Curriculum Design of Undergraduate Engineering Programs in India

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1. Preamble

Curriculum is what you want your students to learn through the program and how you propose to facilitate this learning. Design of curriculum for any program should answer the following questions (Tylor 1949)

- What educational purpose should the program seek to attain?
- What educational experiences can be provided that are likely to attain these purposes?
- How can these educational experiences be effectively organized?
- How can we determine whether these purposes are being attained?

The educational purposes an engineering program in India seeks to attain are **Program Outcomes** are stated by the accreditation agency, National Board of Accreditation and **Program Specific Outcomes** chosen by the Department offering the program**.** Increasing global placements of graduating engineers led to several countries coming together, under Washington Accord, to ensure approximate equivalence of their engineering programs. While Washington Accord recognizes that needs of individual nations can be different, the signatory countries should identify the **Program Outcomes** of their engineering programs in the spirit of Program Outcomes as stated in the Washington Accord.

In view of the many ambiguities that still exist regarding engineering and its relation to science, technology and society it is necessary to state what engineering is before we design engineering programs. Here we state

“Engineering is finding and delivering effective solutions to real life technical problems, within the given material, technological, economic, social, legal and environmental constraints, through the application of available knowledge from mathematics, science, technology, engineering sciences and engineering practice.”

The actual statement is not unique, and it may be treated as an operative definition. It may be rewritten in the spirit of the above statement

This document traces the evolution of engineering education in general and particularly in India, and presents a framework and a process for designing curriculum for any branch of engineering.

2. Evolution of Engineering Education

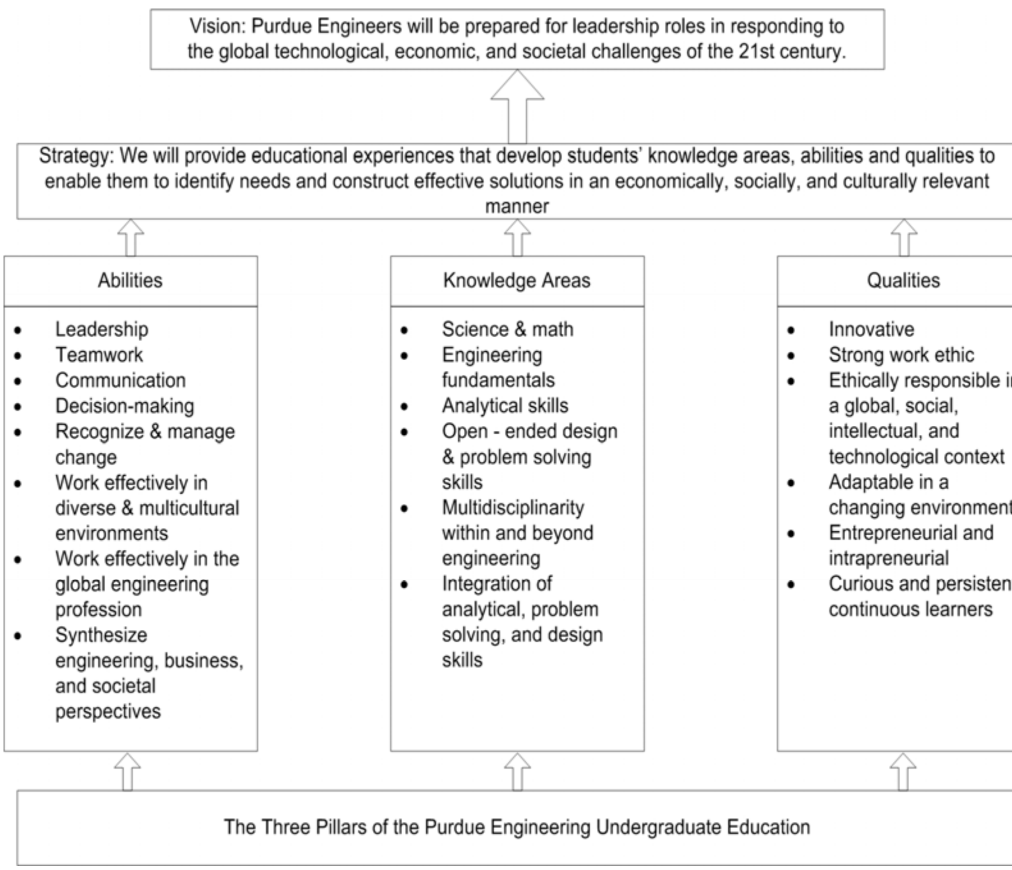
Five major shifts in engineering education have occurred (Froyd et.al. 2012) during the past 100 years.

- From hands-on and practical emphasis to engineering science and analytical emphasis
- To outcomes-based education and accreditation
- To emphasizing engineering design
- To applying education, learning, and social behavioral sciences research
- To integrating information, computational, and communications technology in education

The first two shifts have already occurred, but they continue to have implications for engineering education. The latter three are still in process.

The first shift from hands-on and practical emphasis to more science and engineering science is the most significant change in engineering education during the past 100 years. This was facilitated by the initiatives of F.E. Terman of Stanford University and Grinter report in late 1940s. The Grinter Report stressed the need for adequate science and engineering sciences in engineering curricula.

The second shift occurred as a consequence of requiring accreditation of an engineering program to ensure quality. After overcoming the many issues related to measurement of quality ABET (Accreditation Board for Engineering and Technology of USA) defined EC200 (Engineering Criteria 2000). Most of the countries have defined similar criteria as Program Outcomes of their engineering undergraduate programs. An engineering graduate has to participate in wealth generating activities as a responsible citizen, which in today's world require that he be able to effectively work in a team, communicate well with peers and society at large, continuously learn, and understand the impact of technology on society and environment. While all institutions acknowledge the importance of these program outcomes, many of them are not yet willing to adequately incorporate learning experiences to meet these outcomes. An engineering program designed following this second shift from Purdue University is shown in the following.



The Program Outcomes as identified by accreditation agencies can be met through designing credit courses specifically to achieve some program outcomes (for example courses like Ecology and Environment, Professional Communication and Professional Ethics) or through instructional activities specifically designed to meet some identified program outcomes.

The third major shift is increasing emphasis on design as a major and distinctive element of engineering. One reason for this shift was the sense that the emphasis on engineering science, science, and mathematics has gone too far and many students graduate without experiencing any design. It is worth noting what National Academy of Engineering has to say about engineering in its report The Engineer of 2020 (2004)

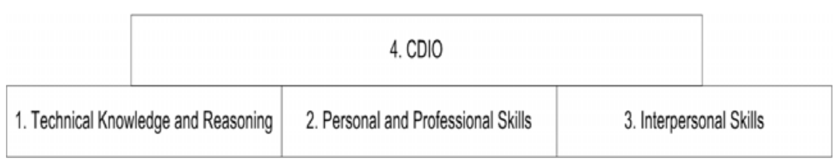
“Engineering is a profoundly creative process. A most elegant description is that engineering is about design under constraint. The engineer designs devices, components, subsystems, and systems and, to create a successful design, in the sense that it leads directly or indirectly to an improvement in our quality of life, must work within the constraints provided by technical, economic, business, political, social, and ethical issues. Technology is the outcome of engineering; it is rare that science translates directly to technology, just as it is not true that engineering is just applied science. Historically, technological advances, such as the airplane, steam engine, and internal combustion engine, have occurred before the underlying science was developed to explain how they work. Yet, of course, when such explanations were forthcoming, they helped drive refinements that made the technology more valuable still.”

