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Lecture - 27
Power Law of Practice, Learning Curve, Numerical Pro

As you remember in the first lecture session of week 6, we are referring to various kinds of work postures and their problems. Depending on the several factors, you can say whether it is an acceptable work posture or it is a poor work posture and what is the negative impact for a poor work posture.

There could be different types of the negative effects particularly the joint pains and the pains on human body. Obviously, the human your performance will be affected and it will have a very long term the harmful side effect.

So, we are referring to several examples and kinds of the constraints, kinds of the problems a person faces in different work postures. Particularly with respect to different kinds of work stations.

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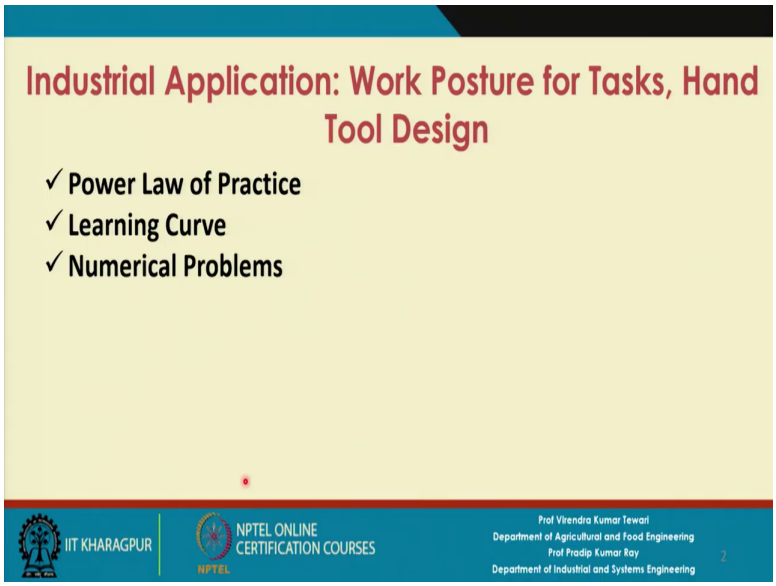

The second lecture session I will be referring to essentially three important topics. We are going to discuss the power law of practice. Next one is the learning curve.

If you believe in the concept of power law of practice, over repetitive trials, what happens for the same job you perform very well in fact. Only thing is the number of trials should be more.

This is basically referred to as the learning curve for different jobs for different persons, the learning curve also will be different, or for the same person for different jobs learning curve will be different. So, this important aspect we are going to discuss and related to the learning curve related to power law practice, there could be several numerical problems.

We will be discussing a few the standard numerical problem related to learning curve and power law of practice.

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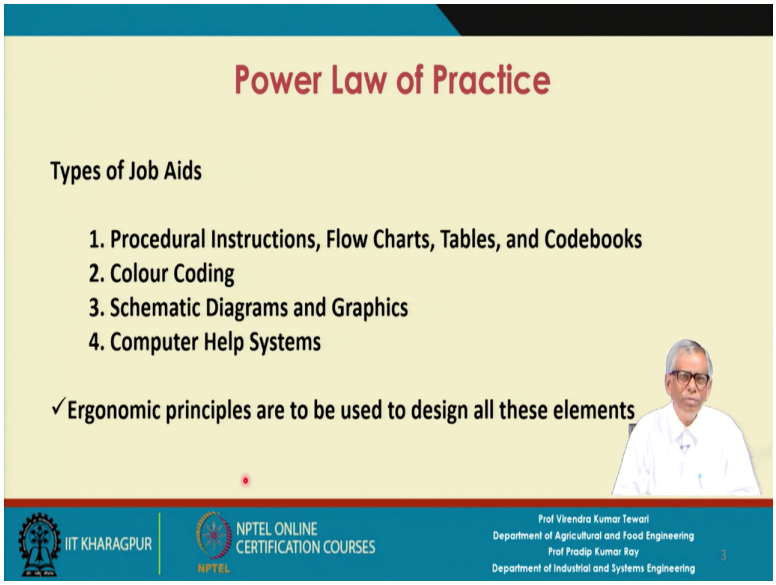

Now, in the last lecture session if you remember we have referred to various kinds of job aids. Sometimes they are referred to as the mechanical aids and these mechanical aids basically they become a part of the job. In many cases what happens that if you want to improve the performance of performance with respect to certain job and if it is manual handling task with bare hands or bare foot there could be body injury.

