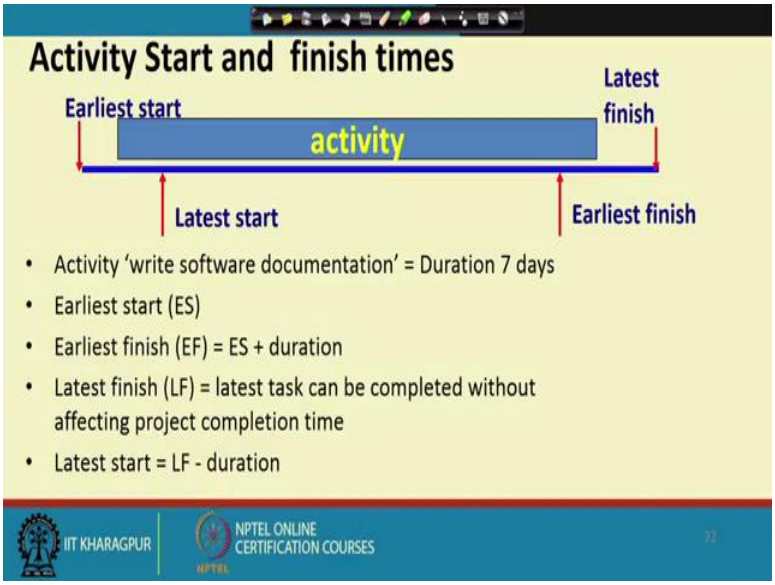
Software Project Management
Prof. Rajib Mall
Department of Computer Science and Engineering
Indian Institute of Technology, Kharagpur

Lecture - 29
Computation of Project Characteristics Using PERT/CPM

Welcome to this lecture. In the last lecture we were discussing about PERT CPM, we had some general ideas regarding PERT CPM. We looked at the task network by which we represent the different tasks or activities and the dependencies between them and then we distinguish between the PERT and CPM. And we said that CPM we use deterministic task times whereas, in PERT we use probabilistic task times because, tasks are uncertain, the completion times are uncertain.

And in CPM we use deterministic times and therefore, we use deterministic conclusions regarding the task parameters. Naturally, CPM is much more simpler then the PERT with statistical times. We will first look at determining various project characteristics using PERT CPM. And then we look at determining project characteristics using PERT where we use statistical times; let us get started with this.

(Refer Slide Time: 01:51)



If you remember in the last lecture we were saying that the project manager during the project scheduling would like to determine various project characters characteristics and then manage the project based on these characteristics. One of the important

characteristics is to identify various activities the tasks and the dependencies among them and also to identify several attributes of the activities. One attribute is of course, the duration of the activity. So, the one that you see in the blue here this is the duration.

For example, the activity may be to 'write software documentation' and the project manager estimates the duration to be let us say 7 days. But, then once the task network is developed that is the PERT CPM network then it becomes possible to use the PERT CPM to identify other characteristics of the activity. For example, earliest start time this is you can see here the arrow mark here red arrow mark here, this is the earliest start time, this is the earliest time at which the activity can start. Similarly, the earliest finish time this is the earliest finish time based on the activity can finish.

These are important characteristics because, the project manager can deploy resources, can start other activities. And another attribute of activity that will be determined based on the PERT CPM is the latest start time. This is the time at which the activity can be started without hampering the project completion time. If the activity starts anything later than this arrow that you can see here this is the time line, the blue line that you see here this is the time line. And, if the activity started anywhere later than the latest start time then the project is going to be delayed. And latest finish time is the time by which the activity must end, if it does not end by this then the project is going to be delayed.