Massachusetts Institute of Technology (MIT) in its CDIO Syllabus Report makes a similar statement “engineers engineer, that is, they build systems and products for the betterment of humanity. In order to enter the contemporary profession of engineering, students must be able to perform the essential functions of an engineer:

Graduating engineers should be able to conceive-design-implement-operate complex value-added engineering systems in a modern team-based environment.

Stated another way, graduating engineers should appreciate engineering *process*, be able to contribute to the development of engineering *products*, and do so while working in engineering *organizations*. Implicit is the additional expectation that, as university graduates and young adults, engineering graduates should be developing as whole, mature, and thoughtful individuals.

MIT’s CDIO curriculum consists of four parts as depicted in the figure.



Capstone courses in the fourth year have been part of several engineering programs in USA. A final year project, spread over the last two semesters, has been the standard feature of all Indian engineering programs. There have been several initiatives in USA to have Cornerstone Engineering Courses in the first year. Surveys of these programs indicate that these courses have a great influence on engineering students. Some universities also consider having design courses in second and third year is also desirable. Some engineering colleges in India have introduced the feature of mini-projects in the first three years besides the final year project.

Fourth major shift is applying education, learning, and social behavioral sciences research. Research in educational psychology, social psychology, cognitive sciences, educational neuroscience and how people learn lead to an understanding the different domains of learning including cognitive, affective and psychomotor domains. Several taxonomies of learning have been developed. It is getting accepted that instruction should be learner centric. Many instructional methods have been explored from behavioral, cognitive and constructivist psychologies. Considerable experience is gained in choosing appropriate instructional method for a given instructional context. It is now possible to systematically design a program or a course to meet educational objectives stated as Program Outcomes/ Program Specific Outcomes or as Course Outcomes.

The fifth major shift is to integrating information, computational, and communications technology in education. Computer assisted teaching and learning are explored since 1960s. As the information, computing and communication technologies are evolving at an ever increasing rate, like every other facet of life education too has been undergoing major changes as a consequence. With information so readily accessible free on the Internet, the traditional classrooms lose their purpose. The ICC technologies offer many possibilities to address the present day issues of cost, scale, access and equity in higher education. Learning Management Systems, Simulators, Virtual Laboratories, Digital Portfolios, Mobiles, SCORM compatible Learning Objects etc. are all finding their place in present day higher education. Some technologies like MOOC (Massively Open Online Courses) are presented from time to time as panacea to solve all problems related to higher education. After the initial euphoric period they will settle down to playing their appropriate role. However, no institution or teacher can afford to ignore the crucial role the ICC technologies can and will play in higher education.

Washington Accord is an agreement signed in Washington by six countries in 1989. It is an international agreement between registering bodies of member countries accrediting academic engineering programs. It recognizes substantial equivalence in the accreditation of parameters and programs. The original first six signatory countries are the US, UK, Canada, Australia, New Zealand and Ireland. As per the provisions of the Washington Accord, a country becomes eligible for full fledged membership after two years of provisional membership if all other members unanimously agree to include the country as a full fledged member. Hong Kong China (1995), South Africa (1999), Japan (2005), Singapore (2006), Korea and Chinese Taipei (2007) and Malaysia (2009) were admitted as permanent signatories increasing the total membership to 13. The signatories of this agreement accept the following rules:

- Accept that accreditation procedures are comparable
- Accept one another's accredited degrees from the date of admission as full member
- Agree to identify and encourage implementation of best practice
- Accept mutual monitoring
- Accept that it applies to accreditations in home jurisdiction only
- Accept the need to encourage licensing and registration authorities to apply the agreement

The traits of a graduating engineer, called as **Graduate Attributes**, are identified by Washington Accord as

GA1. **Engineering Knowledge:** Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

GA2. **Problem Analysis:** Identify, formulate, research literature and analyze *complex* engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

GA3. **Design / development of solutions:** Design solutions for *complex* engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

GA4. **Investigation:** Conduct investigations of *complex* problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.

GA5. **Modern Tool Usage:** Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to *complex* engineering problems, with an understanding of the limitations.

GA6. **The Engineer and Society:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems.

GA7. **Environment and Sustainability:** Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex engineering problems in societal and environmental contexts.

GA8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

GA9. **Individual and Team work:** Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

GA10. **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.

GA11. **Project Management and Finance:** Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

GA12. **Lifelong 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.

Washington Accord particularly emphasizes Complex Engineering Problems and Complex Engineering Activities. These are characterized as

Complex Engineering Problems

- Involve wide-ranging or conflicting technical, engineering and other issues
- Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models

- Requires in-depth knowledge that allows a fundamentals-based first principles analytical approach
- Involve infrequently encountered issues
- Are outside problems encompassed by standards and codes of practice for professional engineering
- Involve diverse groups of stakeholders with widely varying needs
- Have significant consequences in a range of contexts
- Are high level problems possibly including many component parts or sub-problems

Complex Engineering Activities

- Involve the use of diverse resources (and for this purpose resources includes people, money, equipment, materials, information and technologies)
- Require resolution of significant problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues,
- Involve creative use of knowledge of engineering principles in novel ways
- Have significant consequences in a range of contexts
- Can extend beyond previous experiences by applying principles-based approaches

3. Engineering Education in India

Engineering is a preferred career choice for a large number of students, more particularly of their parents, at the 10 + 2 level in India. There has been a phenomenal growth in the number of institutions offering engineering programs since early 1990s. At present more than 3500, Government and Private, institutions offer undergraduate programs in engineering. The approved intake to these programs has increased from 1,700,000 in 2008 to 3,450,000 in 2012. All India Council for Technical Education (AICTE), set up in 1945, monitors and controls engineering education. The institutions offering engineering programs were seeking accreditation by National Board of Accreditation (NBA) on voluntary basis initially. At present such an accreditation is compulsory. In spite of the presence of regulatory mechanisms the quality of education in majority of institutions is suspect. None of the stakeholders in engineering education, particularly the industry, is happy with the outcomes of these institutions. Majority of the programs are still planned and conducted in the framework of 'information transfer'. This led to programs designed on the basis "more transfer of information means better engineering". At present we have programs varying from 160 to 220 credits in spite of the presence of regulatory mechanisms.

A major feature of engineering education in India is the affiliation of a large number of engineering colleges to a single University. With nearly 400 colleges affiliated to a single University, the processes related to admission and examinations take precedence over learning and teaching. Security, confidentiality and uniformity lead to a situation 'what is not examinable and evaluatable on a very large scale cannot be included in the curriculum". The institutions offering engineering programs are now classified as Tier 1 (autonomous) and Tier 2 (affiliated) institutions. Accreditation processes associated with Tier 1 and Tier 2 institutions are different.

Some colleges affiliated to a University have been given academic autonomy in recent years. But their admissions are controlled by the University and their degrees are awarded by the University.

These institutions have to operate as per the guidelines given by the University, and one such guideline is related to the number of credits. IITs, NITs and some private universities have the autonomy required to design their own engineering programs, but they still have wide variations in the credit loads. Most of the other institutions appear to believe that a program with more credits is necessarily better than the program with less number of credits.