Mainly for preventing body injuries these mechanical aids are used; that is the first part. The second important advantage is that you can perform on the job very efficiently, very effectively there are several examples, if you use mechanical aids.

Sometimes they are referring to as the job aids or the task aids. In this case it is slightly different. It is not the mechanical aid it is related to the job. Like say while you carry out a job you must provide the procedural instructions; that means, which particular procedures you have to follow for carrying out the job.

These instructions must be given. Similarly these instructions you can give with help of a flowchart. If you look at the flowchart you will come to know that what are the steps involved in carrying out the job. From the start to end and what are the important the considerations you must understand.

Then there could be several tables, several code books you can also use. These are the part of instruction manual. The second one is the colour coding when you start working with the job. So, one set of the colour you get and when you complete the job maybe the green light is shown.

Like one particular example I am telling you in the Japanese TPS or the Toyota production system. One important approach or the technique is called autonomation. You are working with a particular machine and suddenly what you find that it produces a defective item. So, immediately it will be shown there will be red colour.

Everybody will come to know that the machine is producing defective items and automatically the machine stops functioning. The automated system they have created within the system. So, we have no other alternative, but to go for the corrections; what are the causes of producing defects. Whether it is machine settings have change or not or there could be many other reasons.

So, you have to identify the reasons and those reasons or the causes are to be removed so that again you get back to the initial state of health of the machine. From the red colour you again get the green colour, this is one such approach they apply. Third one is the schematic diagrams and the graphics these are also widely used.

These are also considered the job aids and the last one is the computer help systems. Many a time what happens in many cases you make the lot of errors. And once you start responding to the computer help menu. This is automatic, and many a time there is a kind of interactions you have like say human computer interface. Many a time your performance will be very poor when you start using the computer help menu.

Anyway, it will help you in understand the process ultimately and so that is why it is also referred to as the job aids. Now, we must understand that ergonomic principles are to be used to design all these elements, whether it is the procedural instructions or the colour coding or the schematic diagrams or computer help systems. Because for each type of job aids.

So, what you must consider that is whether interaction is perfect or not. So, interface design is the key. And you need to check that how many different types of ergonomics principles you are basically using at this point in time in designing these job aids.

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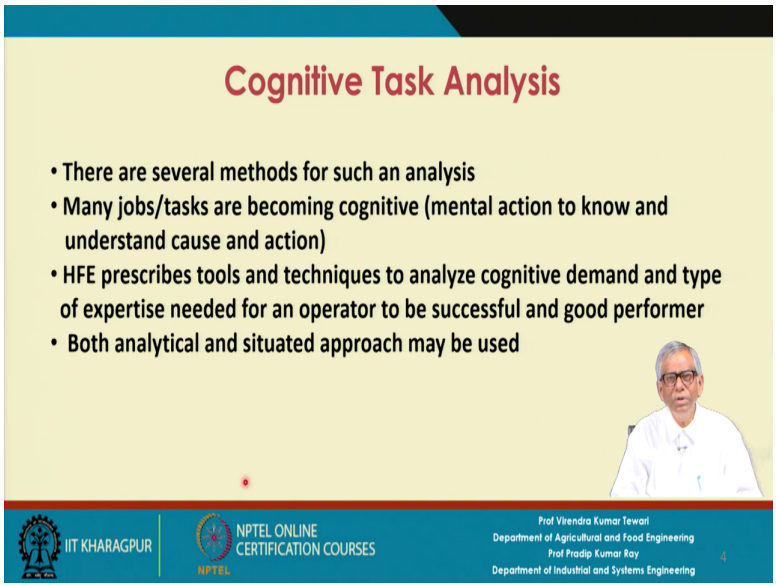

We have already discussed in the previous session- the task analysis. Now, one type of task analysis is referred to as the cognitive task analysis. There are several methods for such an analysis; we are focusing on while you carry out a job, the body is involved.

