NBA Accredition and Teaching-Learning in Engineering
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Lecture 06
POs 10 12

Greetings and welcome to Module One, unit 6 of Nate NBA Accreditation and Teaching and Learning in Engineering. This unit is concerned with PEOs and some of the POs. PEOs are program educational objectives and POs are program outcomes.

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In the earlier unit we kind of reinterpreted, these words are familiar to all faculty, but specific meanings are have been there and we are trying to reinforce or request all faculty to get themselves familiarized with these words and reinterpret the words education, learning, assessment, teaching and instruction, especially, in the context of formal programs and also we emphasized the centrality of assessment in facilitating good learning.

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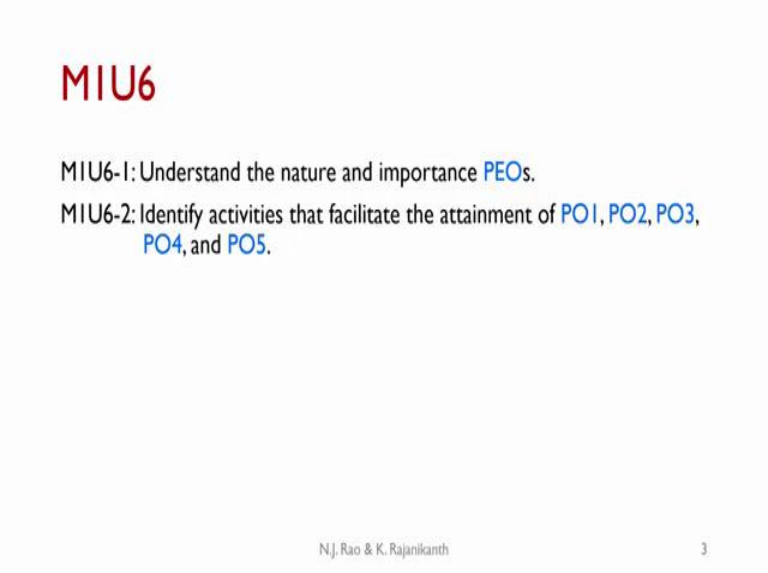

Now, we look at this unit, we will, would want you to understand the nature of and importance of POs. Identify activities that facilitate the attainment of the first 5 POs. As we mentioned, there are 12 POs out of which the first 5 will be addressed in this particular unit.

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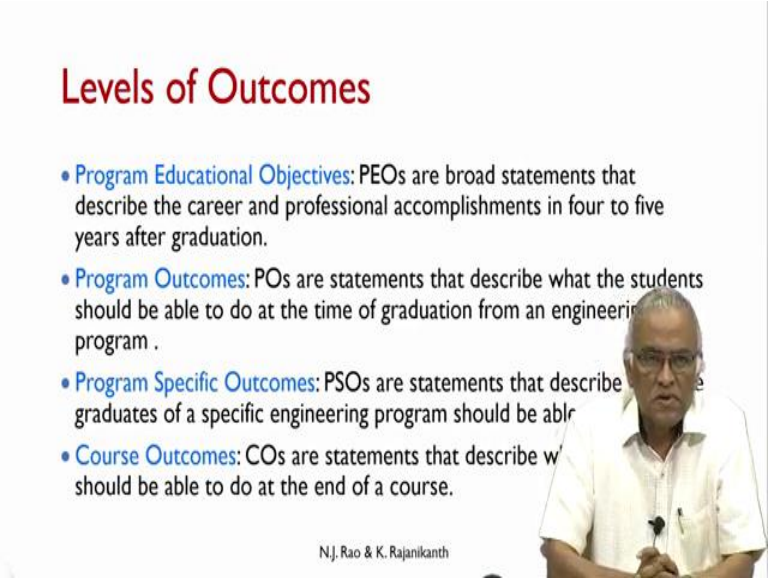

Now, to recap again, there are, there are actually 3 levels of outcomes. The one level is program educational objectives. POs broad statements that describe the carrier and professional accomplishments in 4 to 5 years after graduation, we will explain that presently. And program outcomes are statements that describe what the student should be able to do at the time of graduation from an engineering program. As we as the definition itself says it is irrespective of the particular engineering programs, these program outcomes have to be attained.

And at the same level as program outcomes you have programs specific outcomes and POs was had statements that describe what the graduates of a specific engineering program should be able to do. So, at one level you have PEOs at another level we have POs and PSOs and from POs and PSOs the curriculum comes. Curriculum consists of a large number of one semester courses, formal courses and here come the course outcomes. COs are statements that describe what the students should be able to do at the end of the course. So, these are the 4 types of outcomes, and they are arranged at 3 levels.

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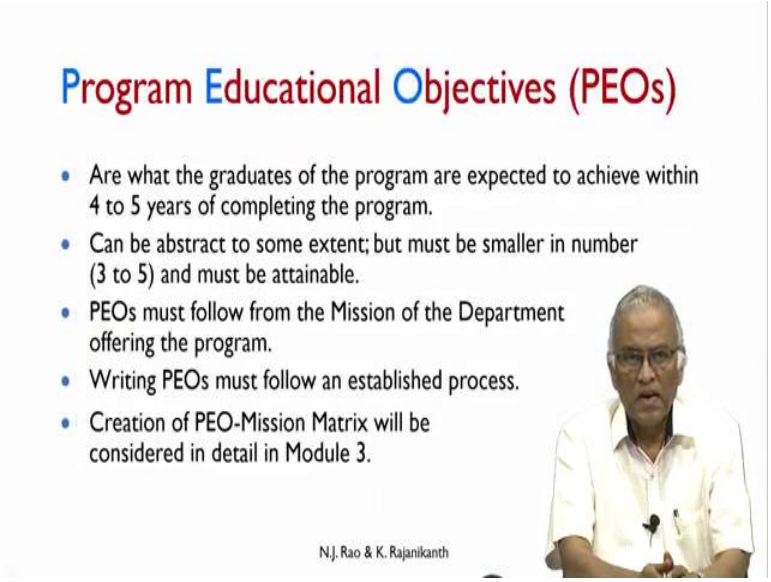

Now, let us look at Program Educational Objectives. As we already stated, or what the graduates of the program are expected to achieve within 4 to 5 years of completing the program. Why is it important? For example, if you look at your where your graduates are after 4 to 5 years, and if those graduates are not using any of the information that you have imparted or knowledge and skills that you have imparted and what they do have no correlation with that, that means the program did not play any role in their careers other than possibly some, they can speak better or do something but it did not play any particular role.

So, if there is too much of deviation from what they are doing and what a program is offering that means it is a signal to take to all the faculty or to the department to take a real look at your curriculum and these PEOs statements can be abstract to some extent but they must be small in number, 3 to 5 is what is prescribed by NBA and they must be attainable. That means, you do not say that the within 4 to 5 years majority for students should become CEOs of companies.

