76	2.73	2.76	2.72	2.82	2.84	0.00	2.85	2.76	2.76
A3	1.20	1.23	1.20	1.20	1.32	1.20	1.20	1.20	1.20	1.20	1.20	1.50	1.20	1.20
A4	2.73	2.74	2.80	2.80	2.80	2.80	2.80	2.80	2.51	2.50	2.40	2.72	2.80	0.00
A5	2.38	2.39	2.40	2.49	2.43	2.60	2.36	2.44	2.60	2.40	2.37	2.49	2.35	2.40
A6	2.27	2.27	4.00	2.13	2.22	2.16	2.20	2.00	2.40	2.40	2.40	2.40	2.40	2.00
A7	2.77	2.76	2.76	2.80	2.76	2.73	2.76	2.72	2.82	2.84	0.00	2.85	2.76	2.76
A8	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.69	2.65	0.00	2.75	2.60	2.60
A9	2.47	2.46	2.40	2.40	2.40	2.40	2.40	2.40	2.69	2.70	2.80	2.48	2.40	0.00
A10	2.09	2.17	2.00	2.29	2.20	2.40	2.13	2.20	2.00	2.00	2.24	2.30	2.00	2.40
A11	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
A12	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Attinment	***2.37***	***2.38***	***2.51***	***2.39***	***2.39***	***2.40***	***2.36***	***2.35***	***2.41***	***2.40***	***1.48***	***2.47***	***2.37***	***1.94***

PROJECT ATTAINMENTS

AY: 2021-22 SECTION-B

BATCH	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
B1	2.57	2.40	2.53	2.80	2.64	2.67	2.65	2.67	2.68	2.74	2.68	2.73	2.69	0.00
B2	2.65	2.70	2.51	2.80	2.67	2.40	0.00	2.56	2.80	2.80	2.80	2.67	2.69	0.00
B3	2.65	2.70	2.51	2.80	2.67	2.40	0.00	2.56	2.80	2.80	2.80	2.67	2.69	0.00
B4	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
B5	1.97	1.96	2.00	2.12	2.00	1.97	1.90	1.91	1.97	1.99	1.93	2.01	1.80	0.00
B6	1.70	1.75	1.60	1.89	1.80	2.00	1.84	1.80	1.60	1.60	1.84	1.90	1.60	2.00
B7	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
B8	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	0.00
B9	1.46	1.43	1.44	1.29	1.44	0.00	1.47	1.20	1.48	1.45	1.20	1.60	1.20	0.00
B10	2.65	2.70	2.51	2.80	2.67	2.40	0.00	2.56	2.80	2.80	2.80	2.67	2.69	0.00
B11	2.07	2.20	2.20	1.93	2.11	1.80	2.00	2.00	2.20	2.20	1.96	2.20	2.20	1.80
B12	1.60	1.60	1.60	1.60	1.60	1.60	0.00	1.60	1.60	1.60	1.60	1.60	1.60	0.00
B13	1.87	1.95	2.00	1.90	1.94	2.00	2.00	1.82	2.00	2.00	2.00	2.00	2.00	2.00
Attinment	***2.13***	***2.12***	***2.09***	***2.16***	***2.13***	***1.96***	***1.39***	***2.07***	***2.16***	***2.17***	***2.14***	***2.17***	***2.10***	***0.75***

