Graduate Attributes and Formulation of Programme Outcomes for Undergraduate Degree Programme in Mechanical Engineering

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Abstract: **National Board of Accreditation, India (NBA) has introduced recently concept of Graduate Attributes (GAs) for accreditation of undergraduate engineering degree programmes, in tune with the Indian membership of Washington Accord. The anticipation is that the institutions will formulate Programme Outcomes (POs) aligned to GAs. Due to introduction of GAs it has become necessary for the institutions to prepare themselves for the change, before they go for accreditation or re-accreditation. This paper looks at**

(a) Changes in the accreditation philosophy by NBA over the years,

(b) Graduate Attributes (GAs) and their relationship with Programme Outcome (POs),

(c) Conceptual framework of outcome based accreditation, including concepts of Programme Educational Objectives (PEOs), GAs, POs and Course Outcomes (COs), and

(d) POs which could be fulfilled by various courses by Rajasthan Technical University (RTU) syllabus of Mechanical Engineering applicable for students admitted during academic year 2012-2013.

Keywords: **ABET, Accreditation of UG Degree programmes, Course Outcomes (COs), Graduate Attributes (GAs), International Engineering Association (IEA), Mechanical Engineering Degree, National Board of Accreditation (NBA), Programme Educational Objectives (PEOs), Programme Outcomes (POs) Rajasthan Technical University (RTU), RTU Syllabus, Washington Accord.**

1. INTRODUCTION

National Board of Accreditation [NBA] is the accrediting body for the accreditation of Engineering and Management programmes in India. Over the years, a lot of changes were brought about in the accreditation philosophy and processes by NBA. Banthiya [1, 2] considered changes which were made in accreditation philosophy and processes at those times. This paper is an update of these papers and includes changes which have occurred in the accreditation process in India since then.

US Accreditation agency for engineering degree programmes ABET [3] used the concepts of Programme Educational Objectives (PEOs) and Programme Outcomes (POs). Major change in accreditation in India was from resource-based accreditation to outcome-based accreditation, which was primarily derived from ABET. In the NBA Manual of Accreditation of June 2009 [4], the concepts of PEOs and POs were adopted. These concepts required that institutions relook at the syllabus or programme offering, which is usually decided by affiliating universities to examine whether anticipated PEOs and POs were achieved by the programme.

Change over to outcome-based accreditation by NBA was the first step undertaken by NBA to become a full member of the Washington Accord. The Washington Accord is an International Agreement among various accrediting bodies in the world for accrediting undergraduate engineering degree programmes. The Accord recognizes the 'substantial equivalency of under-graduate degree programmes accredited by each of these bodies'. Further, it recommends that graduates of programmes accredited by any of the bodies be recognized by the other bodies as 'having met the academic requirements for entry to the practice of engineering in the area of their jurisdiction' [5]. International Engineering Association (IEA) administers the Washington Accord.

National Board of Accreditation has become a permanent member of the Washington Accord on 13th June 2014 [5]. The NBA accredited programmes offered by the Tier -I Institutions are eligible for the recognition of the programmes by other signatories of the Washington Accord [5]. Tier-I institutions are primarily institutions which have academic autonomy, like NITs and Universities running their own programmes. Institutions which do not have academic autonomy are Tier-II institutions, and do not qualify for equivalence under the Washington Accord. Most of the institutions in the country whether government or private do not have academic autonomy, and are thus deprived of Washington Accord status.

After India has become a member of Washington Accord, concept of Graduate Attributes (GAs) has been introduced by NBA [6, 7]. The concept has been adopted from IEA [8, 9].

There is virtually no difference in the accreditation process for Tier-I and Tier-II institutions. Tier II institutions do not have any academic autonomy. Tier-II institutions are also required to use concepts of PEOs, GAs and POs.