That means, it is not likely to happen so, they are not attainable. So, you cannot write such a PEO. PEOs must follow from the mission of the department. Will come to the mission of the department in great detail when you look at the criterion one of NBA in the SEAR. That means the mission of the department and PEOs are to be strongly linked with each other.

So, and how to make sure that they are linked with each other will see by preparing what you call PEO mission matrix. And when you are writing this PEOs it is not like one faculty member sits and writes this PEOs, it is, it should a systematic process it needs to be followed and with a common consent you have to write, you have to identify the PEOs.

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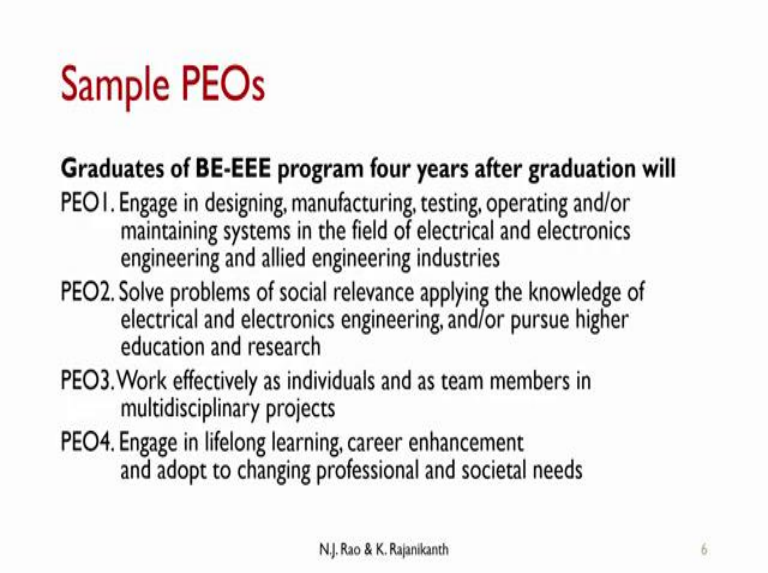

Now, these are some examples of PEOs. This is just one BE triple E program, 4 years after graduation. The graduates should be engaging with designing, manufacturing, testing, operating and or maintaining systems in the field of Electrical and Electronics Engineering and allied engineering industries. When we write a statement like this, it does not mean that after 4 years, the graduate of triple E program should be engaged in all these activities. He should be doing at least one of them.

That is what it means and he should be engaged in solving problems of social relevance, applying the knowledge of Electrical and Electronic Engineering, and or pursue higher education and research. So, here again, we gave two things one is solving problems of social relevance or pursue higher education and research. They should be involved in one of these two. And another aspect is of a any engineer work effectively as individuals and as team members in a multi, in multidisciplinary projects.

That will, we will see, it is a characteristic of an engineer, engineering activities never done as an individual, it is always by a team, but he must play his role, whatever role that is assigned to him. So, he must work effectively both as an individual and as team members. And the other one should engage in lifelong learning, career enhancement and adapt to changing professional and social needs.

So, these are samples given, you do not have to stick to these wordings and one can, that is why it should be written by a group trying to see where do you want it? Why are you designing this program? Where you want your graduates to be doing after 4 to 5 years after graduation that is, that is what PEOs are.

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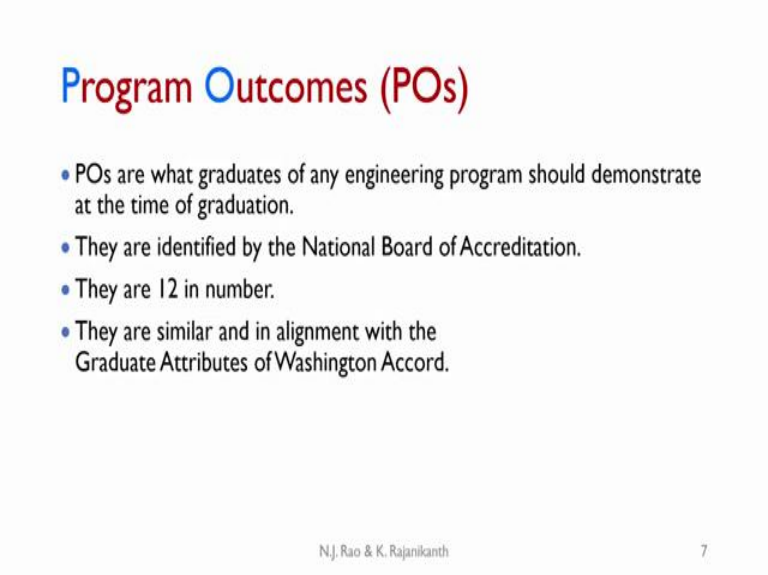

Now, we come to Program Outcomes. POs are what graduates of an engineering program should demonstrate at the time of graduation. See, there is a main difference PEOs are you look at graduates after 4 to 5 years after graduation, but POs are what graduates should demonstrate at the time of graduation itself. That means at the end of 4 years of undergraduate programs. Now, these are identified by the National Board of Accreditation. There is no choice they are given and you have to operate within that. They are 12 in number.

There are 12 program outcomes and they happen to be similar and in alignment with what are called Graduate Attributes of Washington Accord. So, you are only pointing it out. There is no

need to go to Washington Accord and look at graduate attributes and try to say, worry about how am I meeting all that is not relevant, because India is already a signatory to the Washington accord. If your students have attained this program outcomes, it is sufficient for us. You do not have to use the words Graduate Attributes or Washington Accord.

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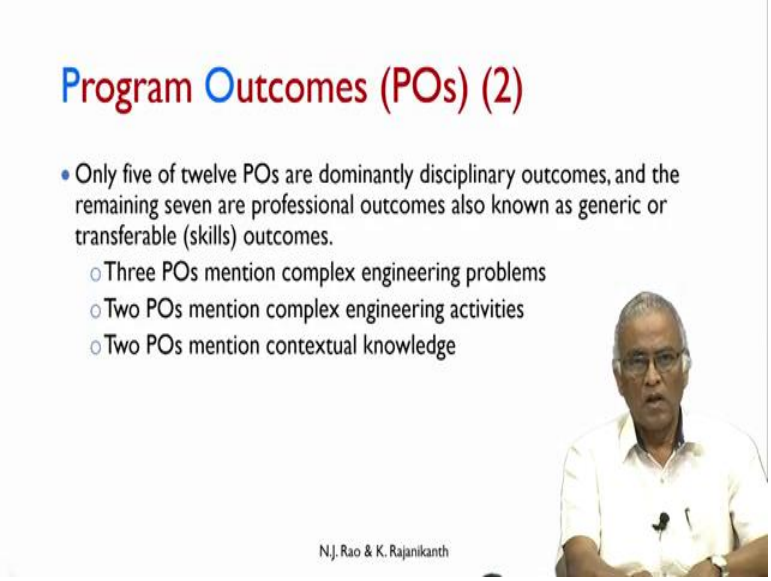

Now, we will look at, at various levels this program outcomes only 5 of 12 POs are dominantly disciplinary outcomes and the remaining 7 or professional outcomes also known as generic or transferable skills or outcomes. So, first thing that we do we classify the POs into two categories, one is disciplinary outcomes, the other one is generic outcomes or professional outcomes.