But your mind also should be involved in the job, my interaction or interface is perfect. Why? Because I am working with the job, my body is with the job definitely, but my mind is also the job. So, whenever we talk about the mental work or any work you do; though we are saying it is a physical work visible the output is visible.

Essentially when you carry out the job your brain is working. This part also you must consider while you go for the task analysis and I am trying to explain it in a simpler manner. for carrying out such an analysis many methods are there many jobs or the tasks

are becoming cognitive; what kind of mental action you have to take that must be known and well understood before you design a particular job as that while you design a job. A particular procedure you follow. We have already taken one example, like say motor mechanics jobs and what are the steps involved.

How many levels you must have in task analysis all these details we have discussed in the previous lecture session. Now, we go one step ahead; we are saying that what kind of mental actions you have to know and understand and the kinds of the causes and if suppose there are some problems you face, what kind of corrective actions or the preventive actions you must take. Human factor engineering is the discipline that prescribes tools and techniques to analyze cognitive demand and type.

With the help of or getting the support of human factor engineering you try to identify those tools and techniques which will help you analyze cognitive demand. The type of expertise needed for an operator to be successful and good performer that is most important.

The performance not only for a specific time period; you have to create a condition you have to create an interface in such a way that the job is designed and the person is involved with the job. At that point in time even there are could be many types of problems you are facing.

But you may ignore it and always you prove yourself to be a good performer. So, that is the ultimate goal whenever we say that we have been using HFE principles. It must be well understood by the workers working at the shop floor- both analytical and situated approach may be used.

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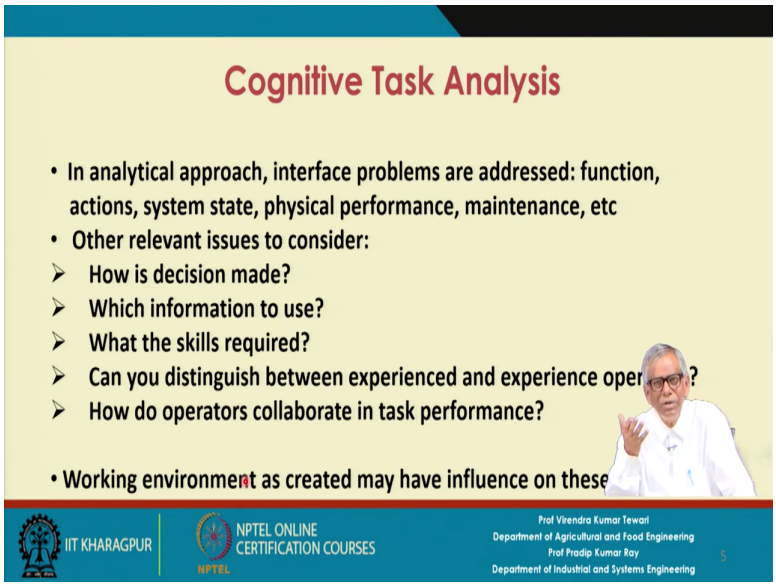

In analytical approach interface problems are addressed: function, actions. So, you need to identify what kind of functions you need to carry out with respect to a particular physical system, what kind of actions you have to take. Then what is the system state at any point in time- the state of the system physical performance, maintenance, all these details you must understand properly.

These are to be documented are you. What are the other relevant issues to consider in cognitive task analysis? The first thing is how is decision made. While you carry out the job at different at all the steps, you have to take certain actions.

