CO-PO Attainment

The major components of Outcome Based Education (OBE) are Course Outcome (CO) and Program Outcome (PO). Based on how well these two parts are defined and evaluated, OBE attainment is measured.

Course Outcomes (COs) are statements that specify what a learner will know or be able to do as a result of a learning activity. Outcomes are usually expressed as knowledge, skills, or attitudes. It is a measurable, observable, and specific statement that clearly indicates what a student should know and be able to do as a result of learning. It describes what students are able to demonstrate in terms of knowledge, skills and values upon completion of a course/a span of several courses.
Program Outcomes (POs) describe what a program is expected to accomplish. POs describe what students should know and be able to do at the end of the programme.
Program Specific Outcomes (PSOs) describe what the Postgraduates/graduates of a specific program should be able to do. Clear articulation of course outcomes, POs, and PSOs serves as the foundation for evaluating the effectiveness of the teaching and learning process.

The course correlation matrix shows the learning relationship (Level of Learning Achieved) between Course Outcomes and Program Outcomes of a course. This matrix strongly indicates whether the students are able to achieve the course objectives/outcomes. The matrix can be used for any course and is a good way to evaluate a course syllabus/content/structure.
Assessment Process for CO Attainment:
For the evaluation and assessment of CO's and PO's, rubrics are used. The rubrics considered here are given below:

CO Assessment Rubrics:

Direct assessment 1: refers to evaluation through internal assessments which include Mid Term Examinations
Direct assessment 2: refers to evaluation through End Term Examination (ETE)

Indirect assessment: refers to the exit feedback survey taken by students/faculty/employers. The exit feedback survey must be taken up before the end of the semester. The exit survey may be based on a marking scheme (1-3) for each CO.

• The course exit survey samples are given below for student/faculty/employer
(Kindly note the respective course teacher may modify these templates according to the requirements of the course)

Sample1: Course Outcome exit survey for students

Course Outcome		**1(Low)**	**2(Moderate)**	**3(High)**
CO1	Understand the role and applications of data structure in real life			
CO2	Develop abstract data types for solving the complex problems			
CO3	Understand the concepts of non-linear data structures and applications			
CO4	Analyze the efficiency of algorithms			

Sample 2: Course Contents exit survey for students

Questions	**1(Low)**	**2(Moderate)**	**3(High)**
Quality of the Course Content			
Relevance of the textbook to this course			
Were the lectures clear/well organized and presented at a reasonable pace?			
Did the lectures stimulate you intellectually?			
Are the assignment/lab experiment procedures clearly explained?			

Sample3: Faculty/Employer Survey

Questions	**1(Low)**	**2(Moderate)**	**3(High)**
Satisfaction with the caliber of the graduates			
Courses are relevant to the organization's vision and mission			
Satisfaction with the speed at which course content is being adapted to meet changing industrial needs			
Relevant subject or discipline knowledge			
Quality of employability skills and attributes			
The satisfaction that graduates are learning the right skills			

CO Attainment Calculation of a Course:

7.1 Sample calculation- CO Mapping

Table 1: Mid Term Exam (Maximum Marks: 20)

	Question No. (1)	**Question No. (2)**	**Question No. (3)**
Roll No.	**MM :05**	**MM :05**	**MM :10**
Mapping of Event to CO	**CO1**	**CO1**	**CO2**
2102080001	3	5	2
2102080002	2	5	1
2102080060	0	4	8
No. of students attempted	**54**	**57**	**58**
Attempted (%)			
Mapping of Event to CO1	**CO1**	**CO1**	
Mapping of Event to CO2			**CO2**
Mapping of Event to CO3			
Mapping of Event to CO4			

Table 2: End Term Exam (Maximum Marks: 50)