And again to, to kind of look at it from the top 3 POs mentioned complex engineering problems, they use this phrase complex engineering problems in 3POs and two POs mentioned complex engineering activities and two POs mentioned contextual knowledge. So, the words like complex engineering problems, complex engineering activities, contextual knowledge these all play an important role with respect to the identified POs.

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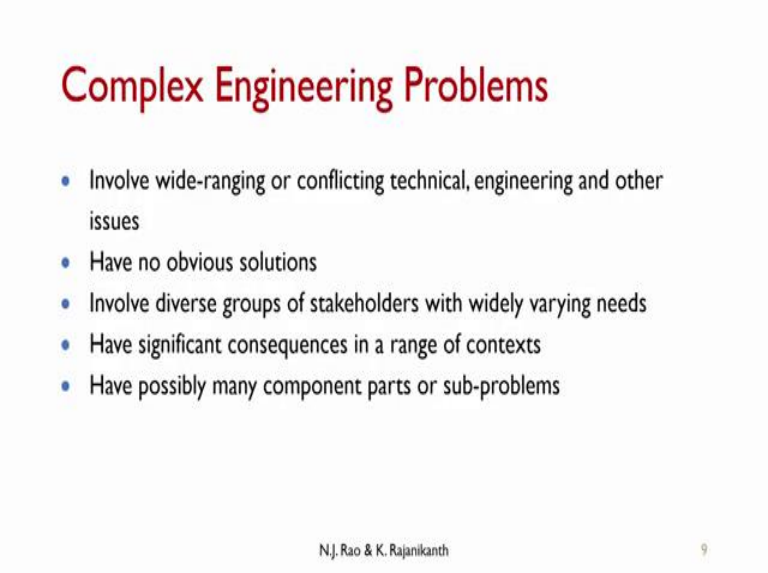

Now, what a really Complex Engineering Problems first thing, they are involved wide ranging or conflicting technical engineering and other issues. If you take any problem, like you take any recent, let us say, the kind of flood havoc that is happening and we are trying to address that particular issue, you will have conflict in technical engineering and other issues.

They are not, there is if you solved, if you solve one problem purely from one point of view, it may conflict with some other requirement and complex engineering problems no, have no obvious solutions like the end, end of the chapter problems, solutions are not obvious and they involve diverse groups of stakeholders with widely varying needs and have significant consequences in a range of contexts.

If you offered a solution to a let us say like again managing the floods, whatever solution that you produce, it will have consequences on different people in different contexts and they have possibly many component parts. First of all, it is not a single solution, they will have many component parts and sub-problems to be addressed. I think one look at the newspaper anytime, will tell you the nobody is happy with one particular solution when it is really complex like this.

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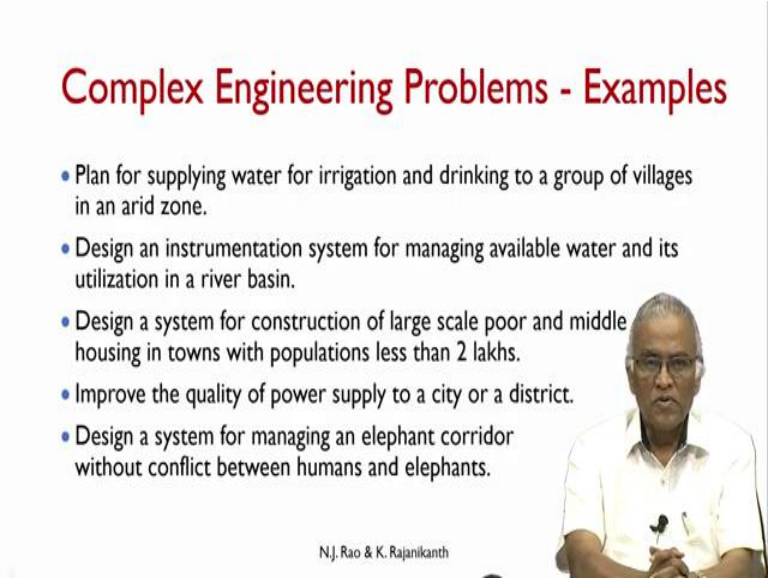

Let us look at some samples plan for supplying water for irrigation and drinking to a group of village, villagers in arid in an arid zone. I am not going to elaborate any of these problems. Design instrumentation system for managing available water and its utilization in a river basin. If you take any river basin as you can see, there are always issues between the states which are what we call riparian states, which are along the river basin.

Design a system for construction of large scale poor and middle class housing in towns with population less than two lakhs improve the quality of power supply to a city or a district. Design a system for managing an elephant corridor without conflict without conflict between humans and elephants. So, these are a few small problems I am sure you can design you can identify any number of complex engineering problems in your own environment.

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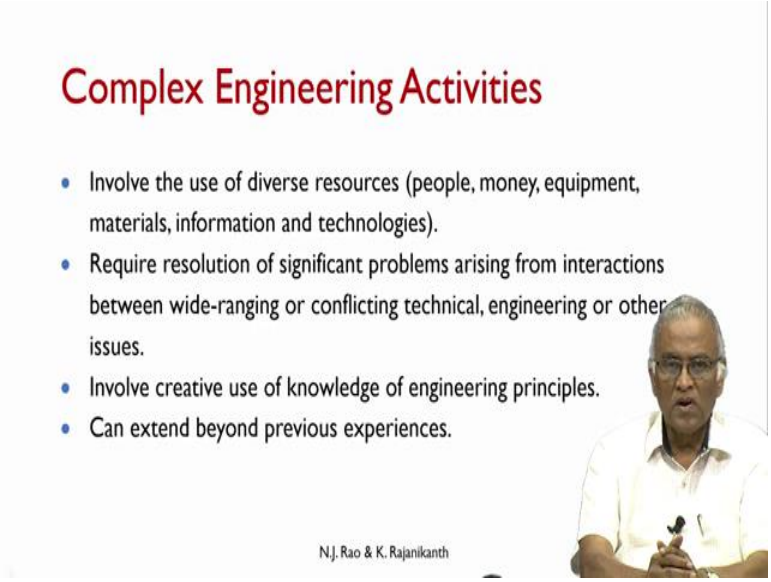

What are Complex Engineering Activities? They involve the use of diverse resources, diverse resources means people, money, equipment, materials, information and technologies. And they require solution resolution of a lot of significant problems arising from interaction between wide ranging and conflicting technical engineering and other issues. Mostly first thing that will happen if it is a complex problem where there are several stakeholders involved, we will have conflicting requirement from different groups of people.

They involve create creative use of knowledge and engineering principles and they can extend beyond the previous experiences. This is something you should not try to find solutions based only on your previous experience, because the nature of problem requires you to look at the, look at it, what we people call us out of the box solution kind of thing.