A survey of Indian industries by Andreas Blom and Hiroshi Saeki in 2010 "Employability and Skill Set of Newly Graduated Engineers in India" suggest that engineering education institutions should: (i) seek to improve the skill set of graduates; (ii) emphasize Soft Skills, (iii) refocus the assessments, teaching-learning process, and curricula away from lower-order thinking skills, such as remembering and understanding towards higher order skills such as analysis and creativity; and (iv) interact more with employers to understand the particular demand for skills in that region and sector. The Soft Skills also called Transferable Skills are further classified into Core Employability, Communication Skills, and Professional Skills. These are further elaborated as

Core Employability

- Reliability
- Self-motivated
- Willingness to learn
- Understand/take directions
- Integrity
- Teamwork
- Entrepreneurship
- Self-discipline
- Flexibility
- Empathy

Communication Skills

- Experiments/data analysis
- Reading
- Technical Skills
- Written Communication
- Verbal Communication
- Advanced computer
- Basic computer
- Communication in English

Professional Skills

- Problem solving
- Creativity
- Use of modern tools
- System design to needs
- Contemporary issues
- Apply Math/Sci/Engg knowledge
- Customer Service

The Graduate Attributes as listed by Washington Accord are the basis on which NBA defines its Program Outcomes.

4. Stages of Curriculum Design

The four questions that need to be answered to design the curriculum of an engineering program are addressed through the stages (as per the guidelines of NBA 2015)

- Write Vision and Mission of the Department offering the program
- Identify the context of program
- Write Program Educational Objectives (PEO) consistent with the Mission and Vision of the Department and PEO-Mission matrix
- Write the Program Specific Outcomes (PSOs) in addition to the Program Outcomes stated by NBA

- Prepare PO/PSO-PEO Matrix and ensure that POs and PSOs facilitate realization of PEOs
- Select the number of credits for the program and decide the distribution of Credits
- Identify the courses to meet the stated Program Outcomes and Program Specific Outcomes
- Write Course Outcomes of courses, projects and other credited instructional activities ensuring that all POs and PSOs are addressed satisfactorily

4.1 Vision and Mission of the Department Offering the Program:

Vision states what the faculty members 'see' their Department in the future and/or where they want it to go.

Mission statements are what you propose to "do" to get there. What's the benefit of having these statements? They provide focus, flow, and a foundation for decisions, in other words, thriving instead of surviving. When people within an institution/department align their efforts with an agreed-upon focus they save both time and frustration, and they make the institution/department achieve their academic objectives

These have to be created through brainstorming with several faculty members and the important stakeholders. They should be as simple and brief as possible. It will make it easier to relate to them.

Sample Vision and Mission statement (Engineering College, Carnegie Mellon University)

Vision

To continue to be one of the world's leading engineering schools in both education and research and achieve greater recognition for our efforts in our chosen fields of endeavor. The world will look to us for future trends and innovations in education, research, and technology. The college will build on its traditions of innovation, problem solving, and interdisciplinary collaboration to meet the changing needs of society.

Mission

- To provide students with the fundamental knowledge, interdisciplinary problem solving skills, societal and business awareness, and confidence required to excel in their chosen professions and be leaders in a global environment.
- Be recognized as one of the elite engineering colleges through research, innovation in education, and the transfer of concepts and results to technology and engineering practice.
- To maintain a collegial, supportive, and diverse environment that encourages our students, faculty, and staff to achieve to the best of their abilities.

Some samples of mission and vision statements of educational institutions are given in the Annexure 1

4.2 Context of Engineering Programs

Today's engineer has to function in a world characterized by

- Information and communication technologies completely are redefining how work is carried out and how business is organized and conducted.

- Large scale demographic changes are taking place in every country with population increases in Asian and African countries and practically zero percent growth in advanced countries.
- Continuously changing global economic and political scenarios.
- Changing social and environmental scenarios where hunger, poverty, public health, sustainability, climate change, water resources and security constitute the great problems that face the humanity in general and particularly India at present.
- India is particularly characterized by large religious, linguistic and cultural diversity.

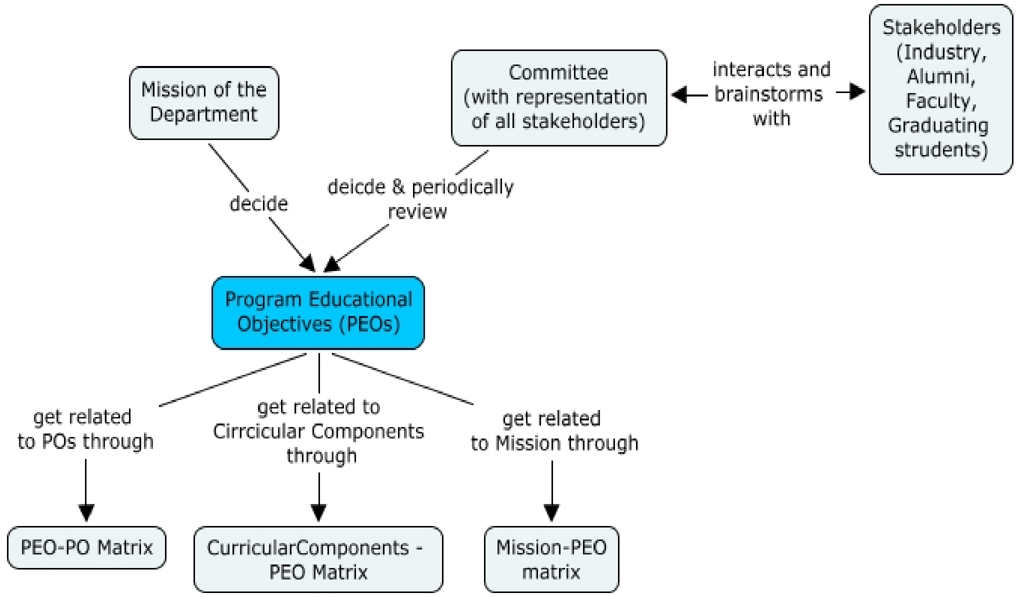
Engineers are at the centre of all developments, and also have to grapple with the consequences of all the technologies and products. Engineering programs are to be designed and conducted to train graduating engineers to work and contribute to the well being of the society, which is the supposed objective of engineering. However the programs have be designed and conducted taking the following factors into consideration.

a. All undergraduate engineering programs are to be designed and conducted to meet the Program Outcomes as identified by National Board of Accreditation (NBA).
b. The number of credits of a program is to be chosen to ensure that students get enough time to be engaged in activities. Students learn well when their learning is activity based, which requires students to spend enough time doing activities related to the courses.
c. As the needs of different branches of engineering are different, and it is likely to be more so in future, all courses under the categories of Humanities and Social Sciences, Basic Sciences and Engineering Sciences cannot be the same for all branches. This issue can be addressed to a limited extent by having soft core courses.
d. As all engineers have to conduct their activities in English in the global context, and English not being the native language for majority of Indians, the programs should provide for adequate training in oral and written communication in English.