	QueNo. (1)	Que No. (2)	Que No. (3)	Que No. (4)	Que No. (5)	Que No. (6)	Que No. (7)	Que No. (8)	Que No. (9)	Que No. (10)	Que No. (11)
Maximum Marks	**2**	**2**	**2**	**2**	**2**	**5**	**5**	**5**	**5**	**10**	**10**
Mapping of Event to CO	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO1**	**CO2**	**CO3**	**CO3**	**CO4**	**CO5**
2102080001	2	1	2	0	2	5	4	4	0	10	7
2102080002	1	1	2	2	0	5	5	1	4	5	6
2102080058	0	2	0	0	2	3	3	5	4	3	0
2102080059	0	1	0	1	1	5	3	3	4	1	10
2102080060	0	2	1	0	2	2	2	4	2	4	5
No. of students attempted	**38**	**52**	**43**	**41**	**48**	**60**	**54**	**61**	**53**	**45**	**12**
Attempted (%)											
Mapping of Event to CO1	**CO1**					**CO1**					
Mapping of Event to CO2		**CO2**					**CO2**				
Mapping of Event to CO3			**CO3**					**CO3**	**CO3**		
Mapping of Event to CO4				**CO4**						**CO4**	
Mapping of Event to CO5					**CO5**						**CO5**

7.2 Sample calculation- CO attainment based on threshold level

Table 3. CO attainment - Continuous Internal Assessments (20 Marks)

Course Outcome	**CO1**				**CO2**				**CO3**				**CO4**				**CO5**			
Student Id	**Max Marks**	**Obtained Marks**	**Percentage**	**CO Attained (60%)**	**Max Marks**	**Obtained Marks**	**Percentage**	**CO Attained (60%)**	**Max Marks**	**Obtained Marks**	**Percentage**	**CO Attained (60%)**	**Max Marks**	**Obtained Marks**	**Percentage**	**CO Attained (60%)**	**Max Marks**	**Obtained Marks**	**Percentage**	**CO Attained (60%)**
2102080001	4	3	75	YES	4	4	100	YES	4	4	100	YES	4	4	100	YES	4	4	100	YES
2102080002	4	2	50	NO	4	4	100	YES	4	2	50	NO	4	1	25	NO	4	2	50	NO
2102080003	4	2	50	NO	4	4	100	YES	4	0	0	NO	4	4	100	YES	4	4	100	YES
2102080060	4	0	0	NO	4	2	50	NO	4	2	50	NO	4	2	50	NO	4	2	50	NO
No. of students attempted	**CO1**			**60**	**CO2**			**60**	**CO3**			**60**	**CO4**			**60**	**CO5**			**60**

No. of students scoring >= threshold (60%)		**36**		**47**		**30**		**37**	**37**
% of students scoring >= threshold		**60**		**78**		**50**		**62**	**62**

Table 4. CO attainment - Mid Term (20 Marks)

Course Outcome	**CO1**				**CO2**			
Student Id	**Max Marks**	**Obtained Marks**	**Percentage**	**CO Attained**	**Max Marks**	**Obtained Marks**	**Percentage**	**CO Attained**
2102080001	10	8	80	YES	10	2	20	NO
2102080059	10	4	40	NO	10	9	90	YES
2102080060	10	8	80	YES	10	0	0	NO
No. of students attempted	**CO1**			**60**	**CO2**			**60**
No. of students scoring >= threshold (60%)				**39**				**44**
% of students scoring >= threshold				**65**				**73**

Table 5. CO attainment - End Term (50 Marks)

Course Outcome	**CO1**				**CO2**				**CO3**				**CO4**				**CO5**			
Student Id	**MaxMarks**	**ObtainedMarks**	**Percentage**	**COAttained**	**MaxMarks**	**ObtainedMarks**	**Percentage**	**CO Attained**	**MaxMarks**	**ObtainedMarks**	**Percentage**	**COAttained**	**MaxMarks**	**ObtainedMarks**	**Percentage**	**COAttained**	**MaxMarks**	**ObtainedMarks**	**Percentage**	**CO Attained**
2102080001	7	7	100	YES	7	5	71	YES	12	6	50	NO	12	10	83	YES	12	9	75	YES
2102080059	7	5	71	YES	7	4	57	NO	12	7	58	NO	12	2	17	NO	12	11	92	YES
2102080060	7	2	29	NO	7	4	57	NO	12	7	58	NO	12	4	33	NO	12	7	58	NO
No. of students attempted	**CO1**			**60**	**CO2**			**60**	**CO3**			**60**	**CO4**			**60**	**CO5**			**60**
No. of students scoring >= threshold (60%)				**37**				**36**				**27**				**27**				**48**
% of students				**62**				**60**				**45**				**45**				**80**

scoring >= threshold										

COs Attainment Level: Course outcomes of all courses are assessed with the help of attainment levels are evaluated based on set attainment rubrics as per the table.

