

**Teaching and Learning in Engineering (TALE)**  
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**Lecture - 06**  
**Outcomes**

Greetings and welcome to the Unit 6 of Module 1 of course TALE. In this unit we are going to look at the nature of outcomes and out of the several outcomes we talk about, we are particularly looking at what we call PEOs and PSOs.

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### Recap

- NBA Accreditation process provides a framework for designing and conducting engineering programs.
- Closing the quality loop can lead to continuous improvement in the quality of learning.



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In the previous unit U5, we looked at the nature of the accreditation process and how it provides the framework for designing and conducting engineering programs. That is the advantage of following an accreditation process identified by a national agency. There will always be some misgivings or you will find some exceptional conditions under which the accreditation process does not suit.

But, that will be the nature of any accreditation process anywhere in the world if you are trying to create one accreditation process for one kind of programs namely for all engineering programs. There will always be a few exceptions but that should not be the reason for giving away or throwing away a national level accreditation process. And the accreditation process, the

core idea or core facet of that is closing the quality loop can lead to continuous improvement in the quality of learning.

That means by trying to close the loop, any institution can keep on lifting itself by its own boot straps to continuously improve the quality of learning. When quality of learning is improved we expect the quality of placements will also improve.

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## MIU6 Outcomes

MIU6-1: Understand the role and nature of Program Educational Objectives (PEOs) and Program Specific Outcomes (PSOs) in the design and conduct of engineering programs.

MIU6-2: Write PEOs and PSOs for an UG engineering program.

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Now, coming to this particular unit, the two outcomes that we look at or we consider are understand the role and nature of Program Educational Objectives and program Specific Outcomes in the design and conduct of engineering programs. And having understood the role and the nature of this the second outcome is one should be able to write the PEOs and PSOs for an engineering program.

What kind of statements that one need to write to represent the PEOs and PSOs of an undergraduate program in engineering.

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## OBE: a review

- Outcome Based Education shifts the focus from teaching to student learning
- An outcome is what a student is able to do at the end of a learning experience
- An outcome should be observable and measurable
- Accreditation by NBA assures the stakeholders and society at large that graduates of the accredited engineering program have attained the required disciplinary and professional knowledge, skills and attitudes
- The outcomes of an engineering program are considered at three levels: PEO, PO & PSO and CO



Now we spend a few minutes to review the our Outcome-Based Education. Fundamentally, Outcome-Based Education shifts the focus from teaching to student learning. It is not that student learning was not important but the focus earlier was teaching, the quality of teaching but now the focus is quality of student learning. And what is an outcome? An outcome is what the student is able to do at the end of a learning experience.

And any outcome that you identify should be observable and measurable. So the statements that you have to make should satisfy this criteria of observability and measurability. Accreditation by NBA assures the stakeholders and society at large that graduates of the accredited engineering program have attained the required disciplinary and professional knowledge skills and attitudes. That is what it assures the society at large.

The outcomes of an engineering program are considered at three levels. These are PEOs, POs, and PSOs are at the same level and CO, Course Outcomes at the course level. So this is the essence of OBE.

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## Levels of Outcomes

- **Program Educational Objectives:** PEOs are broad statements that describe the career and professional accomplishments in four to five years after graduation.
- **Program Outcomes:** POs are statements that describe what the students should be able to do at the time of graduation from an engineering program .They are normally identified by Accrediting agencies like NBA and ABET.

Coming to the levels of outcomes we talk about Program Educational Objectives. Let us briefly spend some time with each type of outcome and then we will more specifically come to PEOs and PSOs. PEOs are broad statements that describe the career and professional accomplishments in four to five years after graduation. That means you are trying to visualize what kind of activities your graduates will be doing or involved in let us say in four to five years after graduation.

Of course, what they do will depend on what kind of experiences, where they are employed during those 5 years, but can we capture the features of the type of activities we expect them to be involved. Coming to the other one namely Program Outcomes, POs are statements that describe what the student should be able to do at the time of graduation from actually any engineering program.