The faculty responsible for the curriculum will prepare the context of the program in consultation with stakeholders and the vision and mission of the college/institution/University. (Sample of a context is given in the Annexure 2)

4.3 Program Educational Objectives

Program Educational Objectives (PEOs) are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve. They must be consistent with the mission of the Institution and Department. Department faculty members must continuously work with stakeholders (local employers, industry and RD advisors, and the alumni) to review the PEOs and update them periodically. The number of PEOs should be manageable and small in number, say 4 ± 1, and should be achievable by the program. The process of preparation of PEOs is depicted in the following figure.



Sample sets of PEOs are presented in the Annexure 4.

4.4 Program Outcomes and Program Specific Outcomes

Design of any program invariably starts with the debates on liberal versus utilitarian or conceptual versus industry ready education, debates that have been going on for several decades. The two views or sides are not mutually exclusive. The balance between these two dimensions can be stated, as normally done by the Accreditation agencies in any country, and gets redefined fom time to time. Design of any program in engineering requires statements on what engineering is and who is considered to be a good engineer. The desirable traits of a good graduating engineer are decided by the requirements of the profession at the given time and are stated as **Program Outcomes** by the Accreditation Agency. Engineering programs are to be designed and conducted to train graduating engineers to work and contribute to the well being of the society, which is the supposed objective of engineering.

Program Outcomes are statements that describe what the students are expected to know and be able to do upon the graduation. These relate to the knowledge, skills and behavior the students acquire through the program. POs represent what the graduating engineer should be able to do and are program non-specific that is, all engineering graduates irrespective of the program should achieve these outcomes.

Program Outcomes as stated by NBA: Engineering 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.

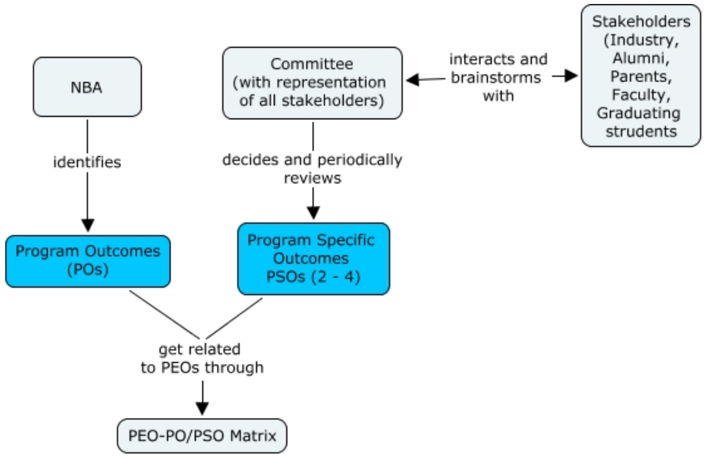
PO10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

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 (PSOs) are outcomes specific to the program as selected by the faculty of the Department offering the program in consultation with the stakeholders. It is through PSOs a Department can differentiate itself from other programs. They should be (as per NBA) two to four in number. Sample PSOs are given in the Annexure 5.

In order to ensure that the identified Program Educational Objectives are addressed by the POs and PSOs a PEO-PO/PSO matrix should be created. The PEO-PO/PSO matrix presents pictorially the compatibility of chosen PEOs with POs and PSOs, and can be used to iteratively improve the quality of PEOs and PSOs. The dependencies and process through this matrix is created is shown in the following figure.



It is convenient to represent the strength to which a PO or PSO meets a given PEO. Three strength levels may be identified as 1 – Slightly, 2 – Moderately and 3 – Substantially.

The **PEO-PO/PSO matrix** of the sample Civil Engineering program is

PEO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
1	3	3	3	3	3	3		1	2	2			3	3	3	3
2	3	3	3	3	3	3		1		2		2	3	3	3	3
3											3	2	1	1	1	1
4											1	1	1	1	3	3

The core courses of the program should be designed to meet all the Program Outcomes and Program Specific Outcomes.

4.5 Credits of UG Programs in Engineering

Knowledge in all areas of Engineering and Science is exponentially growing. There is no way in which it is possible to include in curriculum what is considered to be adequate by any branch of engineering or any stream in a given branch. What can be attempted is facilitating students to learn well or learn meaningfully. Learning well is understood as acquiring knowledge and skills at higher cognitive levels, which include as per Bloom's taxonomy Apply, Analyze, Evaluate and Create. Such learning is ensured by making it heavily activity and practice oriented rather than lecture oriented. It is well established that for every one hour of classroom interaction, the student is required to spend two or more hours (Olin college officially identifies this as three hours) working alone or in a group. It is also acknowledged that

- An undergraduate student can put in a maximum of 60 hours in a week including classroom outside classroom activities
- With the current definition of credit (one hour of lecture, two/three hours of laboratory per week or one hour of tutorial per week over a semester) the total credit load for an undergraduate degree program in engineering can be about 160 to 175 credits.
- Programs around the country are operating anywhere from 160 to 230 credits.

- The model curriculum of AICTE suggests 175 as typical. A survey of programs across the world indicates that 160 is a more desirable credit load.

Any credit load beyond 175 is likely to result in reduction in the quality of learning.

4.6 Credit Distribution

All India Board for UG Studies in Engineering and Technology suggests a credit distribution among various categories of courses. A credit distribution very close to it is suggested as

S.No.	Course Work - Subject Area	Range of Total Credits (%) *Min.*	*Max.*
1	Humanities and Social Sciences *(HSS)*, including Management;	10	15
2	Basic Sciences*(BS,)* including Mathematics, Physics, Chemistry, Biology	15	20
3	Engineering Sciences *(ES)*, including Materials, Workshop, Drawing, Basics of Electrical/ Electronics/ Mechanical/ Computer Engineering, Instrumentation	10	20
4	Professional Subjects-Core *(PSC)*, relevant to the chosen specialization/branch	25	35
5	Professional Subjects – Electives *(PSE)*, relevant to the chosen specialization/ branch	8	12
6	Open Subjects- Electives *(OSE)*, from other technical and/or emerging subject areas	5	10
7	Project Work, Seminar and/or Internship in Industry or elsewhere	8	10
	Range	81	122
8	Mandatory non-credit Courses (Maximum of 6 credits)	6	

The mandatory non-credit courses, in which performance need not be taken into consideration for determining CGPA (Cumulative Grade Point Average), include

- Constitution
- Sensitivity to Environment
- Professional Communication
- Professional Ethics

However, if these issues are addressed through credit courses, there is no need to separately offer them as non-credit courses. It is desirable to address these issues through formal credit courses.

4.7 Identification of Courses

Courses need to be identified to meet the stated POs and PSOs under different categories: Humanities and Social Sciences, Basic Sciences, Engineering Sciences, Professional Subject Core, Professional Subject Electives, Projects, General Electives and Mandatory Non-credit courses. In order to assure that all POs are adequately met through the courses and activities of the program it will be convenient to create a Course-PO matrix. While no course is designed to meet all the POs, all the courses and activities together have to meet all the POs adequately. A Course-PO matrix can facilitate this process.

Each category of the courses is explored in the following and some sample solutions are proposed.

Humanities and Social Sciences courses should constitute 10 to 15% of total number of credits, which for 175 credits program works out to be 17 to 26 credits. These courses include English, Communication, Social Sciences, and Management. At present, courses belonging to this category are usually the first level courses from Humanities, Social Science and Management disciplines. Such courses are designed for students who would eventually wish to specialize in those disciplines, and are rarely designed to meet the needs of engineering students.