Table 6. CO attainment Levels

Assessment Methods	**Attainment Levels**	
Mid Term Exam	Level 1	60% of students scoring more than 60% marks.
	Level 2	60.01-80% of students scoring more than 60% marks.
	Level 3	80.01% of students scoring more than 60% marks.
End Term Exam	Level 1	60% of students scoring more than 60% marks.
	Level 2	60.01-80% of students scoring more than 60% marks.
	Level 3	80.01% of students scoring more than 60% marks.

Overall Attainment: The Final CO attainment is calculated by combining the indirect attainment and direct attainment in a ratio of 20:80. Final Value (V) = 20% Indirect Attainment + 80% Direct Attainment.

Table 7. COs Attainment Level: Sample Calculation

Event		**Mid-Term Exam (MM 20)**		**End-Term Exam (MM 50)**		**Average CO Attainment**		**Average CO Attainment (% Calculation)**		
Course Code	**Course Outcome**	**CO Percentage (%)**	**CO Attainment Level**	**CO Percentage (%)**	**CO Attainment Level**	**Sum of Overall CO Attainment**	**Final Average (Average Co Attainment per Course)**	**Sum of Overall CO Attainment %**	**Overall CO Attainment**	**Final Average (Average Co Attainment per Course)**
SMAW218A	CO1	65	2	62	2	2.00	0.40	62.62	2.00	52.29
	CO2	73	2	60	2	2.00		63.81	2.00	
	CO3			45	1	1.00		45.00	1.00	
	CO4			45	1	1.00		45.00	1.00	
	CO5			80	3	3.00		80.00	3.00	

No of students securing more than 60% marks	**Mapping Level**
No of students securing >=80% marks	**3**
No of students securing >=60% marks	**2**
No of students securing <=60% marks	**1**

CO – PO AND CO – PSO MAPPING OF COURSES:

All the courses together must cover all the POs (and PSOs). For a course we map the COs to POs through the CO-PO matrix and to PSOs through the CO-PSO matrix as shown below.

The various correlation levels are:

- "1" – slightly (Low) Correlation
- "2" – moderately (Medium) Correlation
- "3" – substantially (High) Correlation
- "-" indicates there is no correlation between CO and PO.

Table 8. Course Evaluation Matrix (Target).

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	2			1		3			1			1	3	
CO 2	2	3						1			1		1	
CO 3			2		3					3		2		3
CO 4				3			2		2		2			
CO 5		1	1											2
Average	**2**	**2**	**1.5**	**2**	**3**	**3**	**2**	**1**	**1.5**	**3**	**1.5**	**1.5**	**2**	**2.5**
Round off	**2**	**2**	**2**	**2**	**3**	**3**	**2**	**1**	**2**	**3**	**2**	**2**	**2**	**3**

Calculating PO attainment:

The PO attainment is calculated by using the predefined CO/PO matrix and the value of Final CO attainment for the subject.

Course level PO & PSO Attainment Calculation: The PO & PSO attainment for the course is calculated using the formula.