That is the National Board Of Accreditation considers there are certain outcomes any graduate engineer should attain, irrespective of the branch from which he is coming. So to that extent they are normally identified by accrediting agencies like NBA or in the US context by ABET. They are written in a language that every branch of engineering can relate itself to.

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## Levels of Outcomes (2)

- **Program Specific Outcomes:** PSOs are statements that describe what the graduates of a specific engineering program should be able to do. A department can differentiate its program from similar programs through its PSOs.
- **Course Outcomes:** COs are statements that describe what students should be able to do at the end of a course. These are either identified by the instructor or by the Board of Studies of the program.



Now, coming to the next one, the program specific outcomes which we consider are at the same level as program outcomes, PSOs are statements that describe what the graduate of a specific engineering program should be able to do. Now all, let us say you take a mechanical engineering program in several colleges. They do not have to be identical.

They can, one Mechanical Engineering program can differentiate itself from another undergraduate mechanical engineering program. That is the nature of higher education. You can differentiate yourself and the nature of outcomes from let us say that branch of mechanical engineering I can write it in such a way I differentiate my program from similar programs through my PSOs. Then come the course outcomes.

After all, much of the learning is done through a large number of core courses. In addition to core courses, there are electives and also there are may be some projects and some extracurricular or co-curricular activities. But the dominant part of any program, undergraduate program are the number of courses that you have. So COs or course outcomes are statements that describe what student should be able to do at the end of a course.

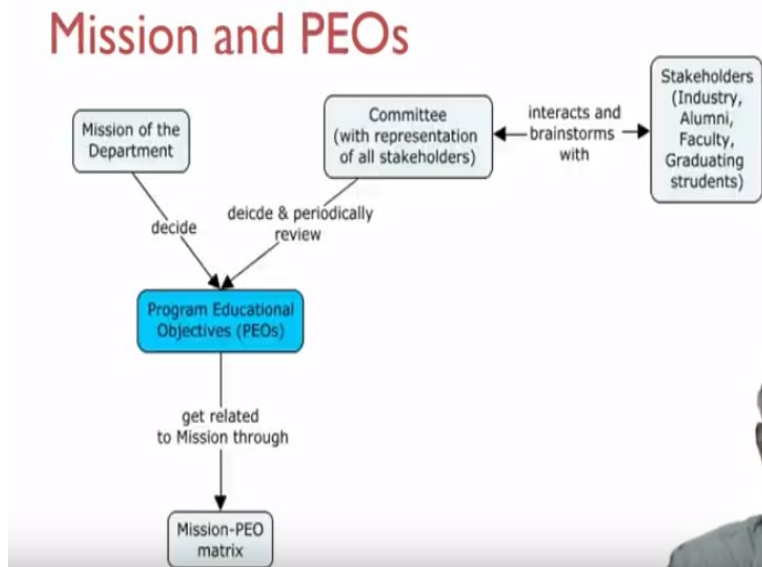
And in Indian context what happens in an autonomous institution, it is the instructor or at the department, the department itself will identify the course outcomes. Because instructor may change from semester to semester and if the system permits instructor himself can define at the

beginning of the semester what the course outcomes are. Such a thing happens with institutes like NITs and IITs in India.

But in other cases you may have to follow the course outcomes as defined by the department itself. In tier 2 institutions where institution is a non-autonomous institution in a university, then the board of studies of the program of that university will identify the course outcomes and here what happens is within the broad course outcomes that are already identified by boards of studies, the instructor has some freedom to tweak the course outcomes given by the university.

That kind of freedom is permitted by National Board Of Accreditation when it looks at a particular college will also ask what kind of their interpretation of the curriculum is performed by the a particular department vis-à-vis the course outcomes.