Let us choose 18 credits for this category. It should also be noted that several Program Outcomes can be directly met through these courses. The specific Program Outcomes of concern include

1. **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.
2. **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.
3. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
4. **Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
5. **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.
6. **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.
7. **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.

These courses need to be designed specifically to meet as many of these Program Outcomes as possible. They may not be based on existing courses offered or readily available text-books. However, there is no dearth of resources on the Internet. As many students come from rural and small town areas they need strong inputs in English and Professional Communication. The suggested courses include

English	2:0:1	6
Professional Communication	1:0:2	

While the course in English needs to be given in the first year, the Professional Communication course needs to be given in a later semester after certain exposure to engineering.

In the Management discipline, students need to understand how different types of organizations work, and how financial resources are managed at individual, family, small organization, corporate and national levels. The two courses need to be specially designed and may be called as

Organizations	3:0:0	6
Economic Citizenship	3:0:0	

Social Science courses in engineering programs should mainly focus on interactions among humans, and humans and technology. These courses should be heavily case based and should relate to local, national and international scenarios. Issues and cases should be carefully chosen so that students can readily relate to them. Two courses from a collection of such courses can meet these requirements. A suggested list of courses is

Energy and Society	3:0:0	3
Water and Society	3:0:0	3 (selected by Department)
Complexity	3:0:0	
Development	3:0:0	
Habitat	3:0:0	
Sustainability	3:0:0	

More courses can be added to this list**.**

Basic Sciences courses should constitute 15 to 20% of total number of credits, which for 175 credits program works out to be 26 to 35 credits. Keeping the need for adequate number of professional core courses, it is proposed to have 27 credits for this category. The following basic science courses are proposed:

- Two courses in mathematics common to all branches are proposed in the first and second semesters. One course is related to the system of linear ordinary differential equations (LODE). Student should be able to solve single and system of LODEs in time domain as well using Laplace transforms. The second course is related to Statistics, which is needed by all branches. Ability to collect data and doing statistical processing of data is one of the Program Outcomes.
- Two more courses in Mathematics, as decided by the Departments, may be included. These two can be selected from a pool of courses and are offered in third and fourth semesters.
- There can be two courses in Engineering Physics, Engineering Chemistry and Biology. It may be noted most of the topics presently considered in a course on Physics are already covered in Physics at 12th Standard or Pre-university. One course in Ecology and Environment is also added to this category.

These courses can be

Engineering Physics	3:0:1	8 (as decided by the Department)
Engineering Chemistry	3:0:1	
Biology	4:0:0	
Ecology and Environment	3:0:0	3
Ordinary Differential Equations	3:1:0	8
Statistics	3:0:1	

Linear Algebra	3:1:0	8 (decided by the Department)
Functions of Several Variables	3:1:0	
Partial Differential Equations	3:1:0	
Numerical Methods & PDEs	3:1:0	
Numerical Analysis	3:1:0	
Discrete Mathematics	3:1:0	
Finite Element Methods	3:1:0	

Engineering Science courses should have 15 to 20% weightage, which for 175 credit program works out to be 26 to 35 credits. Keeping the need for adequate number of professional core courses it is proposed to have 35 credits for this category. This category of courses includes Materials, Workshop, Drawing, Problem Solving through Programming, Basics of Electrical/Electronics/Mechanical/Aerospace Engineering, Computing and Instrumentation. One possible combination of courses under this category is given in the following. All the suggested courses can be considered as compulsory to all branches.

Workshop	0:0:1	1	27
Engineering Drawing	1:0:2	3	
Problem Solving through Programming	3:0:1	4	
Measurements and Instrumentation	3:0:1	4	
Engineering Materials	3:0:0	3	
Electrical Engineering Systems	3:0:0	3	
Mechanical Engineering Systems	3:0:0	3	
Civil Engineering Systems	3:0:0	3	
Electronic and Communication Systems	3:0:0	3	

The remaining 8 credits can be taken from the following pool of courses as determined by the Departments

Information Technology	3:1:0	4
Data Structures	3:1:0	4
Human Computer Interface	3:1:0	4
Engineering Mechanics	3:1:0	4
Fluid Mechanics	3:1:0	4
Thermodynamics	3:1:0	4
Electromagnetics	3:1:0	4
Linear Electrical Networks	3:1:0	4
Operations Research	3:1:0	4

At present the following courses are offered in the first year of engineering.

Basics of Electrical Engineering

Basics of Electronics

Basics of Civil Engineering

Basics of Mechanical Engineering

They have been part of majority of the engineering programs in India. These have been designed by the respective Departments addressing the first level concepts or components. As they do not provide any overview of the branch of engineering, students do not find them interesting or useful. These are made compulsory for students of all branches to provide for changing the branch at the end of first year. The following courses are suggested in place of the above

Electrical Engineering Systems	3:0:0	3
Mechanical Engineering Systems	3:0:0	3
Civil Engineering Systems	3:0:0	3
Electronic and Communication Systems	3:0:0	3

They may be called, what IEEE calls, as Cornerstone Courses. They may be designed as problem solving exercises using hardware and software elements, as case studies or a combination of the two depending on the resources available. If needed, all the four courses can be replaced by a single course designated as "Engineering System Design". Several versions of such a course have been offered for several years in India also.

The courses "Engineering Drawing" and "Workshop" have been considered the very essence of engineering, and generally not even debated about their continuation. The manner in which they are conducted at present in majority of the places raises doubts about their usefulness. Some of Indian Institutes of Technology dropped the course on Workshop. All branches do not make Engineering Drawing compulsory. At present computing literacy is becoming a common requirement to all branches. Courses in the area of computing can be considered as replacements for courses on Drawing and Workshop.

Courses during the first two semesters: Courses should be common during the first two semesters to provide an opportunity to students to change their branch at the beginning of the second year. One suggested combination of courses for the first year

Credits for the first two semesters			**41**
Humanities and Social Sciences			**3**
English	2:0:1	3	
Basic Sciences			**16**
Ordinary Differential Equations	3:1:0	4	
Statistics	3:0:1	4	
Engineering Physics	3:0:1	4	
Engineering Chemistry/Biology	3:0:1	4	
Engineering Sciences			**20**
Workshop	0:0:1	1	
Engineering Drawing	1:0:2	3	
Problem Solving through Programming	3:0:1	4	
Electrical Engineering Systems	3:0:0	3	
Mechanical Engineering Systems	3:0:0	3	
Civil Engineering Systems	3:0:0	3	
Electronic and Communication Systems	3:0:0	3	
Mini-project	0:0:2		**2**

Another suggested combination of courses for the first year

Credits for the first two semesters			**41**
Humanities and Social Sciences			**6**
English	2:0:1	3	
Energy and Society	3:0:0	3	
Basic Sciences			**20**
Ordinary Differential Equations	3:1:0	4	
Statistics	3:0:1	4	
Life Sciences	3:0:0	4	
Engineering Chemistry	3:0:1	4	
Material Science (Physics)	3:0:1	4	
Engineering Sciences			**14**
Computational Engineering	2:0:1	3	
Information Technology	3:0:0	3	
Problem Solving through Programming	3:0:1	4	
Engineering Systems Design	2:0:2	4	
Mini-project	0:0:2		**1**

Projects: The weightage for this category of activity is 8 to 10%. Keeping the Professional Core requirements in consideration it is proposed that the number of credits for this activity be 17 credits.