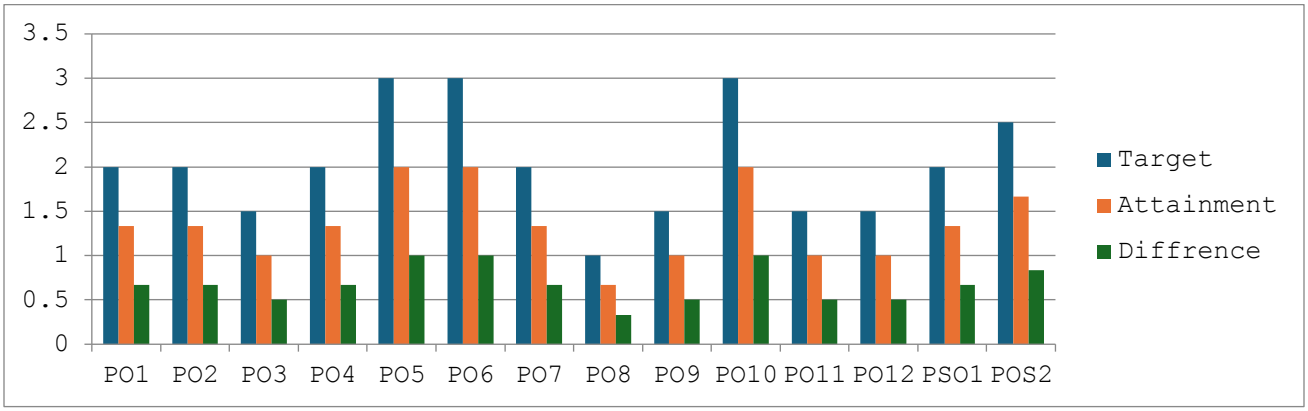
$$\text{CO attainment Ratio of Course (x)} = \frac{Average\ Co\ attaintment * Average\ Corelation}{3\ (Maximum\ attainment\ value)}$$

Table 9. Course Evaluation Matrix (Attained).

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1.33			0.67		2.00			0.67			0.67	2.00	
CO2	1.33	2.00						0.67			0.67		0.67	
CO3			1.33		2.00					2.00		1.33		2.00
CO4				2.00			1.33		1.33		1.33			
CO5		0.67	0.67				0.00							1.33
Average	**1.33**	**1.33**	**1.00**	**1.33**	**2.00**	**2.00**	**1.33**	**0.67**	**1.00**	**2.00**	**1.00**	**1.00**	**1.33**	**1.67**
Round off														

Table 10. PO-Co attainment difference table.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	POS2
Target	**2**	**2**	**1.5**	**2**	**3**	**3**	**2**	**1**	**1.5**	**3**	**1.5**	**1.5**	**2**	**2.5**
Attainment	**1.33**	**1.33**	**1.00**	**1.33**	**2.00**	**2.00**	**1.33**	**0.67**	**1.00**	**2.00**	**1.00**	**1.00**	**1.33**	**1.67**
difference	**0.67**	**0.67**	**0.50**	**0.67**	**1.00**	**1.00**	**0.67**	**0.33**	**0.50**	**1.00**	**0.50**	**0.50**	**0.67**	**0.83**



8. 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 attempts to divide learning into three types of domains (cognitive, affective, and behavioral) and then defines the level of performance for each domain. Consciousefforts 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 are given below:

According to revised Bloom's taxonomy, the level in cognitive domain are as follows:

Level	**Descriptor**	**Level of attainment**
1	Remembering	Recalling from memory of previously learned material
2	Understanding	Explaining ideas or concepts
3	Applying	Using information in another familiar situation
4	Analysing	Breaking information into part to explore understandings and relationships
5	Evaluating	Justifying a decision or course of action
6	Creating	Generating new ideas, products or new ways of viewing things

A suggestive list of skills/ competencies to be demonstrated at each of the Bloom's (COGNITIVE)level and corresponding cues/ verbs for the examination/ test questions

1. Remember

Skill Demonstrated	Question Ques / Verbs for tests
• Ability to recall of information like, facts, conventions, definition, 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, describe, state, recite, recall, identify, show label, tabulate, quote, name, who, when, where etc.

Sample Questions:

1. State Ohm's law
2. List the physical and chemical properties ofsilicon
3. Define the terms: Sensible heat, Latent heat and Total heat of evaporation
4. Describe the process of galvanization.
5. Write truth table and symbol of AND, OR,NOT, XNOR gates.
6. What is the difference between declaration and definition of a variable/function?

2. Understand

Skill Demonstrated	Question Ques / Verbs for tests
• 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.