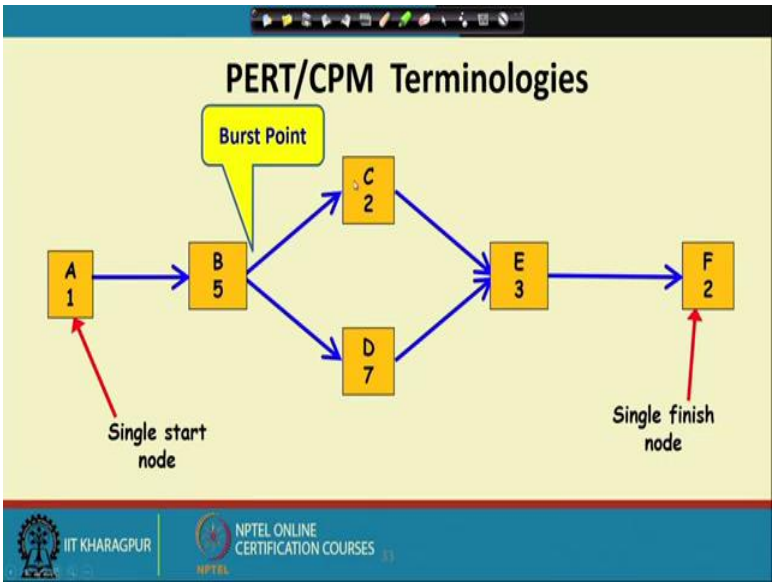
Naturally, the latest finish minus the latest start time is equal to the activity duration, the activity duration is shown in the blue here. And, latest finish to latest start time is the activity duration, similarly earliest start time to the earliest finish time is the activity duration. We will use the PERT CPM to compute these project characteristics and based on these project characteristics, we will also be computing the slack time. The slack time is the time that the task has for which the project manager has some liberty, if the slack is 0 and the project the earliest start time and the latest start time coincide. So, there is no flexibility for the project manager to differ the task for sometime, but then here you can see that there is a slack time.

There is the activity can start anywhere between the earliest start to the latest start and this we call as the slack time. The latest start minus the earliest start which is also equal to the latest finish minus the earliest finish, this is called as the slack time. This is the time that is available to the manager to monitor and control the project; if one activity is

getting delayed you can defer this activity little bit and put resources on the other activity.

But cannot delay this too much beyond the latest start, have to start by the latest start time. Let us look at how to determine these project characteristics and later when we discuss about project monitoring and control, we will see that how this project attributes are actually used by the project manager for monitoring and control purposes.

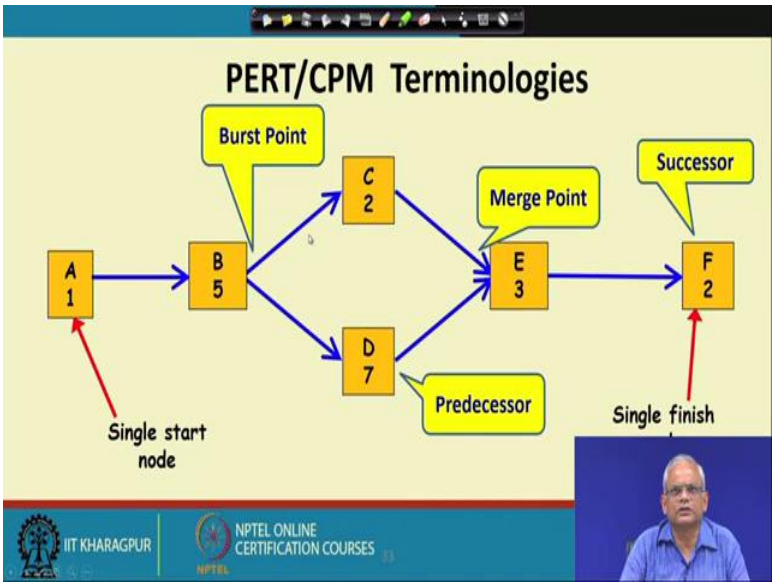
(Refer Slide Time: 07:03)



Before we get started, let us just look at few PERT CPM terminologies which we will be needing as we proceed with our discussion. We had seen the last lecture that a task network the PERT CPM is based on a task network and the tasks are here rectangles, the arrows are dependency. And we said that there has to be a single start node otherwise the methods that we give for computation of project characteristics would become very complicated.