Final year Project	0:0:11	**17**

(The final year project is spread over 7th and 8th Semesters with 2 Credits allotted to 7th Semester and the remaining 9 credits to the 8th Semester)

There will be mini projects in even semesters during the first three years. These will provide opportunities to experience different streams in a discipline. These mini projects can be concerned with explorations, problem identification, problem formulation, conducting surveys, simulation, and design of software or hardware systems, building prototypes.

Mini project 1 (First Year)	0:0:2
Mini project 2 (Second Year)	0:0:2
Mini project 3 (Third Year)	0:0:2

Professional Electives: The weightage for this category of activity is 8 to 12%. Keeping the Professional Core requirements in consideration it is proposed that the number of credits for Professional Electives be 18 credits, amounting to six courses. A Department can offer a large number of electives depending on specializations of its faculty. These courses are designed to enhance the placement opportunities of students. However, some electives should also be offered that promote some students going for higher education programs.

Open Electives: The weightage for this category of activity is 5 to 10%. Keeping the Professional Core requirements in consideration it is proposed that the number of credits for this activity be 6 credits. Each Department will offer a set of such courses that could be taken by students of other

Departments. However, these courses could also belong to Engineering Sciences, Basic Sciences, and Humanities and Social Sciences.

Professional Core Courses: All categories other than Professional Core carry 122 credits, leaving 54 credits to Professional Core. However, taking the Project credits, credits for Professional Electives, and three branch-specific Engineering Science courses the total number of credits for branch specialization will be 107, about 60.8%, of the total number of credits.

4.8 Assessment

Assessment is defined as a measure of performance. Evaluation is an interpretation of assessment. Educational assessment is the process of documenting, usually in measurable terms, knowledge, skills, attitudes and beliefs. Assessment is a mechanism for providing instructors with data for improving their teaching methods and for guiding and motivating students to be actively involved in their own learning. As such, assessment provides important feedback to both instructors and students. Assessment gives us essential information about what our students are learning and about the extent to which we are meeting our teaching goals. But the true power of assessment comes in using it to give feedback *to students*. Improving the quality of learning in a course involves not just determining to what extent students have mastered course content *at the end of the course*; improving the quality of learning also involves determining to what extent students are mastering content *throughout the course*. Thus in addition to providing the instructors with valuable information about our students' learning, assessment should assist the students in diagnosing *their own* learning. That is, assessment should help students "become more effective, self-assessing, self-directed learners." (Angelo and Cross, 1993)

There is considerable evidence showing that **assessment drives student learning**. More than anything else, our assessment tools tell students what we consider to be important. They will learn what we guide them to learn through our assessments. Traditional testing methods have been limited measures of student learning, and equally important, of limited value for guiding student learning. These methods are often inconsistent with the increasing emphasis being placed on the ability of students to think analytically, to understand and communicate at both detailed and "big picture" levels, and to acquire life-long skills that permit continuous adaptation to workplaces that are in constant flux. Moreover, because assessment is in many respects the glue that links the components of a course - its content, instructional methods, and skills development - changes in the structure of a course require coordinated changes in assessment.

The quality of learning in a course can be measured by the quality of assessment instruments used. Metrics to measure the quality of assessment can be defined in terms of distribution, difficulty level and nature of items (questions) among the six cognitive levels of Bloom. The nature of assessments and wightages given to Continuous Internal Evaluation (CIE) and Semester End Evaluation (SEE) are mostly decided at the Institution or University level. However, the instructor can have some freedom at the levels of their courses in an autonomous institution.

Performance in each course of study is normally evaluated based on (i) CIE and (ii) SEE. The assessment pattern suggested below is only a sample. The weightage given to CIE and SEE varies from 60:40 to 20:80 in India. For a CIE: SEE ratio of 50:50 the assessment can be

- Theory Courses (Courses with 3:0:0 or 3:1:0) will be assessed as per

  Finals: 50

  Finals consists of at least one written examination and/or project, report and presentation

  Sessionals: 50

  Sessionals must include at least two mid-semester tests
- Courses with Laboratory (Courses with 3:0:1) will be assessed as per

  Finals: 50

  Finals consists of a written examination (40) and laboratory examination (10)

  Sessionals: 50

  Sessionals must give a weightage of 15 marks to the Laboratory
- Courses with Laboratory (Courses with 2:0:1 like electives with laboratories) will be assessed as per

  Finals: 50

  Finals consists of a written examination (30) and Laboratory (20)

  Sessionals: 50

  Sessionals must give a weightage of 30 marks to the Laboratory, and also include two mid-semester tests each carrying 10 marks each
- Courses with two laboratory sessions per week (Courses 1:0:2 Course) will be assessed as per

  Finals: 50

  Finals consists of a written examination (20) and Laboratory (30)

  Sessionals: 50 (At least one written test)

  Sessionals must give a weightage of 35 marks to the Laboratory, and also include one mid-semester test carrying 15 marks
- Laboratory courses (Courses with 0:0:1) will be assessed as per

  Finals: 50

  Finals consist of laboratory/workshop exercises.

  Sessionals: 50
- Project work may be allotted to a single student or to a group of students not exceeding 4 per group. Each Department will define its own rubrics for evaluation of mini projects and projects.

References

1. Tylor R.W., Basic Principles of Curriculum and Instruction, The University of Chicago Press, 1949
2. Jeffrey E. Froyd, Phillip C. Wankat, and Karl A. Smith: Five Major Shifts in 100 Years of Engineering Education, 2012, Proceedings of the IEEE, Vol. 100.
3. Grinter Report, Report on evaluation of engineering education (reprint of the 1955 report), J. Eng. Educ., vol. 93, no. 1, pp. 74–94, 1994.
4. The Engineer of 2020: Visions of Engineering in the New Century, 2004; National Academy of Engineering, Academies Press at: http://www.nap.edu/catalog/10999.html
5. Andreas Bloom and Hiroshi Saeki: Employability and Skill Set of Newly Graduated Engineers in India Policy Research Working Paper WPS5640, World Bank, 2011
6. Manual of Accreditation (General), National Board of Accreditation, India, 2015.
7. Purdue University: http://www.extension.purdue.edu/extmedia/EC/EC-720.pdf
8. Angelo, T. A. & Cross, K. P., Classroom assessment techniques: A handbook for college teachers, San Francisco, Jossey-Bass, 1993.

Annexure 1: Samples of Mission and Vision Statements

Sample 1

Vision

To be one of the nation's premier engineering colleges by achieving the highest order of excellence in teaching and research. We will be the preferred choice of students seeking engineering

Mission

- To impart quality technical education that meets the needs of present and emerging technological world.
- To strive for student achievement and success, preparing them for life and leadership
- To provide a scholarly and vibrant learning environment that enables staff and students achieve personal and professional growth.
- To contribute to advancement of knowledge in both fundamental and applied areas of engineering & technology
- To forge mutually beneficial relationships with governmental entities, industry, society and the alumni

Sample 2

Vision

To empower young generations for substantial contribution to economical, technological and social progress of the society

Mission

To be a Globally-Socially conscious institute of research and innovation with excellence in professional education to take up the challenges of change for benefit of the society

Sample 3

Vision

The Institute is committed to responsibly serve the global community and local community in particular through offering its students an academic experience of meaningful and active learning and enable them to create effective solutions to real world technical problems.