PROJECT ATTAINMENTS

AY: 2021-22 SECTION- C

BATCH	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C1	2.44	2.49	2.44	2.45	2.40	0.00	0.00	2.44	2.44	2.44	2.44	2.44	2.44	0.00
C2	1.84	1.91	1.84	1.83	1.90	0.00	0.00	1.85	1.85	1.85	1.85	1.85	1.85	0.00
C3	2.40	2.40	2.40	2.00	2.40	2.20	2.00	2.00	2.00	2.00	0.00	2.00	2.40	2.20
C4	1.94	1.92	1.92	2.00	1.92	1.87	1.92	1.94	2.03	2.11	0.00	2.15	1.92	1.92
C5	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80
C6	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80
C7	1.80	1.77	2.00	1.60	1.60	1.60	1.60	1.60	2.00	2.00	1.76	1.60	2.00	1.60
C8	1.86	1.84	1.84	1.90	1.84	1.80	1.84	1.88	1.88	1.89	0.00	1.90	1.84	1.84
C9	1.85	1.90	1.71	2.00	1.87	1.60	0.00	1.76	2.00	2.00	2.00	1.87	1.89	0.00
C10	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	0.00	2.40	2.40	2.40
C11	2.40	2.40	2.40	2.33	2.40	2.53	2.39	2.44	2.51	2.54	2.50	2.53	2.50	0.00
C12	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80
C13	1.70	1.77	1.60	1.92	1.78	2.00	1.84	1.80	1.60	1.60	1.80	1.90	1.60	2.00
Attinment	***2.08***	***2.09***	***2.07***	***2.06***	***2.07***	***1.72***	***1.57***	***2.04***	***2.09***	***2.09***	***1.44***	***2.08***	***2.10***	***1.41***

The average of all sections' PO attainment is calculated as follows.

PROJECT ATTAINMENT CONSOLIDATED

AY: 2021-22

SECTION	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	**2.37**	**2.38**	**2.37**	**2.39**	**2.39**	**2.40**	**2.36**	**2.35**	**2.41**	**2.40**	**1.48**	**2.47**	**2.37**	**1.94**
2	2.13	2.12	2.09	2.16	2.13	1.96	1.39	2.07	2.16	2.17	2.14	2.17	2.10	0.75
3	2.08	2.09	2.07	2.06	2.07	1.72	1.57	2.04	2.09	2.09	1.44	2.08	2.10	1.41
Attinment	***2.19***	***2.20***	***2.18***	***2.21***	***2.20***	***2.03***	***1.77***	***2.15***	***2.22***	***2.22***	***1.69***	***2.24***	***2.19***	***1.37***

RUBRICS FOR SUMMER INTERNSHIP

For Summer Internship, the students can undergo Industrial Training / Internship at Govt. Organizations, Construction agencies, Industries, Hydel and Thermal Power Plants, software MNCs etc. or do Research projects in National Laboratories/Academic Institutions like IITs, NITs etc. during summer breaks after completion of IV Semester and VI Semester End Examinations. However, the Summer Internship shall be evaluated in the V semester and VII semester, respectively. A group of students or even a single student can take up the Internship. Completion of internship is mandatory. After successful completion, students shall submit a summer internship technical report to the department concerned. A certificate from the industry/organization shall be included in the report. The Summer Internship shall be evaluated for 100 marks at the end of the semester based on the report submitted and an oral presentation. The report carries 30 marks and oral presentation carries 70 marks. The student shall appear for the oral presentation before the Project Review Committee (PRC)* and an External Examiner appointed by Principal. There shall be no sessional marks for Summer Internship.

ASSESSMENT RUBRICS FOR INTERNSHIP EVALUATION

It is suggested that the Internship evaluation shall be of two parts namely Internship report and Oral presentation. Report is evaluated for 30 marks and Oral presentation is evaluated for 70 marks.

Rubrics developed for Internship Report : 30 marks

Description of parameters	**Marks awarding scale**	**Review Assessment Weightage**
Project report documentation, presentation of results & conclusions effectively	*Inadequate (0- 40%)* *Satisfactory (41-70%)* *Good (>70%)*	30 marks

Criteria	**Inadequate (0-40%)**	**Satisfactory (41-70%)**	**Good (>70%)**
Documentation(10)	Documentation of the project is not up to the mark as specified in the format. Language is also not proper. (0-4)	Documentation of the project is in line with the format. Few language corrections present. Typographical errors also present. (5-7)	Documentation of project is in line with the format specified. No spelling mistakes or typographical errors. (8-10)

Presentation of results and conclusions(20)	Results and conclusions are presented in an ordinary manner without proper justification or evidence. (0-8)	Results and conclusions are presented in a satisfactory manner with proper justification or evidence. (9-14)	Results and conclusions are presented in a good manner with proper justification or evidence. (15-20)
Max.Marks:30		Marks awarded	