So, you have to take a decision at any point in time. How is decision made, which information to use that is to be identified. What are the skills required? You are carrying out a job, you need certain skills. Then rule based and knowledge based can you distinguish between experienced and inexperienced operators.

Experienced and inexperienced and how do operators collaborate in task performance? In a particular week we will be referring to one particular issue in detail that is job satisfaction. In order to get the job satisfaction what are the HFE principles you have to apply.

Ultimately someone is carrying out a job and by observing how he or she is carrying out a job you will conclude that whether he or she is getting job satisfaction or not such that

you can except how they collaborate within themselves; how do operators or the individuals collaborate in task performance.

Many a time what happens though we are saying that this job is being carried out individually, but you will find in many cases this the job you are performing very well, but it is a collaborative work. So, the working environment as created may have influence on these factors. So, there are five important issues we have highlighted.

What is important that this particular task which you carry out it is within a working environment and ultimately the design of the working environment may significantly influence the task design.

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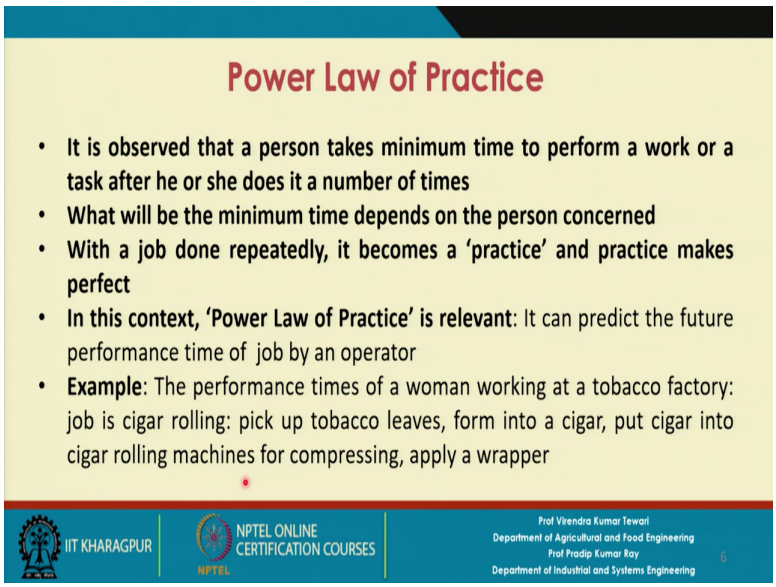

Now, let us talk about the power law of practice. It is observed that the person takes minimum time to perform a work or a task after he or she does it in number of times. It becomes a practice at the first time when you work you might face with lot of problems.

And slowly you are getting used to that and your mind getting involved with the job. On your own you try to improve the performance. It is quite natural for any human being if he or she likes the job, when the job lives in your mind this is going to happen,

At this point in time you take half an hour time, but you yourself feels that it can be improved; nobody is forcing you are intrinsically motivated. That is the one condition

whenever we say that we are trying to apply human factor principles. Ultimately, you are trying to make a person intrinsically motivated.

If the motivation comes from within, obviously, you will try to improve your performance. Right now, maybe you are carrying out the job and it has said suppose 10 steps. Initially someone has prescribed why do not you follow 10 steps as you start working with the job. You feel like combining say step 3 and step 4 you yourself is doing automatically.

So, slowly you try to make the work simple right and, if you want the simple, your interface will be better all the time. It is expected that ultimately you will take minimum time to perform the work. Right now it may be half an hour. After say 1000 times you connect repetitive task, you can just perform in 20 minutes of time.

This minimum time depends on a particular individual as well it depends on also what could be the minimum time. It also depends on the kind of the task or the job, what will be the minimum time depends on the person concerned as well as the job. With the job done repeatedly, it becomes a practice and practice makes perfect.

In this context, power law of practice is relevant. When you try to explain it, the context must be known are you so that it can predict the future performance time of job by an operator. When you apply this particular law with respect to a particular job, a person may have a particular learning rate.