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Now, roughly this is the once we come to the PEOs, this is the relationship. There is the mission of the department which is already written. We assume that mission of the department is expressed in terms of a two or three or four sometimes five statements. We are not talking about how to write mission statements. And starting with the mission of the department and you constitute a committee with representation from all stakeholders.

They include industry, alumni, faculty, graduating students and this committee will brainstorm and together looking at the mission statement these two together will decide what the, we will try to write what are the Program Educational Objectives. And here these program educational objectives you may want to review let us say once in four years or once in five years whatever period that you choose.

And when you are trying to review and modify again one has to go through the process of stakeholders meeting together and deciding why should the existing PEOs be modified and after brainstorming the committee prepares and shares it with the stakeholders and then correspondingly you modify.

And these Program Educational Objectives we will presently see get related to mission through the dependency of PEOs on the mission of the department is expressed through what is called Mission-PEO matrix. The mechanics of preparing this Mission-PEO matrix while we see in a limited extent in the presently but more elaborately when we come to the fourth module on accreditation.

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## Program Educational Objectives (PEOs)

- What the Graduates of the program are expected to achieve within 4 to 5 years of completing the program.
- Can be abstract to some extent; but must be smaller in number and must be achievable.
- Must follow from Vision and Mission of the Department offering the program and follow an established process.
- Number of PEOs should be 3 to 5
- The attainment of PEOs should be measurable.  
(At present NBA does not require closure of PEO quality loop)

Now, what are Program Educational Objectives? As we mentioned, what the graduates of the program are expected to achieve within four to five years of completing the program. These statements can be abstract to some extent but must be smaller in number and must be achievable.

You cannot say a Civil Engineer will lead a project to define let us say one of the major dams in the country within four to five years.

While it is desirable, I do not think any of the persons will grow to that stage. So it should be anything that we write should be achievable. And as we said must follow from the vision and mission of the department offering the program and follow an established process. This is most important. You should write a document on what is the process that we are following and it should be documented and actually follow the process.

So the number of PEOs, we limit it to anywhere from three to five. This is also required as by the NBA. The attainment of PEOs should be measurable but one thing that happens as of now because of the market conditions are the placement conditions NBA does not insist on closing the loop around PEOs. They say you write PEOs and measure to what extent they are attained and leave it at that.

For example that provide statistics whether the, if 80% of the mechanical engineers have shifted to IT disciplines, but that is the way the market is. So we do not complain but you have to acknowledge that they have left practically the mechanical engineering and went into some other discipline. So at present NBA does not require closure of the PEO quality loop while an agency like ABET in USA will also require the closure of the loop around PEOs.

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## PEOs (2)

- All stakeholders through their representatives should identify the PEOs and review them periodically.
- Process for design and review of PEOs should be defined and documented
- Minutes of the meetings of the designated committee should be recorded
- Must be shared with all stake holders!



As we said all stakeholders through their representatives should identify the PEOs and review them periodically following a well-defined process. And the process for design and review of PEOs should be defined and documented and minutes of the meetings held specifically to review or write of the designated committee should be recorded. That NBA insists on this record of the minutes as well as the process to be made available.

And these final statement should be shared with all stakeholders. Okay, that is the nature of PEOs.

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## PEOs (3)

- PEO statements should strongly correlate with Mission statements
- Key elements (generally) of PEO statements:
  - Professional success
  - Life-long learning, Higher Education, Research
  - Ethical professional practice
  - Communication skills
  - Team player
  - .....



Let us look at, also look at some other features of PEO statements. First thing is PEO statement should strongly correlate with mission statements. They should not, There should be tight correlation. We will presently see this correlation can be seen through a matrix specifically created for this. What are the key elements of PEO statements? One is professional success. That means they are involved in professional activities related to that branch of engineering.

And as present day requires they are involved in lifelong learning. That means they are continuously learning and some of them are likely to go for higher education or go into research as well and whatever they are doing they are doing as per ethical professional practices and they do have communication skills and they are team players. Some kind of proof will have to be collected from your alumni to see that at least they are whatever they are presently working on has these features in it.