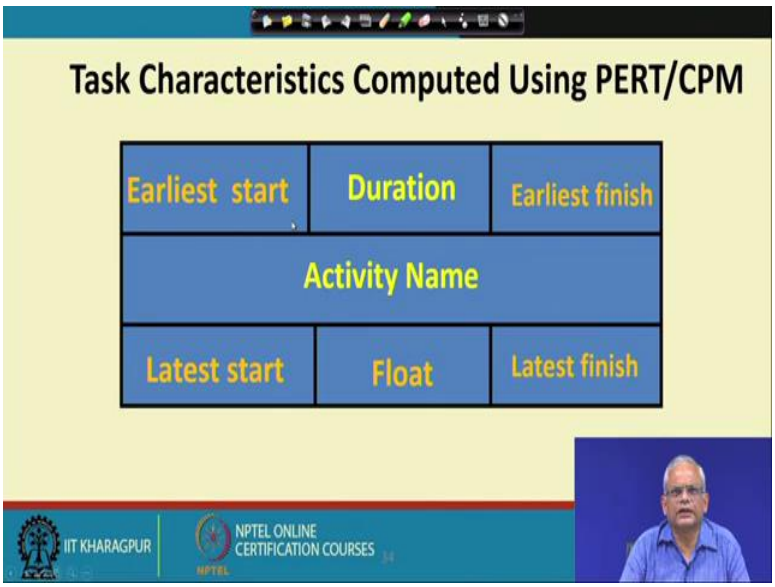
We will need that there is a single start node, if there are multiple start nodes we will put a dummy node and make that as a single start node. Similarly, we need a single finish node, if we find that there are multiple finish nodes we will put a dummy node and we will make it a single finish node. And then we have this burst point where a task or a activity has multiple successors. Once this activity completes this two C and D can start, once B completes C and D can start and that we call as dependency and here there is a burst point multiple tasks are dependent on B, C and D both are dependent on B.

(Refer Slide Time: 08:41)



We have merge point where a task E has multiple predecessors; that means, both C and D must complete before E can start. It may so happen that C completes earlier then D, but E cannot start until D also completes both the predecessors of E must complete before E can start and that we call as a merge point. And, D is a predecessor of E, C is also a predecessor of E and F is a successor of E. These are some of the simple terminologies that will use as we discuss about the PERT CPM technique to determine project characteristics.

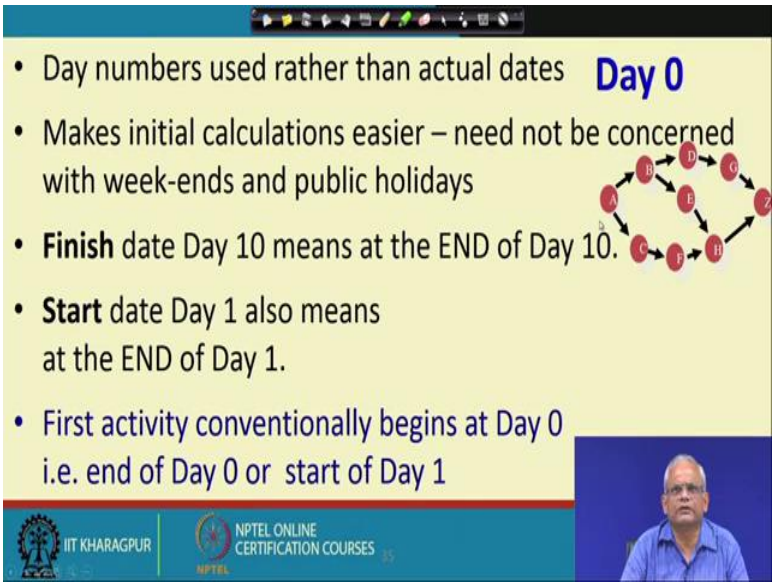
(Refer Slide Time: 09:37)



We had discussed in the last lecture that we will use this kind of notation, for a task will represent a task in a form of a rectangle. The task or activity name will be written in the middle and we would have determined the duration of the activity. Typically in weeks, 1 week, 2 week something like that or it can be in days, but rarely it is in hours or months. It is typically in days or weeks and the one that you are seeing in the red one, the earliest start, earliest finish, latest start, latest finish and the float time these will be computing using the PERT CPM technique.

We already seen the definition of the earliest start, earliest finish, latest start this is the point of time. If the activity starts anywhere beyond or after latest start then the project is going to be delayed. Earliest start at most or at the earliest the activity can start at this point and the float is also computed by our PERT CPM methodology. But, then the float is the latest finish minus latest start which is also equal to the earliest finish minus earliest start both give the float. This is the flexibility that the project manager has we also call it the slack, slack or float.