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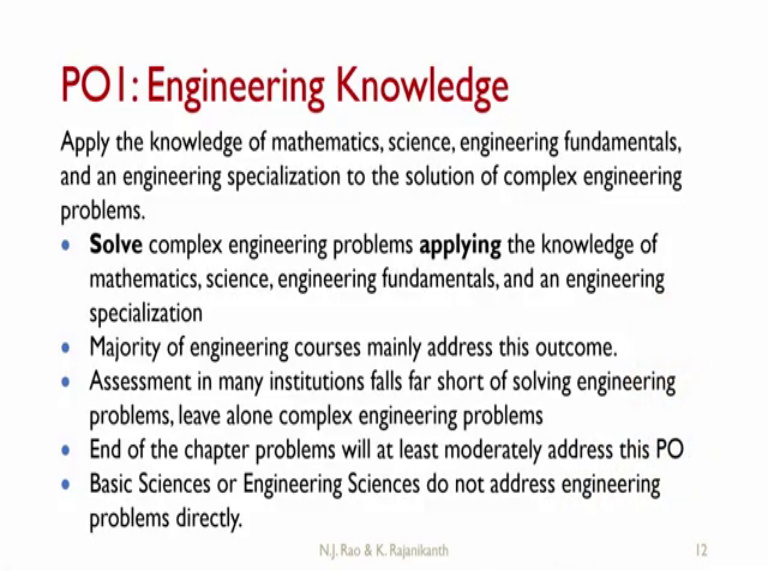

Now, we look at these 5, first 5 POs and the remaining ones we look at it in the later unit. PO1 is related to what is called engineering knowledge and the statement as given by NBA states apply the knowledge of mathematics science, engineering fundamentals and an engineering special, specialization to the solution of complex engineering problems. See the word complex engineering problem comes and you are actually this word this sentence should have been rephrased in slightly different way in my view.

Because the focus is on solution of complex engineering problem. So, if you rewrite that solve complex engineering problems applying the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization, that is how one can reword this because the focus is on solving the problem. So here, but you do not want PO to Sol just arbitrarily intuitively are giving just a command what it occurs to you and so on.

You want the solution to be based on using the underlying required knowledge from all these disciplines. So, the key words are solve and apply. The, now if you look at it, look at all the courses in engineering courses that you are familiar with or the way your program is being conducted. Majority of engineering courses mainly address this outcome. We will see the other outcomes are lot less addressed in the current context.

Assessment in many institutions falls far short of solving engineering problems, leave alone complex engineering problems. Because if you look at many of the courses do not even directly address engineering problems if you take for example, engineering sciences are basically science courses, they will talk about only the science part science issues, they do not directly address engineering problems. So, if you look at the entire program from the perspective of PO1.

You have to first notice that we are not solving complex engineering problems and all courses are not addressing even engineering problems. So, the nearest we come to address this PO1 you can say is the end of, end of the chapter problems at least we will moderately address this PO. This should be kind of noted. But now, can I leave it like this? Can I leave saying that that is the way the curriculum is designed and there is nothing else that I can do, the only thing I can do is make the student solve end of the chapter problems.

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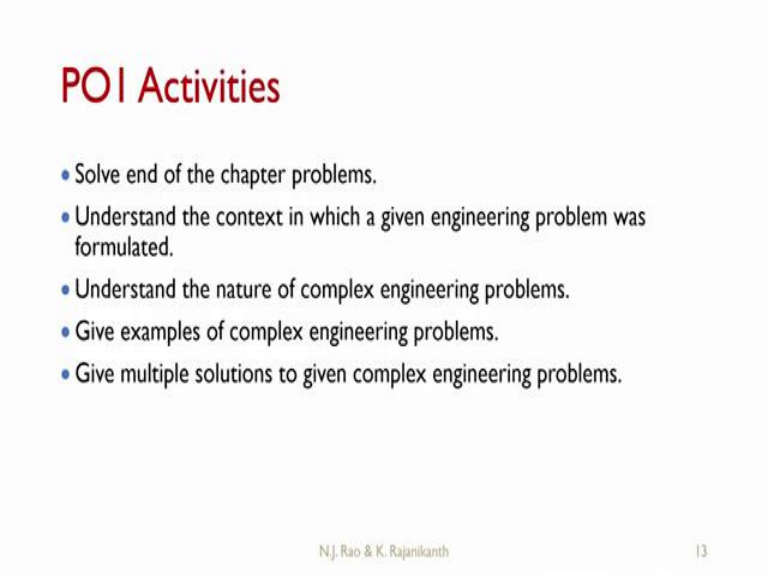

So, what kind of activities should I do to address PO1? First thing is solve end of the chapter problems that is a minimum one should do, then to say some as feature of so called complex engineering problems, understand the context in which a given engineering problem was formulated. Or understand the nature of some complex engineering problems, you can present it as a case study related to your discipline and bring a complex engineering problem to the class.

You are not solving it, but you are understanding the nature of the complex in your own problems. That means, when you present that problem, you talk about the conflicting requirements of different dimensions, different stakeholders, and the non-uniqueness of the solution and so on can be pointed out when by presenting at least a one case at least to the students.

So, understand the nature or give some examples of complex engineering problems. These can be some case studies can be prepared and made available to the students and one or two can be considered in the class. And also give multiple solutions to given complex engineering problems. Once again, you do not have to solve it. You just available multiple solution that itself, in my opinion is a great learning experience to the students that there are no generally unique solutions to complex engineering problems.

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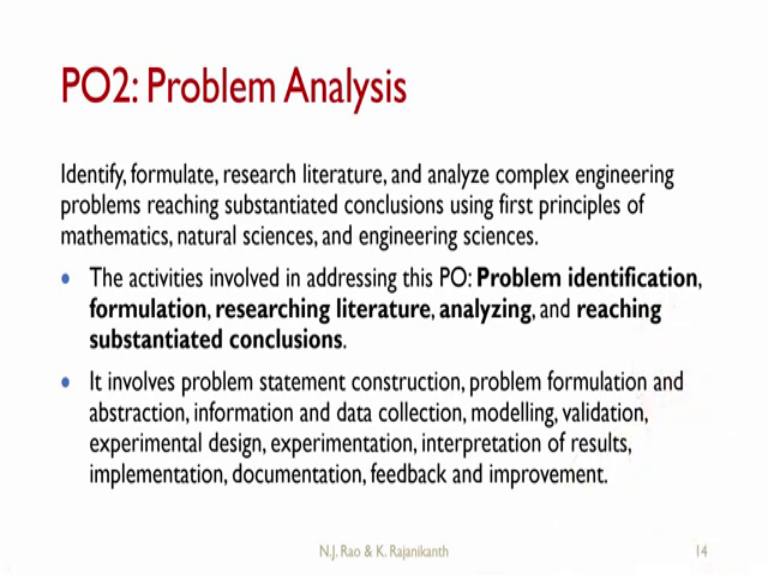

Now, coming to the second one, PO2, this is lot more complex. Let us look at the wording. Identify, formulate a research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural science and engineering sciences. As you can see compared to PO1 this is written in a current in a better order. What are the activities involved in this, in addressing these PO: One is problem identification.

