

1. Introduction

1.1 The basic nomenclature used in the attainment process

Course Outcomes (COs): COs are statements that describe the knowledge or skills the students should acquire after completion of particular course. The Course Outcomes (COs) are stated for each course in all the programs. All the faculty members teaching a particular course formulate the course outcomes and they are finally approved by Academic Advisory Committee in consultation with HOD's. COs are stated by considering the learning levels of Bloom's Taxonomy. There are usually 4 to 6 Course Outcomes for every course.

Program Outcomes (POs): POs are statements about the knowledge, skills and attitudes (attributes) the graduate of a formal engineering program should have. POs deal with the competencies and expertise a graduate possesses after completion of the program. There are 12 POs for Engineering and Technology Programs that are defined by the National Board of Accreditation.

Program Specific Outcomes (PSOs): The PSOs are more specific to the program and are designed by the department offering the program involving the stakeholders. There can be 2-4 program specific outcomes.

1.2 Direct and Indirect attainment of POs and PSOs

The attainment to evaluate program outcomes (POs) and program specific outcomes (PSOs) can be broadly classified into direct attainment and indirect attainment. Direct attainment is calculated jointly through the internal evaluation by the institute as well as the university examination. Indirect attainment is carried out through students' exit surveys.

1.3 Direct attainments of POs and PSOs for theory courses

POs in the Engineering and Technology programs -

Engineering Graduates will be able to:

PO-1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO-2 Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

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 the public health and safety, and the cultural, societal, and environmental considerations.

PO-4 Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO-5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitation.

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.

PO-7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO-8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO-9 Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO-10 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.

PO-11 Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply the set to one's own work, as a member and leader in a team, to manage projects and in multi-disciplinary environments.

PO-12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSOs are stated department wise.

2.1 Allocation of correlation levels between COs and POs/PSOs:

This process of setting correlation levels is typically known as CO-PO mapping. The correlation level between COs and POs/PSOs is depicted in a tabular format. The correlation levels between a CO and PO are set to either Low, Medium, or High which are represented by 1, 2, or 3 respectively. No correlation is kept empty.

In the Table 1 below, these correlation levels are shown in a variable form A_{mn} which denotes the correlation of m^{th} CO with n^{th} PO. Similarly the correlation level between m^{th} CO and k^{th} PSO is represented by another variable B_{mk} . It is important for a faculty to understand the impact of a course outcome on every program outcome. An effective teaching-learning process controlled by an appropriate Bloom's level governs the actual outcome attainments of learners. Therefore it is essential to align the evaluation process or the questions asked with the same Bloom's level as it is expected in the concerned CO. In case the above referred evaluation requirement does not exist in reality, the outcome computation becomes a misleading data set. Further it is needless to mention that in the Table 1 below, only a few selected A_{mn} and B_{mk} will be non-zero where the correlation between CO and PO/PSO actually exists.

Table 1. Articulation Matrix : The correlation between Course Outcome and Program Outcomes/ Program Specific Outcomes

Course (Course Code)															
CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO 1	A _{1,1}	A _{1,2}	A _{1,3}	A _{1,4}	A _{1,5}	A _{1,6}	A _{1,7}	A _{1,8}	A _{1,9}	A _{1,10}	A _{1,11}	A _{1,12}	B _{1,1}	B _{1,2}	B _{1,3}
CO 2	A _{2,1}	A _{2,2}	A _{2,3}	A _{2,4}	A _{2,5}	A _{2,6}	A _{2,7}	A _{2,8}	A _{2,9}	A _{2,10}	A _{2,11}	A _{2,12}	B _{2,1}	B _{2,2}	B _{2,3}
CO 3	A _{3,1}	A _{3,2}	A _{3,3}	A _{3,4}	A _{3,5}	A _{3,6}	A _{3,7}	A _{3,8}	A _{3,9}	A _{3,10}	A _{3,11}	A _{3,12}	B _{3,1}	B _{3,2}	B _{3,3}
CO 4	A _{4,1}	A _{4,2}	A _{4,3}	A _{4,4}	A _{4,5}	A _{4,6}	A _{4,7}	A _{4,8}	A _{4,9}	A _{4,10}	A _{4,11}	A _{4,12}	B _{4,1}	B _{4,2}	B _{4,3}
CO 5	A _{5,1}	A _{5,2}	A _{5,3}	A _{5,4}	A _{5,5}	A _{5,6}	A _{5,7}	A _{5,8}	A _{5,9}	A _{5,10}	A _{5,11}	A _{5,12}	B _{5,1}	B _{5,2}	B _{5,3}
CO 6	A _{6,1}	A _{6,2}	A _{6,3}	A _{6,4}	A _{6,5}	A _{6,6}	A _{6,7}	A _{6,8}	A _{6,9}	A _{6,10}	A _{6,11}	A _{6,12}	B _{6,1}	B _{6,2}	B _{6,3}
(Avg)	<u>A₁</u>	<u>A₂</u>	<u>A₃</u>	<u>A₄</u>	<u>A₅</u>	<u>A₆</u>	<u>A₇</u>	<u>A₈</u>	<u>A₉</u>	<u>A₁₀</u>	<u>A₁₁</u>	<u>A₁₂</u>	<u>B₁</u>	<u>B₂</u>	<u>B₃</u>