(Refer Slide Time: 11:36)



Another point we need to mention, here we just write day 1, 2, 3, 4 etcetera rather than giving calendar dates. Please remember that the project scheduling using PERT and CPM is a higher level scheduling, where we do a high level scheduling in terms of days. Starting from day 0, how many days it takes? And later the project manager does a more detailed scheduling using the Gantt chart where, we use the calendar time. The idea is

that at a very high level scheduling we make a simpler plan, where we do not take into consider week-ends, public holidays and so on.

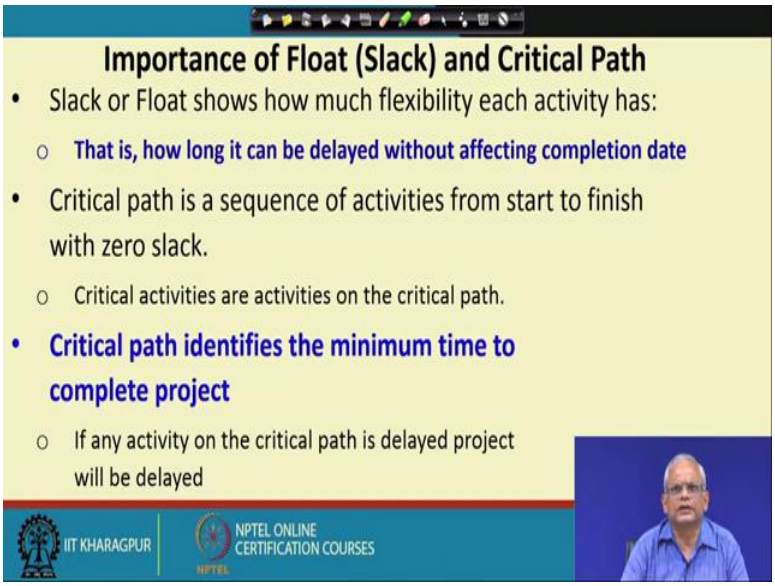
We do not use a calendar time here, this is a high level simple schedule that we prepare and later we consider various constraints. What are the holidays and then we consider the resources whether a activity can be started based on the resource availability and that we will do using a Gantt chart. But, the initial scheduling is done using a PERT CPM chart. We will have this kind of a network here task network, the tasks and the dependencies and as I was saying that these are very old techniques developed over a century nearly a century.

And therefore, we have a divergence of notations. Sometimes we have circles, but then we said that we will use rectangles for activity name and then we will have various attributes that will also be indicated along side this for our computation of the task characteristics.

The day 0 let us try to understand what exactly is meant by day 0 or day 10 or something. If we say that the finish date is day 10; that means, it is the end of day 10 which is also a normal use in our sentences, we say that we will do something by day 10 means end of day 10. But, then the start date of day 1 means end of day 1, but then that is not really what we say. We always start at the beginning of day 1, but for that purpose we will say that we will start in day 0 which means that we will start at the end of day 0 which is also equal to the start of day 1.

Let me just repeat here that we always say that the project starts in day 0 and the implication of that is end of day 0 or start up day 1. If we write day 1 here start of the project activity is day 1 for the activity A, then it will mean end of day 1, but normally we do not do that. We start at the beginning of day 1 and for that we will use the notation day 0.

(Refer Slide Time: 15:44)



One of the important project characteristic, that is very useful to the project manager is the float time or the slack time available for various activities and also the critical path. The project manager looks at each task or activity and finds out how much flexibility he has, in particular you can find how much he can delay the activity the starting of the activity without really affecting the project completion date. This is very important for the project manager during monitoring and control, because to affectively control a project may find that some activity is getting delayed.