In this paper, the main focus is on Graduate Attributes and POs derived from GAs. Current syllabus introduced from session 2012-2013 for B.Tech. Programme in Mechanical Engineering of Rajasthan Technical University (RTU) is being used for analysis [10, 11]. The purpose of this paper is mainly to establish a procedure for such analysis. In the previous paper [2], syllabus applicable at that time was used for analysis [12, 13].

2. GRADUATE ATTRIBUTES (GAS)

Concept of Graduate Attributes in the university education has been under discussion in the literature for a number of years. Barrie [14, 15] states:

"Various forces acting on higher education globally have fueled the re-emergence of universities' claims of 'graduate attributes' Chief amongst these forces have been calls for universities to produce more employable graduates."

Barrie [14] quotes from HEC [16] as follows:

"Generic graduate attributes have come to be accepted as being the skills, knowledge and abilities of university graduates. Beyond disciplinary content knowledge, which are applicable in a range of contexts and are acquired as a result of completing any undergraduate degree. They should represent the core achievements of a university education."

Bowden et al. stated [17]:

"Graduate attributes are the qualities, skills and understanding a university community agrees its students should develop during their time with the institution. These attributes include but go beyond the disciplinary expertise or technical knowledge that has traditionally formed the core of most university courses. They are qualities that also prepare graduates as agents of social good in an unknown future."

Graduate attributes thus may have following characteristics:

a) These include knowledge, skills and attitudes (qualities) which a student should develop,
b) These are qualities which prepare graduates as agents of social good,
c) Attributes go beyond technical or content knowledge related to programme, and
d) Acquisition of those attributes which improve employability.

Recent NBA Manuals [6, 7] introduce the concept of Graduate Attributes (GAs). GAs have been incorporated in NBA documents after India became member of Washington Accord. International Engineering Alliance (IEA) documents on Graduate Attributes [8, 9] state 'Graduate attributes' form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practise at the appropriate level. The graduate attributes are exemplars of the attributes expected of graduate from an accredited programme. Graduate attributes are clear, succinct statements of the expected capability, qualified if necessary by a range indication appropriate to the type of programme.' NBA has also adopted same GAs in recent NBA Manuals.

Graduate attributes from IEA and NBA are given in the first column of Table 1. Examples given in NBA document have been removed in the Table.

It can be seen from the Table that GAs for undergraduate engineering education also have characteristics as stated above. In addition, these also bring about uniformity in expectations from graduates of accredited programmes in the world; thus providing mobility for employment anywhere in the world. It can however be mentioned again that this privilege will not be available to accredited programmes run by Tier-II institutions. Also majority of institutions in the country fall in Tier-II category.

3. GRADUATE ATTRIBUTES (GAs) AND PROGRAMME OUTCOMES (POs)

NBA Guidelines of 2009 [4] defined Programme Outcomes as, "The programme outcomes are the skills and knowledge which the students have at the time of graduation. The outcomes essentially indicate what a student can do from subject wise knowledge acquired during the programme."

Programme Outcomes (a) to (k) were suggested in Annexure I of NBA Guidelines of 2009 [4] for any engineering degree programme. It was stated that the outcomes may be programme specific within broad categories given. These were further elaborated as samples for degrees in Electrical & Electronics Engineering, Mechanical Engineering and Chemical Engineering.

In NBA Self Assessment Report of 2011 [18], Programme Outcomes were defined as, "Programme outcomes are narrower statements that describe what students are expected to know, and be able to do by the time of graduation. These relate to the skills, knowledge and behaviours that students acquire in their matriculation through the programme."

It can be seen that there has been change in thinking about POs, as the later definition also includes 'behaviours'. It was also stated that programme outcomes are (a) through (k) plus any outcomes that could be articulated by the programme. These (a) through (k) lists in the 2009 and 2011 are different, though there are number of similarities.

Mechanical Engineering Department at Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur (SKIT) adopted / adapted following Programme Outcomes for undergraduate degree programme in [19, 20].