This learning rate also will vary from one person to another given the same job. This is an example. The performance time of a woman working at a tobacco factory. Job is cigar rolling, pick up tobacco leaves form into a cigar put cigar into a cigar rolling machines for compressing apply a wrapper. These all the steps mentioned while you carrying out this particular job.

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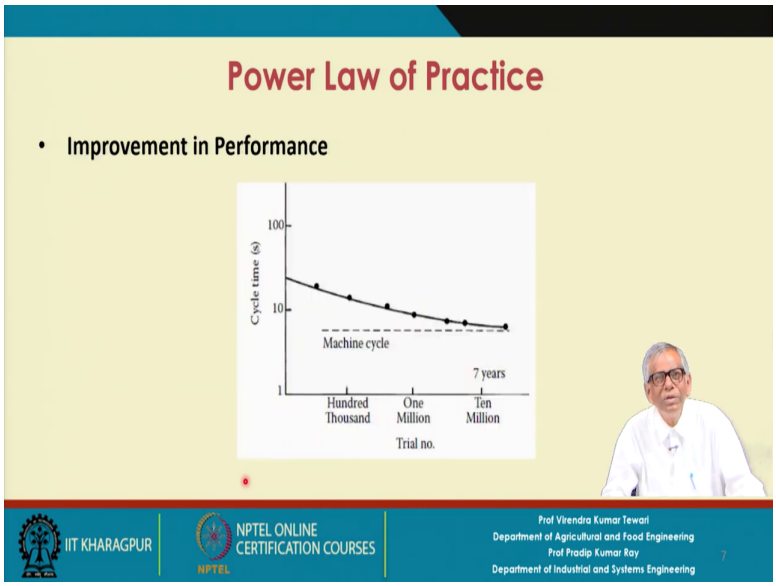

Now, this is the data they have collected. What you find that after 1000 trials, cycle time may be around the 15 seconds, but after 1 million trials, it has decreased to less than 10 and after 7 years, 10 million times.

You just look at this curve. This is the learning curve with respect to a particular job for the person you have named.

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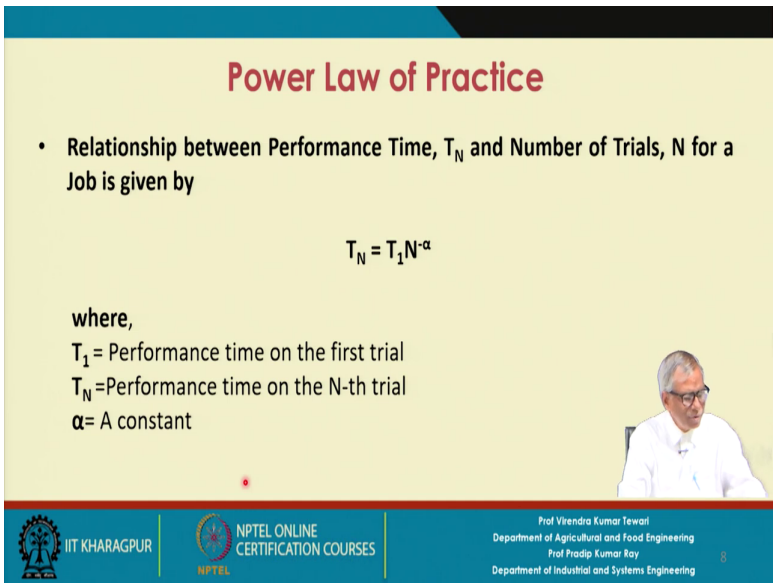

The relationship between performance time.