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## Sample PEOs

### **Graduates of BE EEE program four years after graduation will**

PEO1. Engage in designing, manufacturing, testing, operating and/or maintaining systems in the field of electrical and electronics engineering and allied engineering industries

PEO2. Solve problems of social relevance applying the knowledge of electrical and electronics engineering, 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



Now getting into some sample PEOs, these are prepared by some group of faculty. It does not mean these are the best and these are the ideal or these are bad or anything like that. Okay here what are we trying to we need to write three to five, here the sample shows four and what is PEO 1? Engage in designing, manufacturing, testing, operating, and or maintaining systems in the field of electrical and electronic engineering and allied engineering industries.

That means if you take your alumni from this branch at the end of four or five years, if you look at what they are at that time doing, they are doing one or more of these activities. They are manufacturing, testing, operating, or maintaining systems in the field of electrical and electronic engineering and allied engineering industries because electrical and electronics are also involved, are required in mechanical, civil, chemical all over the place.

But they are involved with electrical and electronic engineering systems. Second one, solve problems of social relevance applying the knowledge of electrical and electronics engineering and or pursue higher education and research. So by and large you are involved in solving socially relevant problems in electrical and electronic engineering or we expect some of them go for higher education or even involved in research.

And the third one, work effectively as individuals and as team members in multidisciplinary projects. So they are working, interacting with what do you call engineers from, engineers or non-engineers from other areas. So to that extent they are involved in multidisciplinary projects. The fourth one is engage in lifelong learning, career enhancement and adopt to changing professional and societal needs.

How do you collect this data, that we will see it in a later module but we must gather enough information about what they are doing at present to say whether for example a specific individual, to what extent he is associated with PEO2 let us say. It may be to a certain degree or we define the level of involvement at three levels. We will presently identify those three levels. As you can see, looking at the present activities of an engineer who graduated four to five years earlier we will be able to say to what extent these PEOs are attained.

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## PEO-Mission Matrix

- Identify the key elements (phrases) of Mission statements
- The matrix is between PEO statements and elements of Mission statements
- The strength of mapping between a PEO and an element of Mission may be marked as
  - Substantial (3)
  - Moderate (2)
  - Slight (1)
- The mapping strengths must be justified.



Now what do we want to call by PEO-mission matrix. Now mission statements can be two, three, four as we said. Each statement can have several phrases in that. So identify, first thing is identify the key elements of mission statements. They could be, if there are three mission statements each mission statement has two to three. So you have a fairly large number of key elements. You can call them as M1, M2, M3 and so on.

The matrix is between PEO statements and the elements of mission statements. That means you create a matrix with PEO statements as the rows and key elements of the mission statements as the columns. So you may have, if I have four PEOs as in the sample and if I have about 8 mission, the key elements of the mission statements, I have a 4 by 8 matrix. Then you look at each cell in the matrix and you put a number.

Strength of mapping between PEO and the element of mission may be marked as - if it is substantial, you mark it as 3. And if it is moderate, you will name it as 2. And then if it is slight, 1. If there is no correlation between a particular PEO statement and the key element of the mission statement you can put a 0 or a dash. But whatever number that you choose, whether 3, 2, or 1 you have to write a justification.

You cannot just write arbitrarily some strength and not write anything. You have to justify why you chose 1, 2 or 3 in a particular cell. So you have 4 by 8 matrix. So you have 32 cells. For each

cell wherever you put this number 3, 2, 1 you have to give a you have to write a justification. That is how the PEO statements, finalizing the PEO statements you have to go through this process of clearly or rather making sure that PEOs are strongly correlated to the mission that you have.

What may happen, from time to time depending on the change in technology, the department may choose to slightly alter the mission even though the vision remains the same, my mission gets altered a little bit. That means what are the specific activities that I want to do to go towards the goal that we express through vision, the mission may get altered.