Average of all applicable correlation values for n^{th} PO, from $A_{1,n}$ to $A_{6,n} = \underline{A}_n$

$$\underline{A}_n = \frac{\sum_{m=1}^6 A_{m,n}}{N}$$

m = Row index varies from 1 to total number of COs in a particular course.

n = Column index for POs and varies from 1 to total number of POs in particular program

N = No. of COs mapped with the particular PO/PSO

Average of all applicable correlations values for k^{th} PSO, from $B_{1,k}$ to $B_{6,k} = \underline{B}_k$

$$\underline{B}_k = \frac{\sum_{m=1}^6 B_{m,k}}{N}$$

k = Column index for PSOs vary from 1 to total number of PSOs in particular program

List of COs of sample course is presented in Table 2 and its CO-PO mapping is shown in the Table 3 below.

Table 2. The Course Outcome format

COs	Course Name
Course Code.1	Course Outcome 1
Course Code.2	Course Outcome 2
Course Code.3	Course Outcome 3
Course Code.4	Course Outcome 4

Table 3. The correlation between COs and POs/ PSOs for the sample course

Course (Course Code)															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
Course Code.1						2							2		
Course Code.2	3			3											3
Course Code.3					1									2	
Course Code.4				2		2								3	
Course Code (Avg)	3	-	-	2.5	1	2	-	-	-	-	-	-	2	2.5	3

2.2 Calculation procedure – Attainment of Course Outcomes of theory examinations.

The evaluation weightages for the theory courses according to the Maharshi Dayanand University are as under

B.Tech	25% internal assessment and 75% university examination
BBA,BCA,MBA,MCA	20% internal assessment and 80% university examination
M.Tech	33.3% internal assessment and 66.7% university examination

2.3 Theory course’s assessment tools

The theory course evaluation process consists of Internal and University Examinations. Internal evaluation process includes Sessional Tests and Assignments.

2.4 Setting Course Outcome attainment targets for internal and university examinations

In every educational program, the concerned department is expected to decide on the target attainment levels. It is like setting one’s own program’s standards. If a low target is set, it becomes easy to attain but in long run it degrades educational quality or the program strengths. Therefore the attainment targets are gradually improved over the years so that enough challenges continue to exist in place to improve the quality. Table 4 presents the target attainment statements to be used for Internal Sessional Tests and the University Examinations.

Table 4. An example of CO attainment targets applicable to Internal And University Examinations

Attainment Level Achieved	If the following target is accomplished
1	50% students scoring 50% marks or more, out of the maximum marks
2	60% students scoring 50% marks or more, out of maximum marks
3	70% students scoring 50% marks or more, out of maximum marks

- It varies with the toughness level of course.

2.5 CO Attainment through internal Assessment Tools

The institute conducts two Sessional Tests in every semester. Every student has to submit two Assignments for each course. All the questions in the sessional test and assignments are mapped with the Course Outcomes. Based on marks obtained by the students for each COs in sessional tests and assignments, the CO weightage is calculated by giving 60% weightage to the sessional test and 40% to the assignments as presented in Table 5.

Table 5. CO Attainment through Internal Assessment Tools (Assignments + Sessional Tests)

S.No	Roll No.	Name	Total Marks	CO1	CO2	CO3	CO4	CO5	CO6
1	16CE001	MANISHA	33	4.8	5.2	6.6	10	6.2	0.4
2	16CE002	MENKA	34	3.4	4.4	7.4	11.4	4.6	2.4
3	16CE003	RAJNI	29	2.2	2.8	8.2	9.4	5.6	1.2
4	16CE004	SONIKA	29	4.4	6	3.6	10.4	3.4	0.8
5	16CE005	SRUTHI M NAIR	26	3.6	3.4	3.4	8.6	4.6	2
6	16CE006	SULEKHA	32	4.4	5.4	8.2	9	4	1.2
7	16CE007	ABHIMANYU KUMAR	32	4.4	5.6	6.8	9.4	5.6	0.4
8	16CE008	ABHISHEK KUMAR	28	3.6	4.8	8.2	6.8	4.6	0.4
9	16CE010	AMIT KUMAR	30	5.4	5	5.6	8.6	4.8	0.8
10	16CE011	AMIT KUMAR	35	3.6	5.2	10	10.4	5.2	0.4
Weightage of COs (60% of Sessional Test + 40% of Assignments)				4.4	9.2	7.2	7.2	10	4
Target Percentage of COs			50%	2.2	4.6	3.6	3.6	5	2
Percentage of Students Achieved CO target				100.00	70.00	90.00	100.00	40.00	20.00