Sample Questions:

1. Explain the importance of sustainability inEngineering design
2. Describe the characteristics of SCR and transistor equivalent for a SCR
3. How many values of the variable number must be used to completely test all branches of thefollowing code fragment?
4. Discuss the effect of Make in India initiative on the Indian manufacturing Industry.
5. Summarize the importance of ethical code of conduct for engineering professionals

6. What is the meaning of base address of the array?

7. Differentiate between entry and exit controlled loops.

3. Apply

Skill Demonstrated	Question Ques / Verbs for tests
• Use information • Use methods, concepts, laws, theories in new situations • Solve problems using required skill or knowledge • Demonstrating correct usage of a method or procedure.	Calculate, predict, apply, solve, illustrate, use, demonstrate, determine, model, experiment, show, examine, modify.

Sample Questions:

1. Model and realize the following behaviors usingdiodes with minimum number of digital inputs.

(i) Turning on of a burglar alarm only during night timewhen the locker door is opened.

(ii) Providing access to an account if either date ofbirth or registered mobile number or both are correct.

(iii) Updating the parking slot empty light in the basement of a shopping mall.

2. One of the resource persons needs to address a huge crowd (nearly 400 members) in the auditorium. A system is to be designed in such a way that everybody attending the session shouldbe able to hear properly and clearly without any disturbance. Identify the suitable circuit to boostthe voice signal and explain its functionality in brief.

3. A ladder 5.0 m long rests on a horizontal ground & leans against a smooth vertical wall at an angle20 with the vertical. The weight of the ladder is 900 N and acts at its middle. The ladder is at the point of sliding, when a man weighing 750 N stands on a rung 1.5 m from the bottom of the ladder.Calculate the coefficient of friction between the ladder & the floor.

4. Write an algorithm to implement a stack using queue.

5. A CPU generates 32-bit virtual addresses. The page size is 4 KB. The processor has a translation look aside buffer (TLB) which can hold a total of 128-page table entries and is 4-way set associative. What is the minimum size of the TLB tag?

4. Analyze

Skill Demonstrated	Question Ques / Verbs for tests
• Break down a complex problem into parts. • Identify the relationships and interaction between the different parts of complex problem.	Classify, outline, break, down, categorize, analyse, diagram, illustrate, infer, select.

Sample Questions:

1. A class of 10 students consists of 5 males and 5females. We intend to train a model based on their past scores to predict the future score. The average score of females is 60 whereas that of male is 80. The overall average of the class is 70. Give two ways of predicting the score and analyses themfor fitting model.

2. Suppose that we want to select between two prediction models, M1 and M2. We have performed10 rounds of 10-fold cross-validation on each model, whereas the same data partitioning in round one is used for both M1 and M2. The error rates obtained for M1 are 30.5, 32.2, 20.7, 20.6, 31.0, 41.0, 27.7, 26.0, 21.5, 26.0. The error rates for M2 are 22.4, 14.5, 22.4, 19.6, 20.7, 20.4, 22.1, 19.4, 16.2, 35.0. Comment on whether one model is significantly better than the other considering a significance level of 1%.

3. Return statement can only be used to return a single value. Can multiple values be returned froma function? Justify your answer.

5. Evaluate

Skill Demonstrated	**Question Ques / Verbs for tests**
• Compare and discriminate between ideas • Assess value of theories, presentations • Make choice based on reasoned argument • Verify value of evidence • Recognize subjectivity Use of define criteria for judgments.	Assess, decide, choose, rank, grade, test, measure, defend, recommend, convince, select, judge, support, conclude, argue, justify, compare, summarize, evaluate.

6. Create

Skill Demonstrated	**Question Ques / Verbs for tests**
•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.

Both higher order cognitive skills 'Evaluate' and'Create' are difficult to assess in time-limited examinations. These need to be assessed in varietyof student works like projects, open ended problem-solving exercises etc.

Typical examples of problem statements or need statements which need higher order abilities to solve are given below

Sample Problem / Need statements:

1. Automatic tethering of milking machine to theudder of a cow. A milk diary wants to automate the milking process. The milking process involves attaching the milking cups to the teats. Design asystem for the same.

2. An electric vehicle uses Lion batteries. The batteries have to be charged and get dischargedduring use. The batteries require continuous monitoring during charging and discharging so thatthey remain healthy and yield a long life. Design a system to monitor and manage the health of the batteries.