Then problem formulation, research in literature related to that and analyzing that literature and reaching substantiated conclusions. There are 5 different activities. Even if you do some we can say we have partly addressed PO2. For example, unfortunately the way the engineering curricular are planned today, that I do not think there is any experience given other than in the project that the students do, where they identify a problem not they have identified problem you do not even formulate that experience is not given through any formal courses. Neither you research literature nor analyze all the issues related to that.

And reaching substantiated conclusion, the only place where you are likely to get involved this are the project. So, the PO2 involves problem statement construction, problem formulation and abstraction, information and data collection, modeling, validation, experimental design, experimentation, interpretation of results, implementation documentation, feedback and improvement. It is a tall order and we will, we will not be able to do all that in every course, but at least if you are convinced all these are important during the design of the curriculum, you should make sure that these different things are addressed in different courses.

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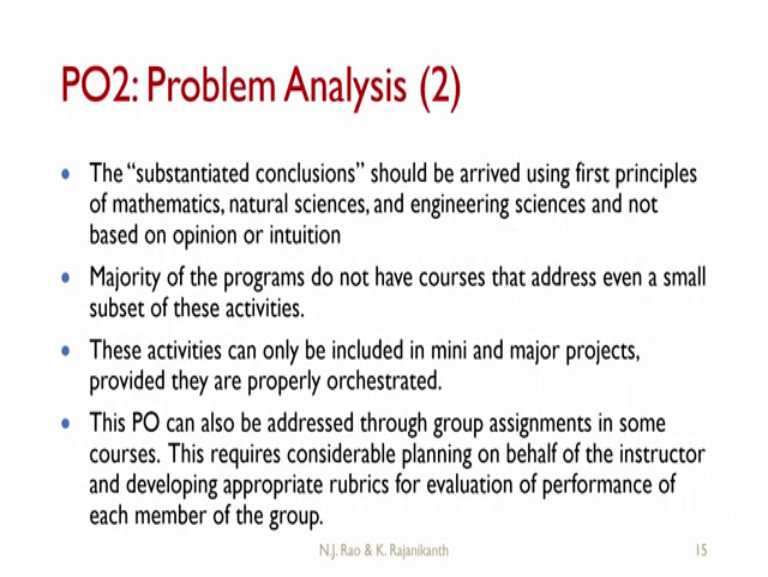

Now, the substantiated conclusion should be arrived using first principles of mathematics, natural sciences and engineering sciences and not based on opinion or institution or intuition. So, these substantiated conclusions. Drawing this substantial conclusion is a part of the PO2 or but that process should be arrived or should be done using first principles of all the subjects. And if

you look at majority, the programs do not have courses that address even a small subset of these activities.

So, it is very difficult to say that my course is addressing PO2, it is not that your course cannot address PO2, but the way it is practiced, especially, where you have 90 percent of the colleges are affiliated to a university where assessment is all centralized. It is very difficult to say that PO2 is addressed and the only place where they can be included or the mini and major projects even there, you can, you can assure that they are addressed if they are properly orchestrated, which is possible to do at the department of it.

This PO can also be addressed through group assignments in some courses. This requires considerable planning on behalf of the instructor and developing appropriate rubrics for evaluation of performance of each member of the group. As you can see, if you want to address any of the POs it requires substantial amount of planning.

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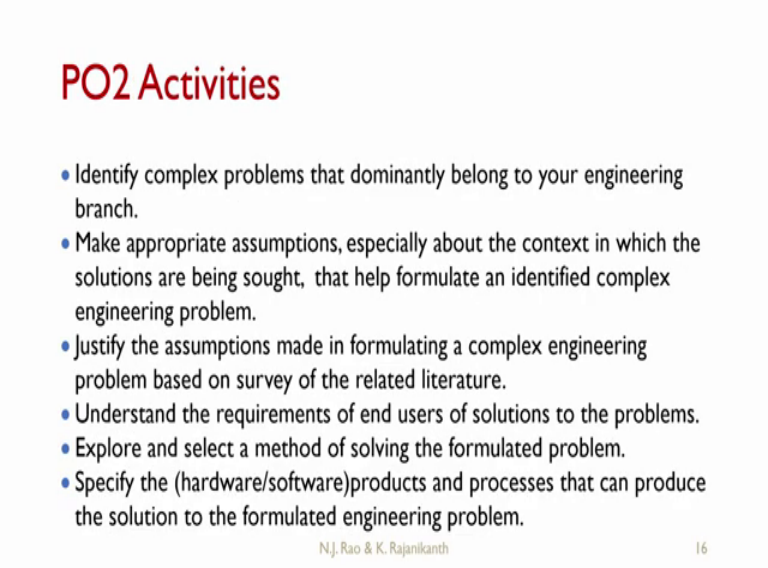

And some of the activities, it does not mean that one can do all of them, just am giving it a small list of them. Identify complex problems that dominantly belong to your engineering branch. Make appropriate assumptions, especially about the context in which the solutions are being sought. That helped formulate an identified complex problem engineering problem and justify

the assumptions made in formulating a complex engineering problem based on survey of the related literature.

Because whenever you are formulating, formulating an identified problem, you have to go through process of making some assumptions. These assumptions have to be stated upfront and they should be what you call reviewed by the consent stakeholders or at least a group of people will have to review whether those assumptions made of are appropriate or not. Then understand the requirements of end users of solutions to the problem. Explore and select a method of solving a formulated problem.

Specify the hardware or software products and processes that the solution to the formulated engineering problem. So, some of these activities can be brought into a course. But as we said, it requires a lot of planning. And you also have to see students will take it seriously, only if they also form part of your assessment. If there is no assessment associated with that, then the students do not, do not necessarily pay attention to what you are doing.

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Now, PO3; design and development of solutions. The statement says design solutions again for complex engineering problems and design system components or processes that meet the specified needs, with appropriate consideration for the public, public health and safety and the cultural, societal and environmental considerations; it is a tall order. Now, what is the focus?

You are designing solutions for engineering problems and the, can only be experienced through projects and assignments because they do not miss easily fit into the single course unless you have a course called some engineering design, it is possible to design such a course as a part of the curriculum, but you call it engineering system design or design of engineering systems, whatever name you give, it is possible to design such a course and give the experience like this.

And also these are time consuming activities and cannot be that easily included in it especially in a limited time written examination. They can only be experienced over a period of time. So, they cannot be part of what do you call a 3 hour, 2 hour examination where for any question you do not have more than half an hour. However, components of systems can be designed through smaller assignments and some identified courses.