Mission

To provide its students education in engineering that combines rigorous academic study and the excitement of designing engineering systems, and develop each member of its community the ability and passion to work wisely, creatively and effectively for improving the quality of life.

Sample 4

Vision

- To Produce World class Engineers for converting global challenges into Opportunities through "Value Embedded Quality Technical Education".
- To develop this College as an Academy of Higher Learning in the field of Engineering & Technology.

Mission

- To Impart Technical Education through effective teaching-learning process,
- To nurture creativity and critical thinking in applying engineering skills to face the fast growing globalization,

- To Develop Holistic Personality of the learners,
- To make this Institute as a Lead Centre of Research.

Sample 5

Vision

The San Francisco Bay Area is a world center for science and technology. It needs large numbers of well-educated scientists and engineers. The College is committed to serving this need by recruiting talented students, providing them with high-quality and up-to-date curricula, and fostering an effective teaching/learning environment. The College will be a leading provider of first-rate scientists and engineers in the Bay Area.

The College is committed to offering students an academic experience of "thinking, learning, and doing." The best way to provide this experience is through involving students in research and the solution of real world problems. Thus, teaching and research are mutually supportive and one cannot excel without the other. The College encourages the faculty to carry on research which involves students and which serves the science and engineering community. The College will be competitive in science and engineering research and teaching at the national level.

The College is committed to full participation in the community through service. This service applies the knowledge and experience of its faculty, staff and students to the solution of problems facing the University, industry, government, or civic organizations. The College will expand its already strong cooperative relationship with various local and national organizations, especially in areas related to K-12 science and math education.

The College is committed to serve a student population that reflects the diversity of the region and includes many international students. The College supports a number of programs designed to encourage and support all students to pursue careers in science and engineering. The College will support and retain a diverse group of faculty, staff, and students, both domestic and international.

Mission

The mission of the College of Science and Engineering at San Francisco State University is to provide an encouraging environment to develop the intellectual capacity, critical thinking, creativity, and problem solving ability of its students so that they may become honorable, contributing, and forward-thinking members of the science and engineering community of the San Francisco Bay Area and beyond; to foster a conducive environment for scholarly and creative activities so that new knowledge or solutions to problems are discovered or created; and to provide science education to all students in the University so that they may be equipped to succeed in the modern world.

Sample 6 (Massachusetts Institute of Technology)

Vision (as expressed in 1991 by Charles Marstiller Vest, Fifteenth President)

MIT will be a preeminent wellspring of scientific knowledge and technological innovation. MIT will foster the pursuits of individual scholars, whose work so often leads to truly fundamental discoveries. We will be known for our ability to establish new and effective methods for analyzing complex and pervasive issues facing the nation and the world. In an invigorated partnership with industry, the government, and other educational institutions, we will contribute profoundly to their solution. MIT will be known for educating engineers who combine the spirit of innovation and invention with a passion for the highest quality and efficiency in design and production.

MIT will better reflect in our students, faculty, and our staff the changing face of America. We will find ways to instill the excitement and romance of science and mathematics in new generations of young people. MIT will spearhead efforts to rekindle our nation's belief in the importance of scientific research and education. We will have found renewed commitment to the deepest values of the academy. MIT will stand for integrity in all that it does. MIT will serve our nation well, but also will be of and for the greater world community.

Above all, the Massachusetts Institute of Technology will be a place to which the brightest young men and women will come for their education. They will be able to attend MIT regardless of their financial circumstances. They will be taught and counseled by dedicated teachers who themselves define the leading edge of human knowledge and invention. Their education will be robust: deep in scientific content, yet providing the flexibility and learning skills to serve them well in ever changing and expanding circumstances. They will be attuned to the complexities of their world, a world that they will help to change. Through that wonderful blend of undergraduate education, graduate education, research and creative activity that is MIT, our students will be enriched and they, in turn, will enrich the Institute.

Mission

To advance knowledge and educate students in science, technology, and other areas of scholarship that will best serve the nation and the world in the 21st century.

The Institute is committed to generating, disseminating, and preserving knowledge, and to working with others to bring this knowledge to bear on the world's great challenges. MIT is dedicated to providing its students with an education that combines rigorous academic study and the excitement of discovery with the support and intellectual stimulation of a diverse campus community. We seek to develop in each member of the MIT community the ability and passion to work wisely, creatively, and effectively for the betterment of humankind.

Annexure 2: Sample "Context of the Program"

BE in Electronic and Communication Engineering

- Information, communication and electronics technologies are completely redefining how work is carried out and how business is organized and conducted.
- Large scale demographic changes taking place in every country with population increases in Asian and African countries and practically zero percent growth in advanced countries.
- Continuously changing global economic and political scenarios.
- Changing social and environmental scenarios where hunger, poverty, public health, sustainability, climate change, water resources and security constitute the great problems that face the humanity in general and particularly India at present.
- India is particularly characterized by large religious, linguistic and cultural diversity.
- Electronics industry is predominantly driven by technology.
- Cost/performance ratios of electronic products and systems continuously decrease.
- A large percentage of electronic products are portable and Internet enabled.
- Electronic product life cycles are becoming shorter.
- There is urgent need to reduce power consumption at every level
- The performance of electronic systems is at present limited by Electronic packaging technologies.
- Electronic industry is organized horizontally worldwide.
- Communication technology defines the culture.
- Recognizing the centrality of electronic industry Government of India has launched ESDM (Electronics Systems Design and Manufacturing) initiative.

Annexure 3: Cognitive Levels and Action Verbs

Cognitive learning is demonstrated by knowledge recall and the intellectual skills: comprehending information, organizing ideas, analyzing and synthesizing data, applying knowledge, choosing among alternatives in problem solving, and evaluating ideas or actions. The cognitive domain of the acquisition and use of knowledge is predominant in the majority of courses. Bloom identified six levels within the cognitive domain, from the simple recall or recognition of facts, as the lowest level, through increasingly more complex and abstract mental levels, to the highest order, which is classified as creation. The six progressive stages of cognitive thinking, as accepted at present, and called as Boom's taxonomy o cognition, are

- Remember
- Understand
- Apply
- Analyze
- Evaluate
- Create

Initial work of Bloom was followed up with research that resulted in a list of Action Verbs representing intellectual activity on each respective level of the cognitive domain.

Action Verbs associated with Bloom's cognitive levels

Remember

- Recognize/Identify
- Recall/Retrieve: List, mention, state, draw, label, define, name, describe, prove a theorem tell, show, label, collect, examine, tabulate, quote, who, when, where, etc.