"Mechanical Engineering degree programme at SKIT would demonstrate that graduates attain the following outcomes:

a) An ability to apply knowledge of mathematics, science, and engineering,
b) An ability to design and conduct experiments, as well as to analyze and interpret data,
c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability,
d) An ability to function on multidisciplinary teams,
e) An ability to identify, formulate, and solve engineering problems,
f) An understanding of professional and ethical responsibility,
g) An ability to communicate effectively,
h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context,
i) A recognition of the need for, and an ability to engage in

life-long learning,

j) A knowledge of contemporary issues,

k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

l) An understanding of quality management, project management, entrepreneurship and safety engineering.

m) An understanding of nuclear power plants, and

n) A knowledge of institutions/organizations/companies related to mechanical engineering in surrounding areas."

In current Accreditation Manual [6], definition of Programme Outcomes continues to remain the same as above. However, it has been mentioned that "the POs formulated for each programme by the institute must be consistent with NBA's Graduate Attributes." Also it has been stated that "The programme will indicate the process involved in defining and redefining POs. It should also describe the process that documents and demonstrates periodically that the POs are based on the needs of the stakeholders of the programme. The extent to which the POs are aligned to the Graduate Attributes prescribed by the NBA shall be provided."

Thus it can be seen that for POs, alignment to Graduate Attributes has become essential. Table 1 gives GAs and POs arrived by Mechanical Engineering faculty at SKIT, Jaipur. Table shows alignment of POs with GAs. While formulating POs, previous POs and views of some of the stake holders have also been considered. In this Table, third column gives Sample Programme Outcomes which can be adopted / adapted in various courses, in the same way or after modifications applicable to the courses. POs as well as sample POs may change as the discussion process continues. POs have also been influenced by current prescribed syllabus of RTU, which has included a number of new courses [10, 11]. It can be seen that number of POs formulated is more than GAs.

Table 1: Graduate Attributes: Relationship with Proposed Programme Outcomes for Department of Mechanical Engineering at Swami Keshvanand Institute of Technology, Management & Gramothan