The target set for the theory courses is decided by the department, say in this example is 50%. In Table 5 the weightage and target of COs is shown. For Example, the weightage of CO1 is 4.4 and the target is 2.2 (50% of the weightage). The percentage of students who score equal to or more than 2.2 is calculated. Here, 100% of students achieved the target of CO1. Similarly, the percentage of students who achieved the target is calculated and presented in Table 5.

2.6 CO Attainment through External Assessment Tools

The university examinations for every program are conducted semester wise. The CO wise marks are calculated from the university question papers. Say for example, in B.Tech Program the question paper is of 180 marks (9 questions, 20 marks each) and the students have to attempt 5 questions (Maximum 100 marks). The COs are calculated according to 180 marks and converted into weightage of 100 marks. Then from the marks obtained by the students in University examinations, the percentage of students achieving the target is calculated as presented in Table 6.

Table 6. CO Attainment through External Assessment Tools (University Exams)

S.No	Roll No.	Name	Total Marks 100	CO1	CO2	CO3	CO4	CO5	CO6
1	16CE001	MANISHA	30	1.67	13.33	8.33	3.33	1.67	1.67
2	16CE002	MENKA	80	4.44	35.56	22.22	8.89	4.44	4.44
3	16CE003	RAJNI	42	2.33	18.67	11.67	4.67	2.33	2.33
4	16CE004	SONIKA	64	3.56	28.44	17.78	7.11	3.56	3.56
5	16CE005	SRUTHI M NAIR	57	3.17	25.33	15.83	6.33	3.17	3.17
6	16CE006	SULEKHA	53	2.94	23.56	14.72	5.89	2.94	2.94
7	16CE007	ABHIMANYU KUMAR	30	1.67	13.33	8.33	3.33	1.67	1.67
8	16CE008	ABHISHEK KUMAR	52	2.89	23.11	14.44	5.78	2.89	2.89
9	16CE010	AMIT KUMAR	12	0.67	5.33	3.33	1.33	0.67	0.67
10	16CE011	AMIT KUMAR	50	2.78	22.22	13.89	5.56	2.78	2.78
Weightage of COs in University Examination				5.56	44.44	27.78	11.11	5.56	5.56
Target Percentage of COs			50%	2.78	22.22	13.89	5.56	2.78	2.78
Percentage of Students Achieved CO target				60.00	60.00	60.00	60.00	60.00	60.00

2.7 Direct CO Attainment through External and Internal Assessment Tools

The combined CO attainment, calculated through external and internal assessment tools is presented in Table 7. The 70% weightage is given to the target achieved through external assessment tools and 30% weightage is given to the target achieved through internal assessment tools. Accordingly the Direct CO attainment level is calculated by using the target set shown in Table 4.

For Example, the attainment for CO1 is 3 as the percentage of students achieved the target is 72%. Similarly the Direct CO attainment level for the entire COs is calculated and presented in Table 7.

Table 7. Direct CO Attainment through External and Internal Assessment tools

CO	Percentage of Students who have achieved Target Through External Assessment Tools	Percentage of Students who have achieved Target Through Internal Assessment Tools	Percentage of Students who have achieved Target =External * 0.7 + Internal * 0.3	Direct CO Attainment Level (X _m)
CO1	60	100	72	3
CO2	60	70	63	2
CO3	60	90	69	2
CO4	60	100	72	3
CO5	60	40	54	2
CO6	60	20	48	1

External

CO1 target of 50% achieved by 60% students
CO2 target of 50% achieved by 60% students
CO4 target of 50% achieved by 60% students
CO5 target of 50% achieved by 60% students
CO6 target of 50% achieved by 60% students

Combined

CO1 target of 50% achieved by 72% students
CO2 target of 50% achieved by 63% students
CO3 target of 50% achieved by 69% students
CO4 target of 50% achieved by 72% students
CO5 target of 50% achieved by 54% students
CO6 target of 50% achieved by 48% students

Internal

CO1 target of 50% achieved by 100% students
CO2 target of 50% achieved by 70% students
CO4 target of 50% achieved by 100% students
CO5 target of 50% achieved by 40% students
CO6 target of 50% achieved by 20% students

Attainment Level

CO1 Attainment Level is 3
CO2 Attainment Level is 2
CO3 Attainment Level is 2
CO4 Attainment Level is 3
CO5 Attainment Level is 2
CO6 Attainment Level is 1

2.8 Indirect CO Attainment through Course Exit Survey

The Course Exit Survey is taken from the students to calculate the Indirect attainment. The CO wise average score is considered for the CO achieved.