Understand

- Interpret: Translate, paraphrase, represent, describe, express, extend and clarify
- Exemplify: Illustrate and instantiate
- Classify: Categorize and subsume
- Summarize: Generalize and abstract
- Infer: Extrapolate, interpolate, predict, conclude
- Compare: Contrast, match, map, distinguish and differentiate
- Explain: Illustrate, construct a model, confirm, state, write down, associate and discuss

Apply

- Execute: Determine, calculate, compute, estimate solve, use, draw, and carry out (a procedure in known situation)
- Implementing: Determine, calculate, compute, estimate solve, use draw, and carry out (a procedure in unfamiliar situation)

Analyze

- Differentiate: discriminate, select, focus and distinguish (between accurate and inaccurate, cause and effect, consistent and inconsistent, dominant and subordinate, essential and inessential, facts and conclusions, facts and hypotheses, facts and inferences, facts and opinions, facts and value statements, plausible and implausible, possible and impossible, relevant and irrelevant, summaries and conclusions, supportive and contradictory, valid and invalid, verifiable and unverifiable, warranted and unwarranted)

- Organize: Identify (adequacy, assumptions, attributes, biases, causes, central issues, completeness, concepts, consequences, contradictions, criteria, defects, distortions, effects, elements, errors, exceptions, fallacies, inconsistencies, inferences, limitations, main ideas, nature of evidence, organization, plausibility, problems, procedures, reasoning, relationships, relevance, stereotypes, trends, validity, variables), structure, integrate, find coherence, outline and parse.
- Attribute: Deconstruct and ascertain (Assumptions, attitudes, biases, conditions, characteristics, motives, organization, points of view, purposes, qualities, relationships)

Evaluate

- Check/test (Accuracy, adequacy, appropriateness, clarity, cohesiveness, completeness, consistency, correctness, credibility, organization, reasonableness, reasoning, relationships, reliability, significance, usefulness, validity, values, worth), detect, monitor and coordinate.
- Critique/judge (Criteria, standards, and procedures)

Create

- Generate alternatives and hypotheses
- Plan/design
- Produce/construct

Annexure 4: Sample PEOs

Electrical and Electronics Engineering

PEO1 Engage in design of systems, tools and applications in the field of electrical and electronics engineering and allied engineering industries

PEO2 Apply the knowledge of electrical and electronics engineering to solve problems of social relevance, and/or pursue higher education and research

PEO3 Work effectively as individuals and as team members in multidisciplinary projects

PEO4 Engage in lifelong learning, career enhancement and adopt to changing professional and societal needs

Information Technology

PEO1 Manage the information technology resources of an individual or organization

PEO2 Anticipate the changing direction of information technology and evaluate and communicate the likely utility of new technologies to an individual or organization

PEO3 Contribute to the scientific, mathematical and theoretical foundations on which information technologies are built

PEO4 Live and work as a contributing, well-rounded member of society

Mechanical Engineering

PEO1 Analyze, design and evaluate mechanical components and systems using state-of-the-art IT tools

PEO2 Plan manufacturing of given mechanical components and systems

PEO3 Analyze and design quality assurance systems

PEO4 Practice modern management to manufacturing of components and systems

PEO5 Work in a team using common tools and environments to achieve project objectives

Civil Engineering

PEO1 Survey, map and plan layouts for buildings, structures and alignments for canals and roads

PEO2 Specify, design, supervise, test and evaluate foundations and superstructures for residences, public buildings, industries, irrigation structures, powerhouses, highways, railways, airways, docks and harbors.

PEO3 Specify, design, supervise and evaluate water conveying systems and environmental engineering systems

PEO4 Analyze water resources hydrological systems to estimate safe and assured withdrawals.

PEO5 Work in a team using common tools and environments to achieve project objectives

Computer Science and Engineering

PEO1 Specify, design, develop, test and maintain usable software systems that behave reliably and efficiently and satisfy all the requirements that customers have defined for them

PEO2 Develop software systems that would perform tasks related to Research, Education and Training and/or E-governance

PEO3 Work in a team using common tools and environments to achieve project objectives

Electronics and Communication Engineering

PEO1 Specify, design, prototype and test modern electronic systems that perform analog and digital processing functions.

PEO2 Architect, partition, and select appropriate technologies for implementation of a specified communication system.

PEO3 Design essential elements (circuits and antennas) of modern RF/Wireless communication systems.

PEO4 Work in a team using common tools and environments to achieve project objectives

Annexure 5: Sample Program Specific Outcomes

Civil Engineering

Sample 1

PSO1. Survey, map and plan layouts for buildings, structures and alignments for canals and roads

PSO2. Specify, design, supervise, test and evaluate foundations and superstructures for residences, public buildings, industries, irrigation structures, powerhouses, highways, railways, airways, docks and harbors.

PSO3. Analyze water resources hydrological systems to estimate safe and assured withdrawals, and specify, design, and evaluate water conveying systems, hydraulic machines and surge systems

PSO4. Specify, select and formulate environmental engineering systems

Sample 2

PSO1. Survey, conduct geo-technical investigations collect data, make feasibility studies, and design as per codal provisions residences, public buildings, industries, irrigation structures, powerhouses and highways, dam, aligning a road or water way and creating a township in a region.

PSO2. Understand the impact of water, air and noise pollution, and the methods of waste containment, and specify, design and analyze water, sewerage and industrial effluent conveying and treatment systems.

PSO3. Analyze water resources and hydrological systems to estimate safe, flood discharges and assured withdrawals, and specify and design/select hydraulic machines/systems and surge systems

PSO4. Understand modern management and construction techniques to complete the projects within the stipulated period and funds.

Electrical and Electronics Engineering

Sample 1

PSO1. Specify, architect, design and analyze systems that efficiently generate, transmit, distribute and utilize electrical power

PSO2. Specify, design, prototype and test modern electronic systems that perform analog and digital processing functions.

Sample 2

PSO1. Specify, architect and analyze power systems that efficiently generate, transmit and distribute electrical power in the context of present ICT

PSO2. Analyze and design modern electrical drive systems and modern lighting systems

PSO3. Understand the principles and construction of electrical machines and determine their performance through testing

PSO4. Specify, design, implement and test analog and embedded signal processing electronic systems using the state of the art components and software tools.

Mechanical Engineering

Sample 1

PSO1. Analyze, design and evaluate mechanical components and systems using state-of-the-art IT tools

PSO2. Plan the manufacturing of given mechanical components and systems (methods design, process plan, process automation and manufacturing methods)

PSO3. Apply modern management methods to manufacturing of components and systems

PSO4. Analyze and design quality assurance systems

Sample 2

PSO1. Analyze, design and evaluate mechanical components and systems using state-of-the-art IT tools.

PSO2. Analyze, design and evaluate thermal systems including IC engines, refrigerating, air-conditioning, and power generating systems.

PSO3. Plan, including methods design, process plan, process automation, and quality assurance systems for manufacturing of given mechanical components and systems.

PSO4. Apply modern management methods to manufacture of components and systems.

Sample 3

PSO1. Design mechanical components and systems as per given specifications using EDA tools

PSO2. Specify and design thermal systems including heat exchangers, condensers, evaporators, air-conditioners, refrigeration systems as per given specifications.

PSO3. Specify and design turbo machines including air compressors, hydraulic turbines and pumps as per given specifications.

PSO4. Plan, including methods design, process plan, quality assurance systems and process automation, the manufacturing of given mechanical components and systems.

Computer Science and Engineering

Sample 1

PSO1. Specify, design, develop, test and maintain usable software systems that behave reliably and efficiently and satisfy all the requirements that customers have defined for them

PSO2. Develop software systems that would perform tasks related to Research, Education and Training and/or E-governance

Sample 2

PSO1. Specify, design, and develop system software (Language Translators, Languages, Operating Systems and User Interface) to allow convenient use of a computer.

PSO2. Determine and optimize the performance of a given algorithm on a given platform

PSO3. Specify, design and develop software for intelligent systems.

PSO4. Specify, design and develop concurrent and parallel programs