Rubrics developed for Oral Presentation : 70 marks

Description of parameters	**Marks awarding scale**	**Review Assessment Weightage**
Defining the objective of the project work, explanation of basic concepts and technical details, oral presentation communicating the project work effectively	*Inadequate (0- 40%)* *Satisfactory (41-70%)* *Good (>70%)*	70 marks

Criteria	**Inadequate (0-40%)**	**Satisfactory (41-70%)**	**Good (>70%)**
Defining the objective of the project work proposed (Max. marks: 20)	Moderately defined objectives but not so clear about methodology. (0-8)	Clearly defined objectives, but not so clear about the methodology and limitations. (9-14)	All the objectives of the project work are clearly stated.(15-20)
Concept explanation and technical details (Max. marks: 20)	Explanation of project concepts is not clear. Lack of communication in explaining technical details. (0-8)	Complete explanation of concepts of the project. Technical details are explained in a normal way. (9-14)	Good explanation of key concepts of the project. Good explanation of technical details of the project.(15-20)
Presentation (Max. marks: 30)	Presentation of project progress is not fair. Less communicative ability is observed. Eye contact is not maintained. (0-12)	Presentation of project progress is satisfactory. Communication with clear voice and language. Eye contact is maintained. (13-21)	Effective presentation of project progress with good communication skills. Proper gestures with good eye contact is observed. (22-30)
Max.Marks:70		Marks awarded	

ANNEXURE VII: LESSON PLAN

LESSON PLAN				
Academic Year	**Semester :B.Tech.- VII Sem.**		**Section : B**	
	Branch : Mechanical Engineering			
	Course : Operations Research			
	Faculty :			
Date	**Topic to be covered**	**Mode of Teaching**	**No. of Periods**	**Reference**
I WEEK	Definition and Scope of Operations Research	Chalk and Talk	1	T1
	Phases of Operations Research - Mathematical formulation of the problem	Chalk and Talk	1	T1,W1
	Graphical solution.	Chalk and Talk	1	T1,T2
	Standard Form of LPP, Basic feasible solutions,Unrestricted variables,	Chalk and Talk	1	T1&T2
II WEEK	Simplex algorithm	Chalk and Talk	1	T1,W1
	Artificial Variables, Big- M method	Chalk and Talk	1	T1,W2
	Two Phase simplex method, Degeneracy	Chalk and Talk	1	T1,W2
	Alternative Optimal, Unbounded Solutions, Infeasible Solutions	Tutorial	1	T1,W1
III WEEK	Introduction to Duality in LPP.	Assignment	1	T2,R1,R2
	Basic feasible solution by North-west corner method/Vogel's approximation method/Least cost method	Chalk and Talk	1	T1,T2
	Finding optimal solution by MODI(u-v) method,	Chalk and Talk	1	T1
	Resolving Degeneracy, Unbalanced transportation matrix, Maximization case.	Chalk and Talk	1	T2, T3
IV WEEK	Hungarian method for minimization case, Optimal solution,	Chalk and Talk	1	T1,W1
	Unbalanced assignment matrix	Assignment	1	T1,T2
	Flight scheduling problems,	Assignment	1	T1,T3

	Traveling salesman problem.	Assignment	1	T1,T2
V WEEK	Introduction – Replacement of items that deteriorate with time – When money value is not counted and counted	Chalk and Talk	1	T1
	Replacement of items that deteriorate with time – When money value is counted	Chalk and Talk	1	T1,T3
	Replacement of items that fail suddenly(Group replacement)	Flip Classroom (research paper)	1	T1,R2,W1
	Problem on Replacement problem	Tutorial	1	T1,T2
VI WEEK	Sequencing Problems, Johnson's method for N-Jobs 2-Machine Problem,	Chalk and Talk	1	T1,W2
	N-Jobs K- Machines Problem, 2-Jobs M- Machines Problem(Graphical method)	Chalk and Talk	1	T1,T2
	Inventory-Factors Effecting Inventory	Chalk and Talk	1	T1,W1
	Derivation of Economic Order Quantity of Finite Replenishment Model	Chalk and Talk	1	T1,R3
VII WEEK	Production model without backordering	Chalk and Talk	1	T1,W1
	Calculation of EOQ with backordering	Chalk and Talk	1	T1,R3
	ABC & VED analysis,Price Breakups	Chalk and Talk	1	T1&R2
	Multi-Item Deterministic Problems. Probabilistic Inventory Problems.	Chalk and Talk	1	T1&R2
VIII WEEK	**I Sessional Exams**			
IX WEEK	Queuing systems and their characteristics. M/M/1: FCFS/∞,	Chalk and Talk	1	T1,T3
	Problems on M/M/1 Model	Tutorial	1	T1,T3
	M/M/2: FCFS/∞,	Chalk and Talk	1	T2,T3
	Problems on M/M/2 Model	Assignment	1	T1,R1,R2