2.9 Calculation procedure – PO and PSO direct attainment level for a theory course

The procedure for calculating direct attainment level of the PO and PSO through Internal and External assessment tools is given below and presented in Table 8.

Direct PO Attainment -

$$\underline{PO}_n = \frac{\sum_{m=1}^6 C_m PO * X_m}{3 * (\text{No. of COs mapped with } PO_n)}$$
$$\underline{PO}_1 = \frac{2 * 3 + 2 * 2 + 1 * 3 + 1 * 2}{3 * 4} = 1.25$$

Direct PSO Attainment -

$$\underline{PSO}_n = \frac{\sum_{m=1}^6 C_m PSO * X_m}{3 * (\text{No. of COs mapped with } PSO_n)}$$

PO_n = PO number

$C_m PO$ = CO_m mapped with particular PO

X_m = Direct CO Attainment Level

\underline{PO}_n = PO Attained

\underline{PSO}_n = PSO Attained

Table 8. Direct PO Attainment through External and Internal Assessment tools

CO	Direct CO Attainment Level (X _m)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1		1			1						2		
CO2	2		2		2	1									2	
CO3	2	2		2	2	1	2								2	
CO4	3	1	1		2			1								2
CO5	2	1					2									
CO6	1															
Direct PO Attainment		1.25	1.11	1.33	1.42	0.67	1.33	1.00						2.00	1.33	2.00

2.10 Calculation procedure – PO and PSO Indirect attainment level for a theory course

The calculation of PO and PSO attainment is calculated in Similar Way as Direct PO & PSO are calculated and presented in Table 9.

Indirect PO Attainment -

$$\underline{PO}_n = \frac{\sum_{m=1}^6 C_m PO * Y_m}{3 * (No. of COs mapped with PO_n)}$$

$$\underline{PO}_1 = \frac{2 * 3 + 2 * 2 + 1 * 3 + 1 * 2}{3 * 4} = 1.25$$

Indirect PSO Attainment -

$$\underline{PSO}_n = \frac{\sum_{m=1}^6 C_m PSO * Y_m}{3 * (No. of COs mapped with PSO_n)}$$

PO_n = PO number

$C_m PO$ = CO_m mapped with particular PO

Y_m = Indirect CO Attainment Level

\underline{PO}_n = PO Attained

\underline{PSO}_n = PSO Attained

Table 9. Indirect PO Attainment through Course Exit Survey

CO	Indirect CO Attainment Level (Yi)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1		1			1						2		
CO2	3		2		2	1									2	
CO3	2	2		2	2	1	2								2	
CO4	3	1	1		2			1								2
CO5	2	1					2									
CO6	2															
Indirect PO Attainment		1.25	1.33	1.33	1.58	0.83	1.33	1.00						2.00	1.67	2.00

2.11 Calculation procedure – PO and PSO overall attainment level for a theory course

The calculation for the overall PO attainment is shown in this section. The 80% weightage is given to Direct PO attainment and 20% weightage is given to Indirect PO attainment as shown in Table 10.

Table 10. PO Attainment (Direct + Indirect)

Program Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	P O 8	P O 9	P O 10	P O 11	P O 12	PS O1	PS O2	PS O3
Direct PO Attainment	1.25	1.11	1.33	1.42	0.67	1.33	1.00						2.00	1.33	2.00
Indirect PO Attainment (Course Exit Survey)	1.25	1.33	1.33	1.58	0.83	1.33	1.00						2.00	1.67	2.00
Overall PO attained (80% Direct + 20% Indirect)	1.25	1.16	1.33	1.45	0.70	1.33	1.00						2.00	1.40	2.00

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

Example for PO₂=80/100*1.11+20/100*1.33=1.16

Referring to a sample calculation, other calculated values of POs and PSOs attainments are presented in the Table 10 above.

3. Closure: Attainment levels of all the courses taught in a session are computed as per the procedure described in this section and compiled in a tabular form separately for each PO and PSO. Similarly the PO and PSO attainments of other courses are also evaluated and combined in the same table. Once all the courses are included in the attainments, the gap identification process is deployed and remedial measures are decided and placed into practice.