$T_N = T_1 N^{-\alpha}$

T_1 is the performance time on the first trial

T_N is the performance time on the N-th trial

α is a constant

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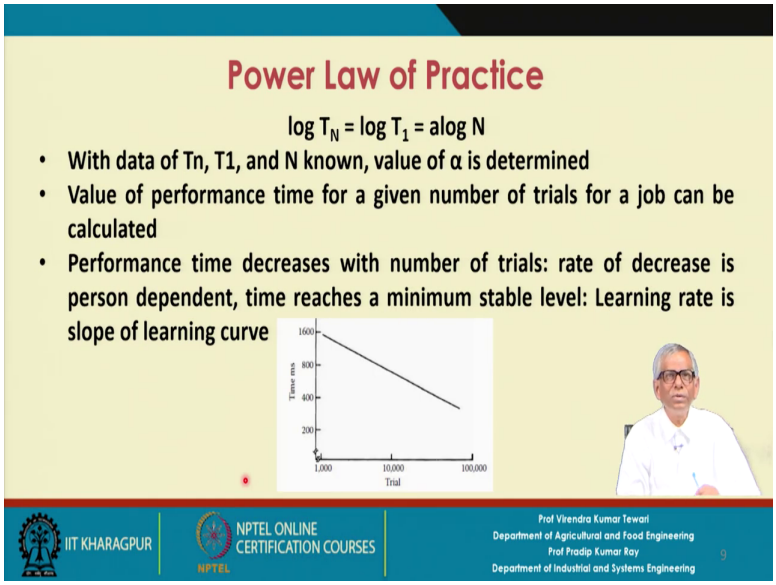

$$log\ T_N = log\ T_1 - \alpha\ log\ N$$

The value of performance time for a given number of trials for a job can be calculated once α is known and T_1 is also known.

Suppose you say that 1000 trial what is the timing and 2000 trial what is the timing? Easily you can determine when you specify the curve. Performance time decreases with number of trials, that is the learning effect. There is a kind of learning you have- the corresponding learning theory - Peter Keynes trial and error.

The learning theory states that rate of decrease is person dependent. Time reaches a minimum stable level. Beyond that you cannot reduce. Learning rate is slope of the learning curve. This learning rate will vary from one person to another with respect to a particular job.

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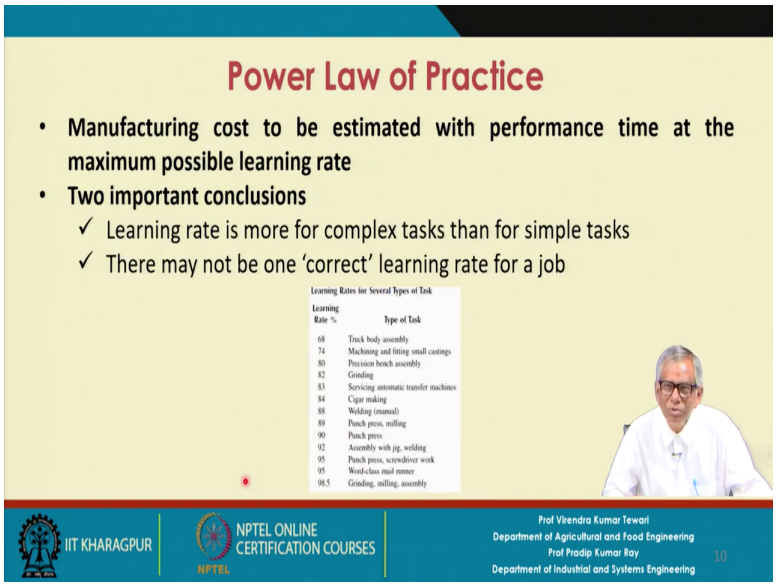

These also will vary from one job to another. The manufacturing cost is to be estimated with performance time at the maximum possible learning rate. What we assume that you reach your maximum learning rate and in the process that interface has become a stable one and then you calculate the manufacturing cost.

If you try to apply continuously the human factor principles for your jobs at your workplace, ultimately your entire production system or manufacturing system or the service systems, in all likelihood it becomes a stable system. Two important conclusions. Learning rate is more for complex tasks than for the simple tasks and there may not be one correct learning rate for a job.