When the mission gets altered, you may want to, that is the time also to take a look at whether same PEO statements are still I consider relevant and valid. If necessary, the committee that we are talking about should work on it and review and modify. That is the role of PEOs.

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## Program Specific Outcomes

- PSOs represent what the students should be able to do at the time of graduation from a specific program.
- PSOs are program specific, 2 to 4 in number, and need to be defined following a well documented process.

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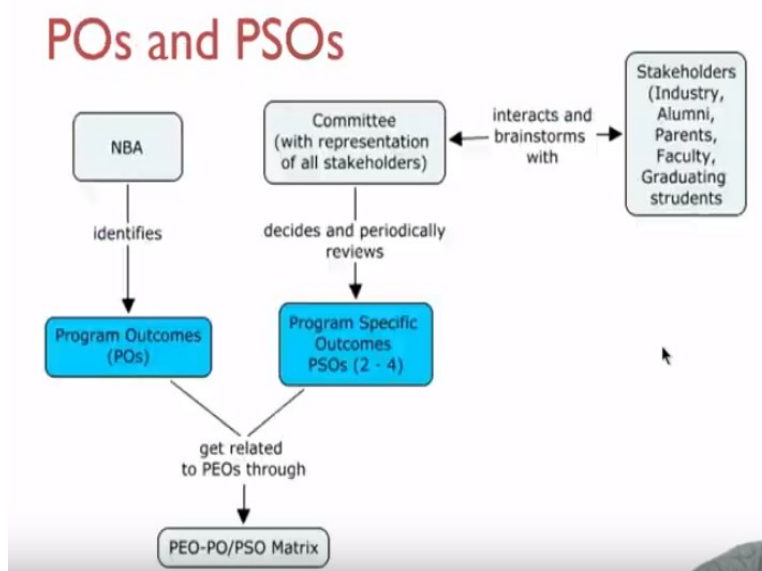


Now coming to Program Specific Outcomes, PSOs represent what the student should be able to do at the time of graduation. Unlike PEOs where we are looking at four to five years after graduation, here PSOs represent what the student should be able to do at the time of graduation from a specific program. So to that extent, there is specificity with respect to the program that you are talking about.

They will be different for mechanical engineering, they will be different for civil engineering and so on. And PSOs are program specific. One can write large number of them, but the National Board Of Accreditation specifies there should be two to four in number and need to be defined again following a well-documented process. The kind of process that we followed for writing PEOs the same, similar kind of process should be followed by for writing PSOs as well.

You will not be reviewing PSOs ever so often. You may want to do it once in let us say one cycle generally of a program is four years, so you may want to review them once in 4 years unless there is some other urgency that requires to reword your PSOs in a lesser time period.

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Now, coming to this POs and PSOs; NBA identifies the POs and here there is a committee specifically created. The same committee can look at the other one as well, PEOs. This committee will, the stakeholders interact and brainstorms with the committee will interact and brainstorms with this and then decides and periodically reviews Program Specific Outcomes which are two to four in number.

And now Program Outcomes and Program Specific Outcomes are at the same level and they get related to PEOs through what you call PEO-PSO matrix and now this is a fairly large size matrix. Let us assume I have four PEOs and there are 12 POs and let us assume there are three PSOs. So 12+3, 15 and PEO 4 it is a 4 by 15 matrix that you have to see. And why is the matrix important?

When I try to fill the matrix with the strength of correlation between these things what would happen is, if some columns are empty, that means PEOs and POs and PSOs are not correlated. You have to take a look at it whether you need to modify PEOs or whether you need to modify PSOs. So that kind of access that matrix will act as a great feedback to the committee as well, okay?

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## Structure of PSO Statements

- The PSO statement should start with one or more action verbs.
- The action verbs should be followed by clearly identified technical objects, and if required by the conditions under which the actions have to be performed.