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The design criteria and specifications of components and process need to be evolved from the solution to a given problem. This experience it can be given in a in a classroom provided you care for it. For example, the one of the very main important things that engineers should be familiar with is what our criteria and specifications. Unfortunately, most of the courses do not pay attention to these at all. So, if you are offering a solution then from that solution you should be able to draw the criteria and specifications of components and process.

I think at least they should go through this exercise in 2 or 3 courses for 4 years. These criteria and specification should be developed taking issues and again here, public health and safety, cultural, societal and environmental considerations. We hardly touch any of these dimensions. And the only way they can be addressed instead of making it very complicated, generally the standards associated with any particular engineering activity, they will, they would have gone through all these factors and the standards would have evolved.

So, if you design some product or a process for using the relevant standards, possibly, you would have addressed this PO3 very well. And cultural and social considerations will require inputs from non-engineering fields and get incorporated into what we call nonfunctional specifications. Yes, it requires a lot of elaboration we will not do that, but it requires inputs from non-engineering fields.

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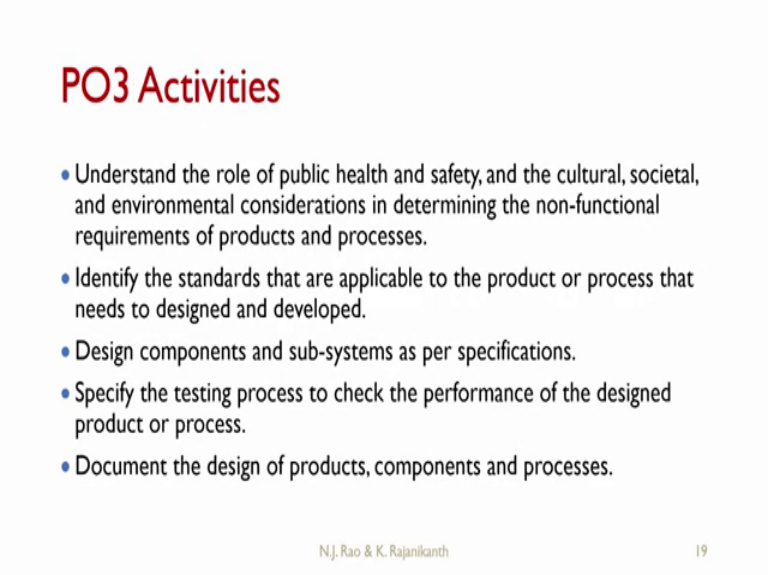

And which are some of the PO3 activities? Understand the role of public health and safety and the cultural, societal and environmental considerations in determining the nonfunctional requirements of products and process. This can be done through taking a one simple case study and making a presentation of that. Identify the standards that are applicable to the product or process that needs to be designed and developed. Let us say you are designing a, you are teaching a course on design of an electrical emission, emission like induction motor.

So, you just identify the standards that need to be followed and possibly the standards can be elaborated to explain how various requirements have been incorporated into that and then you are just identifying the standards and within those standards you have to design you have to develop your design, design components and subsystems as per specifications, specify the testing process to check the performance of the design product or process, document the design of products, components and processes. These are some of the possible activities that it can be incorporated into a regular curriculum to address PO3.

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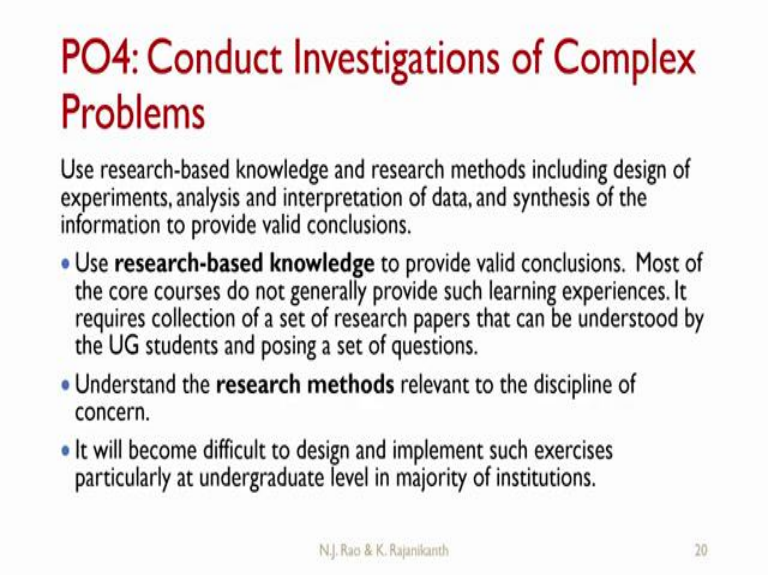

PO4 conduct investigations of complex problems, this is still a much more involved activity. Use research based knowledge and research methods, including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions. At least I am not, I am not aware of any course that addresses all of them or any of them. So, if you elaborating this statement a little bit use research base knowledge to provide valid conclusions.

Most of the core courses do not generally provide such learning experiences at all. It requires a collection of a set of research papers that can be understood by the UG students and posing a set of questions. This requires such an activity, if you can incorporate, yes, your conduct, you are at least addressing a part of PO4. Understand the research methods relevant to the discipline of concern. It will become difficult to design and implement such experiences, particularly undergraduate level in majority of the institutions.

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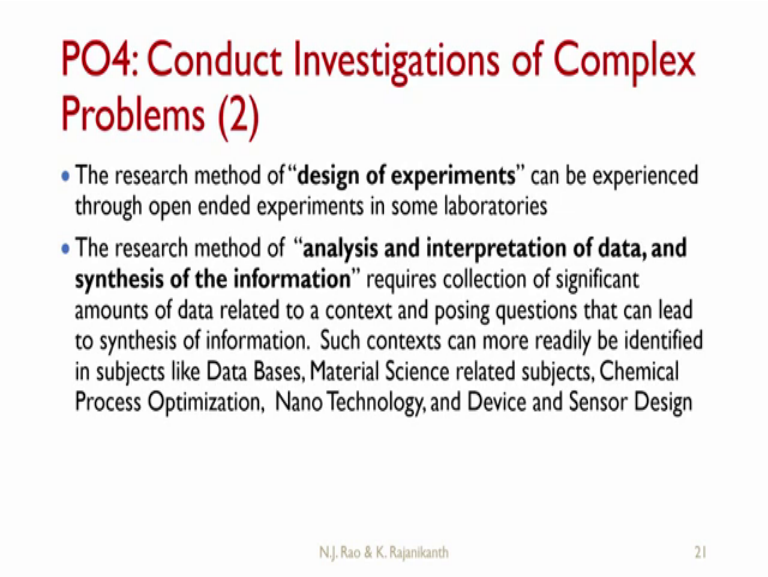

Further the research method of Design of Experiments can be experienced through an open ended experiments in some laboratories. It is possible to incorporate. Even if you are able to incorporate one such open experiment, possibly you can claim that I am addressing PO4. The research method of analysis and interpretation of data and synthesis of information requires collection of significant amounts of data related to a context and posing proper questions that can lead to synthesis of information.