Graduate Attributes from NBA [6]	Proposed Programme Outcomes (Based on Graduate Attributes)	Sample Programme Outcomes which can be achieved in various courses
	Mechanical Engineering degree programme at SKIT would demonstrate that graduates attain the following outcomes:	Students will be able to
1. Engineering knowledge: Apply the knowledge of mathematics, science, Engineering fundamentals, and an engineering specialisation for the solution of complex engineering problems.	**1. Engineering knowledge :** An ability to apply the knowledge of mathematics, science, engineering fundamentals and mechanical engineering courses for the solution of engineering problems.	1.1 Understand (c*ourse and its important /essential concepts, principles, theories etc.).* 1.2 Apply (*important / essential concepts, principles, theories etc.)* for the solution of problems. 1.3 Use appropriate knowledge of mathematics, science, engineering science and other courses for solving complex problems.
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.	**2. Problem analysis :** An ability to identify, formulate, research literature, and solve engineering problems using mathematics, sciences, and engineering sciences.	*(Related to the course/s)* 2.1 Identify a problem. 2.2 Formulate the problem. 2.3 Research literature related to the problem. 2.4 Solve problem using appropriate (*courses and tools)*
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.	**3. Design / development of solutions:** An ability to design system components or processes that meet the specified needs with appropriate considerations for public health and safety, and cultural, societal, and environmental considerations.	3.1 Appreciate considerations of public health and safety, and cultural, societal, and environmental issues during designing process. 3.2 Apply considerations of public health and safety, and cultural, societal, and environmental issues during designing process. 3.3 Design (*system components / processes*) for (*specified*) needs and other considerations.
4. Conduct investigations of complex problem	4. **Conduct investigations of complex problems :** An ability to conduct investigations for solving problems.	4.1Use experimental skills related to the course(s). 4.2 (*For a problem)* determine alternative ways of solving the problem. 4.3 Using available resources in (*laboratory / laboratories / workshops*), and time constraint, solve / investigate the problem. 4.4 Present findings appropriately.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and Modelling to complex engineering activities, with an understanding of the limitations.	**5. Modern tool usage :** An ability to create, select and use appropriate techniques, skills, resources, and modern engineering and IT tools.	5.1 Use techniques / skills related to (*course* / *various courses*). 5.2 Select and use appropriate techniques / skills / resources when required 5.3 Create a new tool as and when required. 5.4 Use various IT tools.
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. The engineer and society :** An ability to assess societal, health, safety, legal, and cultural issues for responsibilities relevant to the profession / practice of engineering, specifically mechanical engineering	6.1 Understand and apply societal, health, safety, legal and cultural issues falling in the domain of engineering profession / practice, specifically mechanical engineering. 6.2 Appreciate responsibilities of an engineer at different levels. 6.3 Appreciate principles of sociology and economics as a citizen and engineer.
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.	**7. Environment and sustainability:** Understand the impact of the engineering solutions in societal and environmental contexts, and ability to demonstrate the knowledge of, and need for sustainable development.	7.1 Understand environment related issues. 7.2 Understand sustainable development and its need. 7.3 Understand the impact of engineering solutions on society and environment.
8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	**8. Ethics:** Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	8.1 Appreciate responsibilities and norms of engineering practice. 8.2 Apply ethical principles in different situations.
9.Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	**9.Individual and team work:** An ability to function effectively as an individual, and as a member or leader in diverse teams, and also in multidisciplinary settings.	9.1 Work as a member and/or leader of a team in different settings e.g. laboratory / workshop / industry visit/ project / organizing seminars & conferences / organizing and participating in extra and co-curricular activities.
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.	**10. Communication:** An ability to communicate effectively with the engineering community and with the society at large.	10.1 Answer questions in writing or orally on prescribed readings. 10.2 Prepare engineering drawings. 10.3 Read engineering drawings, for the purpose of giving proper instructions. 10.4 Prepare appropriate PPTs. 10.5 Write appropriate reports for problem solving exercises / design problems / seminars / industry visits / practical training / project work etc. 10.6 Make oral presentations in different situations, including with PPTs. 10.7 Listen to presentations and report back about understanding. 10.8 Give and receive clear instructions.
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 manage projects and in multidisciplinary environments.	**11. Project management and finance:** An ability to demonstrate knowledge and understanding of project management principles and apply these to manage projects.	11.1 Understand project management principles. 11.2 Apply project management principles in different situations, especially during industry visits and project work.
12. Life- long learning: Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	**12. Life - long learning:** An ability to recognise the need for, and have the preparation and ability to engage in independent and life-long learning.	12.1 Recognise the need of independent and lifelong learning. 12.2 Use library, internet and other resources in different settings.
	13. An awareness of contemporary issues	13. Show awareness about contemporary issues.
	14. Participate and succeed in competitive examinations.	14.1 Show proficiency in soft skills. 14.2 Show proficiency in courses relevant for success in competitive examinations.

3. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

In June 2009 Manual of NBA [4], Programme Educational Objectives were defined as, "The statements that describe the expected achievements of graduates within first few years of their graduation from the programme." It was further stated that, "These 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 programme must continuously work with local employers, industry and RD advisors, and the alumni." Also sample examples for PEOs were given for under-graduate degree programmes in Mechanical Engineering and Chemical Engineering. Based on above, following PEOs were adopted for Mechanical Engineering degree programme at [19].

I. Preparation: To prepare students for excelling in postgraduate programmes or to succeed in industry through rigorous education.

II. Core Competence: To provide students with a sound foundation in mathematical, scientific and engineering fundamentals necessary to formulate, solve and analyze engineering problems and also to prepare them for higher studies.

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

IV. Professionalism: To inculcate in students professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate engineering issues to broader social context.

V. Learning Environment: To provide students with an academic environment aware of excellence, leadership, written ethical codes and guidelines, and the life-long learning needed for a successful professional career.