I am just the showing you one table. The learning rate is mentioned for different types of tasks and what you find for the same task there could be two different the learning rate. So, this is unavoidable.

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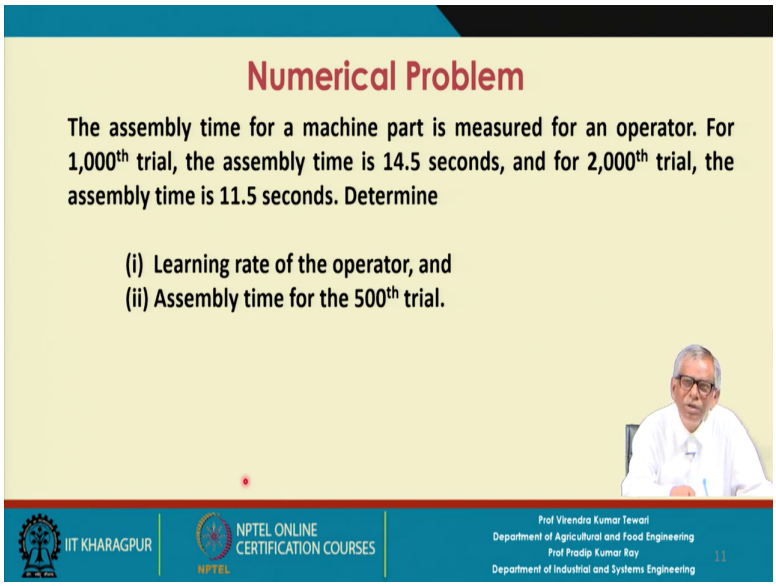

Just one another numerical problem we will go through before I close this session. The assembly time for a machine part is measured for an operator for 1000s trial. The assembly time is 14.5 seconds and for 2000's trial the assembly time is 11.5 seconds. Determine learning rate of the operator and assembly time for the 5000's trial 5000's trial.

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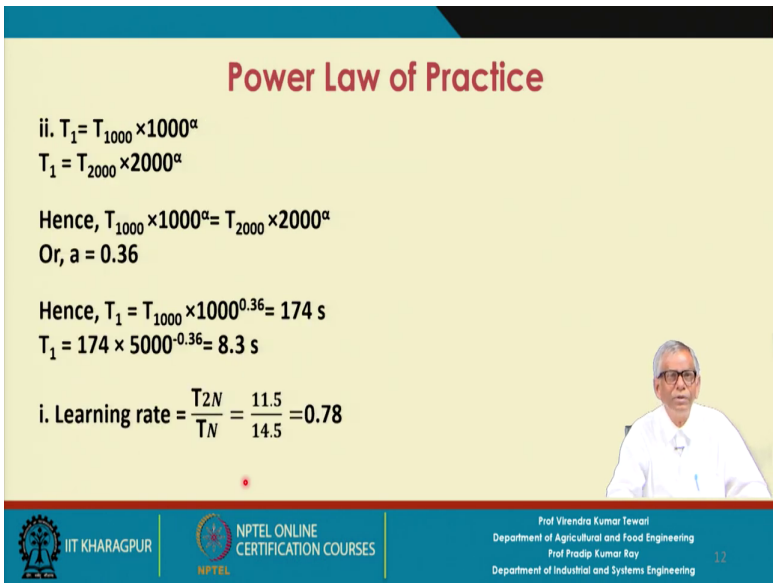

ii. $T_1 = T_{1000} \times 1000^{\alpha}$
$T_1 = T_{2000} \times 2000^{\alpha}$

Hence, $T_{1000} \times 1000^{\alpha} = T_{2000} \times 2000^{\alpha}$
Or, a = 0.36

Hence, $T_1 = T_{1000} \times 1000^{0.36} = 174$ s
$T_1 = 174 \times 5000^{-0.36} = 8.3$ s

i. Learning rate = $\frac{T2N}{TN} = \frac{11.5}{14.5} = 0.78$

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