X WEEK	M/M/1: FCFS/∞ /N queuing models.	Chalk and Talk	1	R1,R2
	Problem on Queueing models	Tutorial	1	T1,T2
	Introduction, Rectangular two-person zero person games,	Chalk and Talk	1	T1,T2
	Saddle point, Solution of rectangular games with Saddle point, .	Chalk and Talk	1	T1,T2
XI WEEK	Problems on Saddle point games	Chalk and Talk	1	T1,T2
	Mixed Strategies, Concept of dominance to reduce the given matrix ,	Chalk and Talk	1	T1,T2
	Graphical method for 2xn and nx2 games	Chalk and Talk	1	T1,T2
	Graphical method for 2xn and nx2 games-problems	Assignment	1	T1,T2,R1
XII WEEK	Solution of 2x2 games – Value of the game	Chalk and Talk	1	T1,T2
	Problems on Game theory - Graphical method	Tutorial	1	T1,T2
	Introduction – Bellman's principle of optimality –	Chalk and Talk	1	T1,T2
	Applications of Dynamic programming	Chalk and Talk	1	T2,T3
XIII WEEK	Capital Budgeting problem	Chalk and Talk	1	T1,R1
	Capital Budgeting problem-Problems	Tutorial	1	T1,T2
	Shortest path problem	Chalk and Talk	1	T2,T3
	Shortest path problem-Problems	Chalk and Talk	1	T2,T3
XIV WEEK	Networking models	Assignment	1	T1,R1,R2
	Problems on networking and shortest path problem	Assignment	1	T1,T2,R3
	Definition and applications, Mantel Carlo simulation.	Chalk and Talk	1	T1,R4
	Random numbers and random number generation	Chalk and Talk	1	T1,T2
XV WEEK	Application of Simulation in Inventory control	Chalk and Talk	1	T1,W1
	Application of Simulation in Inventory Control - Problems	Tutorial	1	T1,T2,R4

	Application of simulation in Queueing Theory	Chalk and Talk	1	T1,W1
	Application of simulation in Queueing Theory-Problems	Tutorial	1	T1,T2
XVI WEEK	**II Sessional Exams**			
Total number of classes			**56**	
Text Books				
T1	Operations Research, S.D Sharma Kedarnath Ramnath & Co, 15th Edition.2012			
T2	Operations Research, P. Ramamurthy, New Age International,2nd Edition, 2007			
T3	Operations Research, Kanti Swaroop, P.K. Gupta, Manmohan, Sulthan chand & Sons, 15th Edition, 2010.			
Reference Books				
R1	Introduction to Operations Research, Hiller and Libermann, Nag,Basu, 11th Edition, Mc Graw Hill publishers, 2017.			
R2	Operations Research – An Introduction, Handy A Taha ,7th Edition, Pearson Education			
R3	Operations Research ,R. Panneerselvam, 2ndEdition, Prentice Hall of India, 2016.			
R4	Operations Research, Wayne Winston, 4th Edition, Cengage learning, 2003.			
Weblinks				
W1	https://nptel.ac.in/courses/110/106/110106062			
W2	https://www.youtube.com/playlist?list=PLjc8ejfjpgTf0LaDEHgLB3gCHZYcNtsoX			

ANNEXURE VIII: FEEDBACK / SURVEY FORMS


ADITYA