It can be seen that most of the PEOs adopted were those given in Annexure I of [4] with slight changes. It can be seen that ABET also gave similar PEOs [3].

In [18], PEOs were defined as, "These are broad statements that describe the career and professional accomplishments that the programme is preparing the graduates to achieve."

Some points for framing PEOs were also suggested. In the light of these, PEOs were modified as follows:

"Mechanical engineering programme at SKIT will produce graduates who will be:

I. Suitable for employment, venturing own business enterprise or pursuing higher studies.

II. Capable mechanical engineers with the requisite knowledge, skills and attitudes.

III. Responsible citizens, competent leaders, good team workers, good human beings and ethical engineers."

Mechanical Engineering Department at SKIT is still keeping these PEOs. It has started consulting stakeholders for reframing PEOs.

4. COURSE OUTCOMES (COs)

A programme has a large number of prescribed courses (subjects) in which a student has to attain at least minimum proficiency level (usually marks or grades), as prescribed by the affiliating University for obtaining the degree. Usually University provides a syllabus which has to be followed by the institution. Syllabus provides a teaching scheme and prescribed content for each course. It does not provide outcomes or objectives of the courses.

For accreditation purpose or otherwise, each course in the programme will have its outcomes i.e. "what a student would be able to do at the end of the course." Course outcomes for a course will have to be formulated by faculty members teaching the course. Course outcomes for a course have to be consistent with POs for that course.

This activity has been undertaken by faculty members of the Department of Mechanical Engineering at SKIT.

5. COURSE OUTCOMES (COs), GRADUATE ATTRIBUTES (GAs), PROGRAMME OUTCOMES (POs) AND PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

Figure 1 shows diagrammatically the relational framework of various concepts discussed in this paper.

a) Each course in a programme will have Course Outcomes. Achievement of Course Outcomes of all the courses combined would lead to achievement of Programme Outcomes by students.

b) As Programme Outcomes are mainly formulated on the basis of Graduate Attributes, achievement of Programme Outcomes would lead to achievement of Graduate Attributes by passouts.

c) Achievement of Programme Outcomes and additional training/work for about four to five years after graduation would lead to achievement of PEOs.

At every stage, gaps will have to be found in contents, processes and other activities and additional inputs will have to be provided.

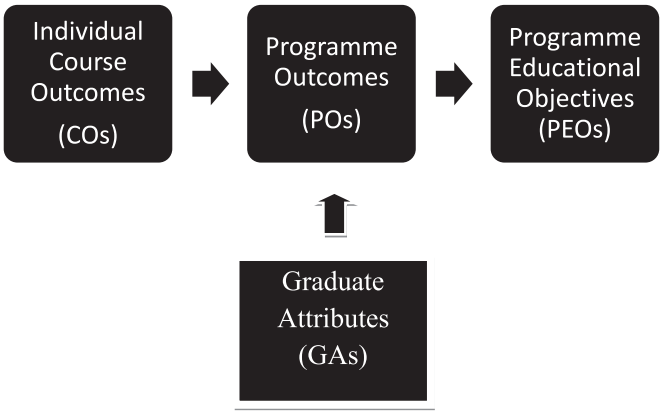

Fig 1: Relationship between Individual Course Outcomes (COs), Graduate Attributes (GAs), Programme Outcomes (POs) and Programme Educational Objectives (PEOs)

6. ANALYSIS OF RAJASTHAN TECHNICAL UNIVERSITY (RTU) SYLLABUS FOR B.TECH. MECHANICAL ENGINEERING ON THE BASIS OF PROGRAMME OUTCOMES

RTU was established in the year 2006-2007. It has a common syllabus for all branches for the First (I) and Second (II) Semesters. Each branch has its own syllabus from the Third (III) semester onwards. Current syllabi, applicable from batch admitted during 2012-2013 session for different branches of engineering are available on Rajasthan Technical University website.