And to my knowledge, such contexts can more readily be identified in subjects like databases, material science related subjects, chemical process optimization, nanotechnology, device, and sensor design. If there are such core courses near the program, they can incorporate this part of PO4.

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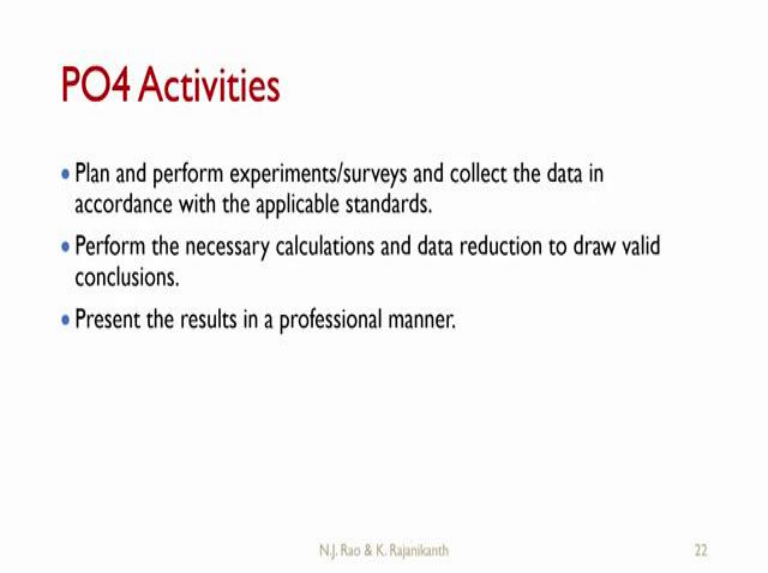

Some activities, plan and perform experiments surveys and collect the data in accordance with the applicable standards. It is possible to do so but you have to incorporate in one of the courses. Perform the necessary calculation and data reduction to draw valid conclusions. So, what can be done, you do not have to collect the data collect, you start with some data that is collected and made the students go through the necessary calculation to and data reduction to draw conclusions. And present the results in a professional manner. These are some suggested activities you can add you can add a lot more of your own within your discipline.

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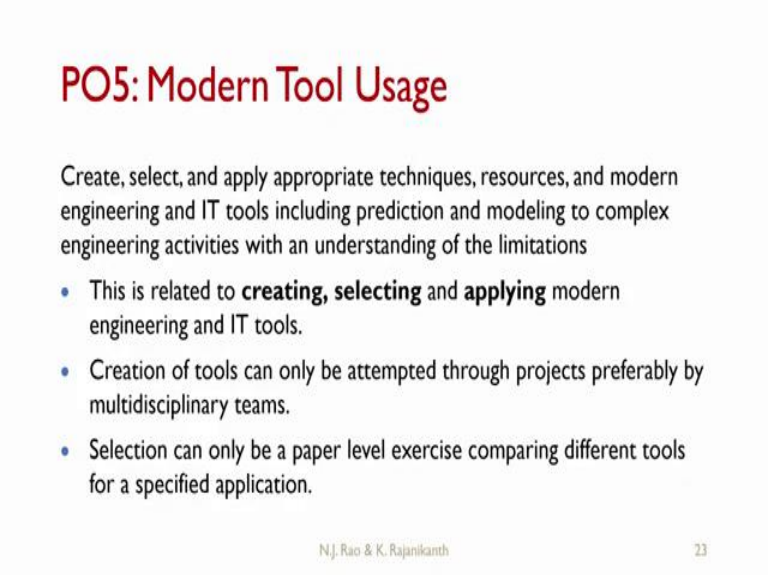

And PO5 is modern tool use age, create select and apply appropriate techniques resources and modern engineering and IT tools including production and modeling to complex engineering activities with an understanding of the limitations. Now, it once again a bit of analysis of the statement if you look at, this is related to creating selecting it and applying modern engineering and IT tools you have to look at IT tools or familiar with using this particular kind of software. Whereas, engineering it could be, what you call modern present state of the art engineering equipment and so on. But it is related to creating, selecting and applying.

So, creating an IT tool or selecting an IT tool, for example, are not in the realm of regular classroom teaching. The only exercise that you can do is you present the data about a set of IT tools and say ask the students to select what is best in a given particular context. Whereas applying modern IT tools is possible and some of the many of the programs do so, state of the art tools either through simulation or for design, analysis. Every branch has its own tools, they can be used, but creating a tool can at best be attempted through a project.

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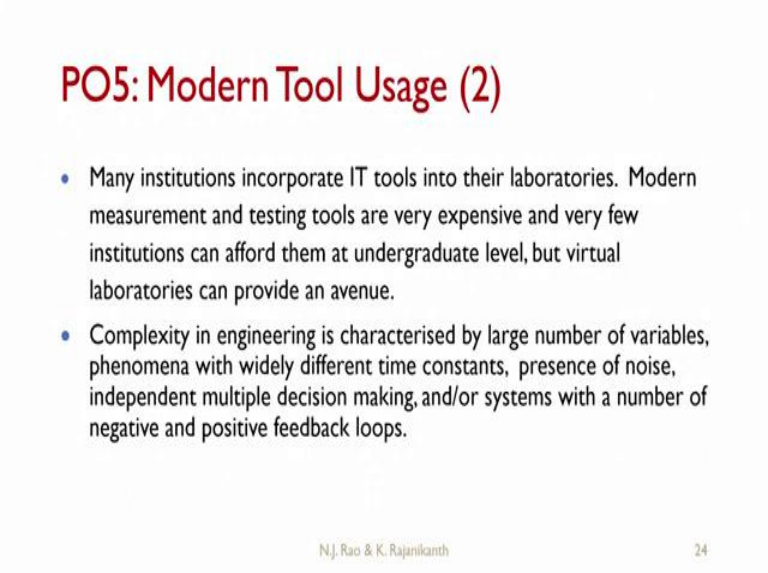

As we said many institutions already incorporate IT tools into the laboratories. So, this PO5 is reasonably addressed in courses where you are using the IT tools in the laboratory. The complexity in engineering is characterized by first thing is large number of variables. Any complex problem has large number of variables phenomena with widely different time constants.

Some things happen at microseconds, some things happen at milliseconds, something happens at second, sometimes some of the process take hours and they do happen in the presence of noise that is unwanted inputs. Independent multiple decision making may be involved in a complex problem and systems and many of the complex systems will have number of negative and positive feedback loops within that.