Some examples of action verbs

- Formulate, specify, conceive, design, plan, architect, build, implement, test, operate
- Select
- Analyse, determine, estimate, calculate



Now let us look at the structure of PSO statements. We want the PSO statement to start with one or more action verbs. And the action verbs you can have multiple of them, should be followed by clearly identified technical objects and if required by conditions under which the actions have to be performed. We will see examples. And then what kind of action verbs do you want to use?

What do engineers do? They formulate problems, specify products and systems, conceive a plan or conceive a product, design, plan, architect, build, implement, test, operate and so on or sometimes they have to select a technology, select products from available range of products, analyze, determine, estimate, calculate. These are some examples of action verbs that you can use. We will look at more action verbs when we come to Course Outcomes.

But these are reasonably adequate number of action verbs that you can use in the context of writing PSO statements.



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## Sample: PSOs -Civil Engineering

- 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 harbours.
- PSO3. Analyse 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



Now here is a sample of PSOs of civil engineering. For example action verbs here are survey, map and plan. These are the three action verbs. What are the technical objects? Layouts for buildings, layouts for structures or layouts for alignments for canals and roads. So those are the technical objects. For example in this statement we have not written, let us say any conditions like you can say you can also put conditions using certain specified tools.

Like using the AutoCAD or some survey tool or MATLAB whatever you call it, you can also put some conditions under that. Now second one, specify, design, supervise, test, and evaluate. These are the action verbs. Foundations and superstructures for residences, public buildings, industries, irrigation structure, powerhouses, highways, railways, airways, docks and harbors. Yes, this is a long list. A particular program that means is emphasizing more on this aspect.

And in some other program, I may not include that many technical objects. Third one, analyze water resource/resources, hydrological systems to estimate safe and assured withdrawals and specify design and evaluate water conveyance systems, hydraulic machines and surge systems. So the entire field of hydraulics is captured and specifically what you are planning to do to your program is captured here.



And specify, select and formulate environmental engineering systems. So as you can see civil engineering generally uses something like four to five specialties. And whether you can capture but you cannot write more than four. So that is where a compromise is required in trying to write the PSOs that truly represent the particular branch.

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## Assignments

- Write 2-5 PEOs for a BE program in your branch.
- Write 2-4 PSOs for a BE program in your branch.

These assignments are proposed only to understand the nature of PEO and PSO statements. The outputs of these assignments should never be considered as final. It should be remembered that PEO and PSOs are to be written by the specially designated committee as indicated following a well documented process.



Now, what we have seen is, we have seen what are PSOs, PEOs and what are PSOs and how do you write them and what are the conditions that need to be fulfilled in writing them. So we consider or we ask you to write these assignment. Write two to five PEOs for a B.E. program in your branch and similarly write two to four PSOs for a B.E. program in your branch. It looks like this requirement is, does not fulfill the conditions that we have been emphasizing in writing PEOs and PSOs.

So these assignment are proposed only to understand, to facilitate the understanding of the nature of PEO, PSO statements. So you do an exercise at individual level. But in actuality, these outputs of these assignment should never be considered as final. It should be remembered that PEOs and PSOs are to be written by the specially designated committees as indicated following a well-documented process. So they can be considered at first level.

At department level, a group of faculty can sit together and prepare these statements and present it to the committee as the first version and the committee can debate/deliberate over that and finalize the PEO statements and PSO statements.

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## MIU7: Program Outcomes

- Understand the nature of complex engineering problems.
- Identify activities that facilitate the attainment of PO1, PO2, PO3, PO4, PO5

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And the program, we will be in the next unit U7 you will be looking at the Program Outcomes. Program Outcomes are 12. We will not be able to address all the 12 outcomes in one unit. So in the next unit we will try to understand the nature of what the NBA calls complex engineering problems and we then we look at the first five POs and try to look at what kind of activities facilitate addressing the first six outcomes of NBA. Thank you very much.