A detailed analysis of the syllabus existing in 2009-2010 was done in [2].

Analysis of the present syllabus of Mechanical Engineering [10, 11] has been undertaken in the department. Preliminary data about the analysis is presented in Table 2. At present, this new syllabus is being implemented up to VL Semester. VIII semester students are having courses according to the old RTU syllabus.

As shown in Figure 1, each course will have its own outcomes, which cumulatively will result in Programme Outcomes. There are courses (theory, practicals / sessionals), variety of learning experiences (laboratory, workshop, drawing, design, Practical Training, Industrial Visits, Project work, Seminar, interaction with external experts, conferences, extra and co-curricular activities) and learning spaces (classrooms, laboratories, workshops, drawing halls, computer centre, industries, playgrounds etc.); for which it may be worthwhile for institutions to identify outcomes in line with POs. Table 2 gives possible Programme Outcomes which could be achieved by various courses prescribed. Programme Outcomes are dependent on nature of learning experiences and perceived methodology by faculty and learning spaces where students go/would go through these experiences. Table is based on work undertaken by the faculty, and may get modified during further discussions among concerned faculty members. The programme outcomes would be possible only if sufficient attention would be paid in planning each course and implementing it in the right spirit.

To do the analysis for each course the possibility of achieving each outcome has been given weights as follows:

1. To a little extent
2. Average extent
3. To a large extent

This data for each course with weightages as above is given in Table 2.

Table 2: Prescribed Courses by RTU and Achievement of Programme Outcomes (POs) for batch admitted in 2012-2013

Legend: ( ) Indicate weightage of an elective course, and not included in the total.

Code	Courses	Programme Outcomes Weightages													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
	I Semester														
101	Communicative English										1				
102	Engineering Mathematics-I	1													1
103	Engineering Physics-I	1													
104	Engineering Chemistry	1													
105	Basic Electrical & Electronics Engineering	1													
106	Engineering Physics Lab-I	1			1										
107	Engineering Chemistry Lab	1			1										
108	Electrical & Electronics Lab	1			1										
109	Practical Geometry	1									1				
110	Workshop Practice	1				1	1	1							
111	Discipline & Extra Curricular Activities									1				1	
	Total I Semester	9	0	0	3	1	1	1	0	1	2	0	0	1	1
	II Semester														
201	Communication Techniques										1				
202	Engineering Mathematics-II	1													1
203	Engineering Physics- II	1													
204	Chemistry & Environmental Engineering Lab	1						1							