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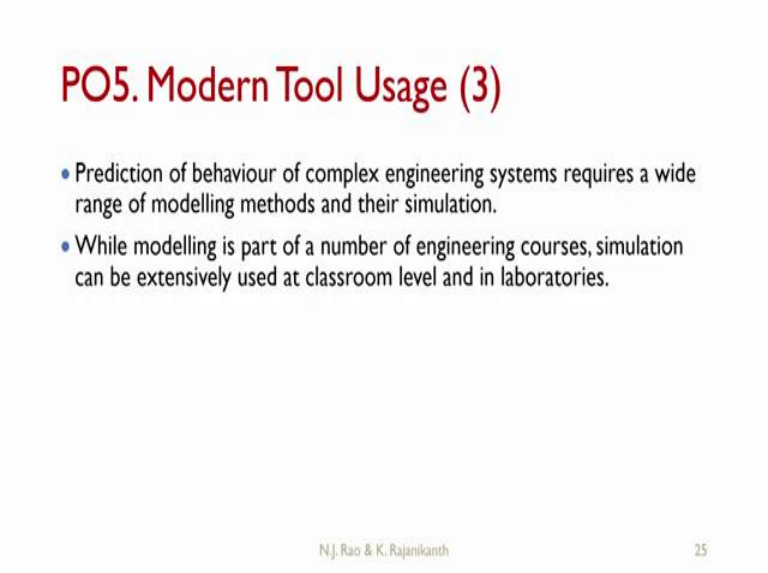

So, and such things can only be addressed through some of the tools used for simulation, there are a whole host of tools today are available to complex to understand the behavior of complex engineering problems. If those are incorporated, then you can say at least you are using modern tools for studying complex engineering problems. While modeling is a part of a number of engineering courses, simulation can be extensively used at the classroom level are now also in the laboratories.

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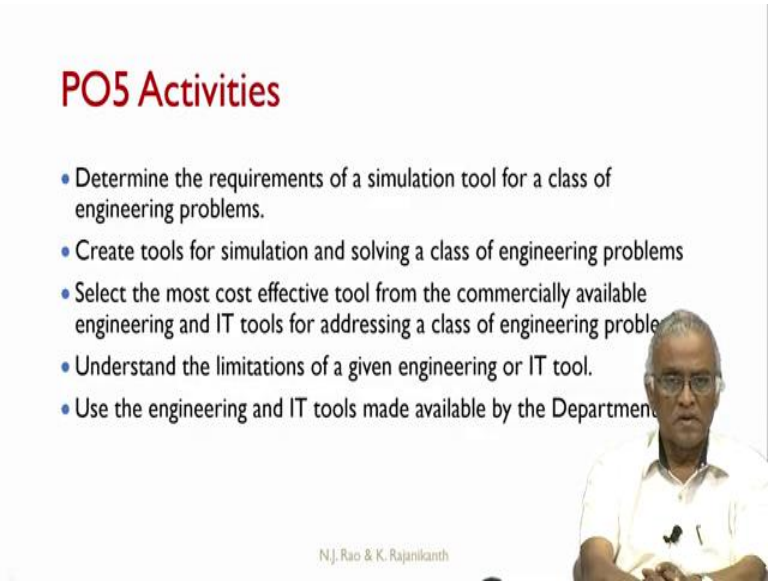

And which are the possible activities? Determine the requirements of a simulation tool for a class of engineering problems that can be one of the exercises. Create tools for simulation and solving a class of engineering problems. Creating such tool can be done as a project. Select the most cost effective tune from the commercially available Engineering and IT tools for addressing a class of engineering problems. Understand the limitations of a given engineering it tool.

That is you show a tool and say find out what are its limitations, where it can be applied? Where it cannot be applied? Use the engineering IT tools made available by the department that is being done practically by all institutions. So, these are all possible PO5 activities.

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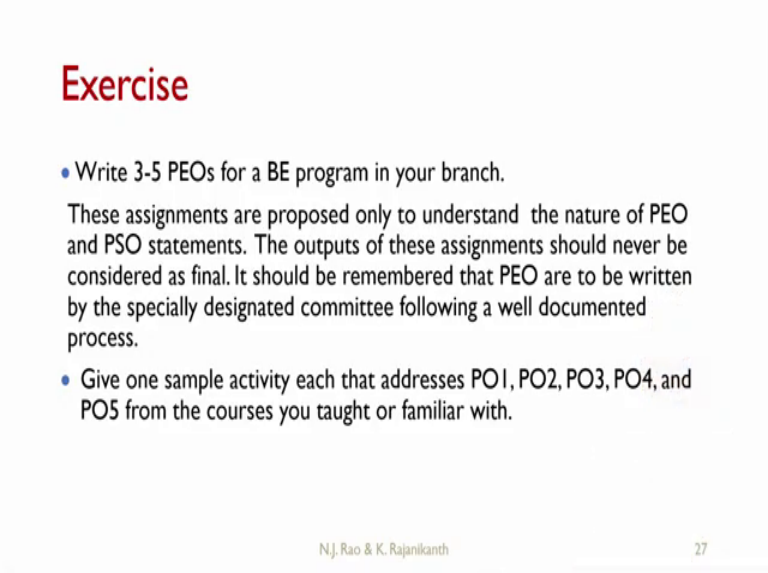

Now, coming to exercise, write 3 to 5 PEOs for a BE program in your branch. But when you are doing this, it does not mean that you are giving the final solution because PEOs had to be written by specially designated committee following a well-documented process. But at least all teachers should experience writing such PEOs. Give one sample activity each that address PO1, PO2, PO3, PO4 and PO5, from the courses you taught are familiar with. Like the other one, we appreciate if you share your results of your exercise with us, it will be a great learning experience for us.

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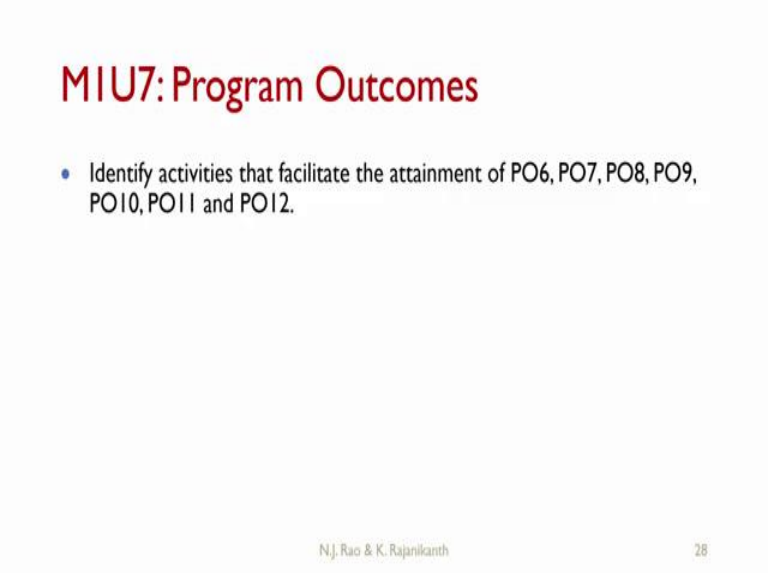

And in the next unit, we will be looking at the remaining 7 program outcomes. That means what is the nature of this program outcomes? And what are the possible activities that facilitate the attainment of them. Thank you very much for your attention.