Code	Courses	Programme Outcomes Weightages													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
205	Engineering Mechanics	1	1												1
206	Fundamentals of Computer Programming	1				1									
207	Engineering Physics Lab-II	1			1										
208	Chemistry & Environmental Engineering Lab	1			1			1							
209	Computer Programming lab	1				1									
210	Machine Drawing	1									1				
211	Communication Technique Lab										1				
212	Discipline & Extra Curricular Activities									1				1	
	Total II Semester	9	1	0	2	2	0	2	0	1	3	0	0	1	2
	III Semester														
3ME1A	Mechanics of Solids-I	1	1												1
3ME2A	Material Science and Engineering	1	1												1
3ME3A	Engineering Thermodynamics	1	1												1
3ME4A	Manufacturing Processes	1	1												1
3ME5A	Object Oriented Programming in C ++	1				1									
3ME6A	Advanced Engineering Mathematics	1													1
3ME7A	Material Science and Testing Lab	1			1					1					
3ME8A	Basic Mechanical Engineering Lab	1			1					1					
3ME9A	Production Practice – I	1			1	1									
3ME10A	Computer Programming Lab	1				1					1				
3ME11A	Mechanical Engineering Drawing	1													
3MEDC	Discipline & Extra Curricular Activities									1				1	
	Total III Semester	11	4	0	3	3	0	0	0	3	1	0	0	1	5
	IV Semester														
4ME1A	Kinematics of Machines	1	1												1
4ME2A	Fluid Mechanics & Machines	1	1												1
4ME3A	Machining & Machine Tools	1	1												1
4ME4A	Design of Machine Elements – I	1		1											1
4ME5A	Industrial Engineering	1	1												1
4ME6A	I.C. Engines	1	1												1
4ME7A	Kinematics of Machine Lab	1			1					1					
4ME8A	Fluid Mechanics Lab	1			1					1					
4ME9A	Production Practice-II	1			1					1					
4ME10A	Machine Design Sessional - I	1		1											
4ME11A	Thermal Engineering Lab-I	1			1					1					
4MEDC	Discipline & Extra Curricular Activity									1				1	
	Total IV Semester	11	5	2	4	0	0	0	0	5	0	0	0	1	6
	V Semester														
5ME1A	Heat Transfer	1	2												1
5ME2A	Dynamics of Machines	1	1												1
5ME3A	Measurement & Metrology	1	2												1
5ME4A	Quality Assurance and Reliability	1	2												1
5ME5A	Sociology and Economics for Engineers	1					1							1	
5ME6.2A	Automobile Engg.	1	1												
5ME7A	Heat Transfer Lab	1			2										
5ME8A	Dynamics of Machines Lab	1			1										
5ME9A	Production Engineering Lab	1			2										
5ME10A	Professional Ethics and Disaster Management						1	2	2		1				
5MEDC	Discipline & Extra Curricular Activities									1				1	
	Total V Semester	8	7	0	5	0	2	2	2	1	1	0	0	2	4
	VI Semester (Courses from January 2015)														
6ME1A	Design of Machine Elements – II	1		2											1
6ME2A	Newer Machining Methods	1	1												1

Code	Courses	Programme Outcomes Weightages													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
6ME3A	Mechatronics	1	1												
6ME4A	Vibration Engineering	1	1	1											1
6ME5A	Steam Engineering	1	1												1
	Electives														
6ME6.1A	Non Destructive Evaluation and Testing	(1)	(1)												
6ME6.2A	Design and Manufacture of Plastic Products	(1)		(1)											
6ME6.3A	Maintenance Management	(1)	(2)	(1)						(1)					
6ME7A	Machine Design Sessional –II	1		2											1
6ME8A	Industrial Engineering Lab-I	1			2	1				1					
6ME9A	Mechatronics Lab	1			1	1				1					
6ME10A	Vibration Engineering Lab	1			1					1					
6MEDC	Discipline & Extra Curricular Activities									1				1	
	Total VI Semester	11	4	5	4	2	0	0	0	4	0	0	0	1	4
	VII Semester (Courses from July 2015)														
7ME1A	Finite Element Methods	1	1			1									
7ME2A	Refrigeration & Air-conditioning	1	1					1							1
7ME3A	Operations Research	1	1												1
7ME4A	Turbomachines	1	1												1
7ME5A	Operations Management	1	1												1
	Electives														
7ME6.1A	Micro and Nano Manufacturing	(1)	(1)			(1)									
7ME6.2A	Robotics	(1)	(1)			(1)									
7ME6.3A	CNC Machines and Programming	(1)	(1)			(1)									
7ME7A	Thermal Engineering Lab-II	1			1	1				1					
7ME8A	FEM Lab	1			1	r				1					
7METR	Practical Training & Industrial visit									1	2	1	1		
7MEPR	Project-1 *(Depending upon nature of project)*		1	1	1	1				1	2	2	2		
7MEDC	Discipline & Extra Curricular Activities									1				1	
	Total VII Semester	7	6	1	3	4	0	1	0	5	4	3	3	1	4
	VIII Semester (Courses from January 2016)														
8ME1A	Computer Integrated Manufacturing Systems	1	1												
8ME2A	Laws for Engineers	1					1							1	
8ME3A	Power Generation	1	1												1
	Electives														
8ME4.1A	Product Development and Launching	(1)		(1)	(1)										
8ME4.2A	Computational Fluid Dynamics	(1)	(1)			(1)									
8ME4.3A	Total Quality Management	(1)	(1)					(1)							
8ME5A	CAM Lab	1	1			1				1					
8ME6A	CAD Lab	1			1	1				1					
8ME7A	Industrial Engineering Lab – II	1	1		1					1					
8MEPR	Project-1I *(Depending upon nature of project)*		1	1	1	1			1	1	2	2	2		
8MESM	Seminar *(Participating and presenting)*										2	1	2		
8MEDC	Discipline & Extra Curricular Activities									1				1	
	Total VIII Semester	6	5	1	3	3	1	0	1	5	4	3	4	1	1
	Grand Total	70	32	9	29	15	4	5	3	25	15	6	7	9	28

From the data given in Table 2, it can be seen that

a) There will be ample opportunity for fulfilling PO1 related to Engineering Knowledge. However, there has to be shift towards application of knowledge in various courses.

b) There will be opportunity for achieving PO2 related to Problem Analysis. However, faculty members will have to involve students in such a way that they understand aspects of problem analysis.

c) PO3, Design / Development of Solutions\ finds comparatively low weightage, as opportunity for this is limited in the syllabus. Some more additional efforts will be required.

d) PO4, Conduct investigations of complex problems, has sufficient opportunity to achieve. However, laboratory work has to be specifically planned to achieve the outcome.

e) Though PO5, Modern tool usage, is showing small weightage, faculty in courses other than identified, would have to be encouraged to use modern tools in their courses.

f) PO6, The Engineer and Society; PO7, Environment and Sustainability and PO8, Ethics; have very small weightages in the courses. However, institutions can introduce these aspects in more courses and cover these by other activities.

g) PO9, Individual and Team Work has fairly good weightage. However, achievement of this PO will depend on processes being followed during laboratory, sessional, industrial tour, project, extra and co-curricular activities.

h) PO10, Communication has average weightage. Communication has not been included in many courses, where it does occur. More emphasis will be required from the perspective of employability of graduates.

i) PO11, Project Management & Finance has very low weightage. There is no specific course on this aspect. A course may have to be planned specifically for this purpose to fill in the gap.

j) PO12, Life-long Learning has comparatively low weightage. It may have to be increased in planned way by prescribing library work in various courses.

k) PO13, Awareness of Contemporary Issues finds low weightage, as usually it does not form part of any course.

l) PO14, Competitive Examination is finding good weightage. Usually institutions organize Soft Skills Classes to make students competent in Soft Skills. Also institutions can arrange classes for GATE and other competitive examinations.

7. CONCLUSIONS

The paper looked at the features of outcome-based accreditation adopted by National Board of Accreditation (NBA). With India becoming member of Washington Accord a new concept of Graduate Attributes (GAs) has been adopted, in addition to earlier concepts of Programme Education Objectives (PEOs), Programme Outcomes (POs) and Course Outcomes (COs). Paper converted GAs into POs for adoption by the Department of Mechanical Engineering at SKIT, Jaipur for their under-graduate degree programme. The paper also analysed Rajasthan Technical University (RTU) new syllabus introduced in 2012-2013 session from the point of achievement of POs, and thus GAs. The purpose of this paper is mainly to establish a procedure for such analysis.

It can be stated that most of the POs can be achieved by proper strategies in the institutions. Some additional inputs and activities however will be required. A few of these have been suggested in the paper.

8. ABBREVIATIONS

ABET- Accreditation Board for Engineering and Technology

COs- Course Outcomes

GAs- Graduate Attributes

GATE- Graduate Aptitude Test in Engineering

IEA- International Engineering Association

NBA- National Board of Accreditation

PEOs- Programme Educational Objectives

POs- Programme Outcomes

RTU- Rajasthan Technical University

SKIT- Swami Keshvanand Institute of Technology, Management & Gramothan

UG- Under-graduate

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