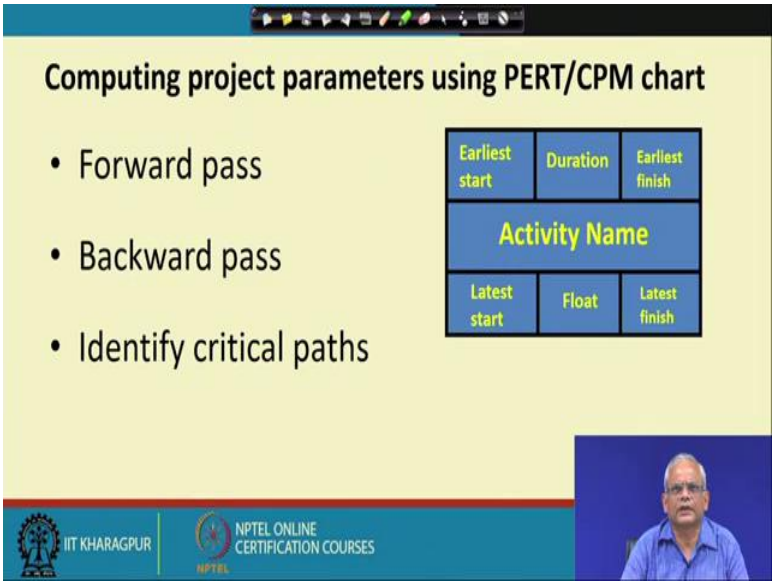
And, then can find out the activities which have enough slack and then may be take some man power from the activity which has enough slack, put it on activity which is getting delayed so, that there is no overall project delay. Therefore, the PERT CPM provides very important results to the project manager which are the earliest starting time, earliest completion time, latest start time, latest completion time, the float or the slack time and the critical path.

The critical path is the sequence of activities from the start task to the last task with zero slack. So, all the activities on a critical path will have zero slack, the project manager should be very careful about the critical tasks or the critical activities. That is the activities that are appearing on the critical path, the project manager gives special attention to the critical activities or the critical tasks because, any delay to the critical activities will delay the overall project. And therefore, the project manager typically

closely monitors the critical activities and at the eventuality or at the slightest indication that critical activity is getting delayed, the project manager takes corrective action.

For example: deploy a additional resources for the critical activity so, they do not get delayed. For this reason it is very important to identify the critical path and the critical activities. Not only that the critical path also identifies the minimum time to complete the project, that is if we sum all the critical activity durations that appear on a critical path we will get the project duration. Let me just repeat, if we sum the durations of all activities the critical activities appearing on a critical path then we get the project duration, that is the minimum time by which the project can be completed if the project manager monitors and controls the project well.

(Refer Slide Time: 19:40)



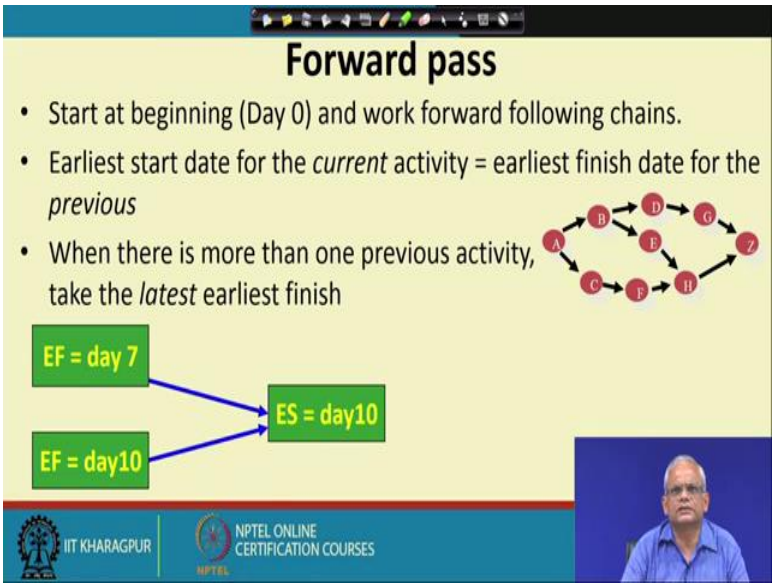
Now, let us looks at the technique that we will be using the PERT CPM using the PERT CPM we will compute the earliest start time, the earliest finish time, the latest start time, the latest finish time and the float. To start with will have the task network with activity names and their duration. All the activities would have been identified, the durations and the dependencies between the activities will be present. And we will now discuss a technique by which we will identify the other project attributes like earliest start, earliest finish, latest start, latest finish and the float.

Here we will have three steps; one we call as the forward pass where we look at the activities are the nodes appearing on the network from left to right and compute the

earliest start and the earliest finish. And then we have a backward pass start from the last node or the last activity and then slowly proceed towards the first activity. And we compute the latest start, latest finish for every activity and also we compute the float or the slack time which is the difference between the latest finish and the latest start time.

And, after having done that we identify the critical paths that is the path on which all the activities have zero slack, there may be more than one critical path. But, we mark all the critical paths typically on red color so, that the project manager gives attention to the critical path, the critical activities.

(Refer Slide Time: 21:48)



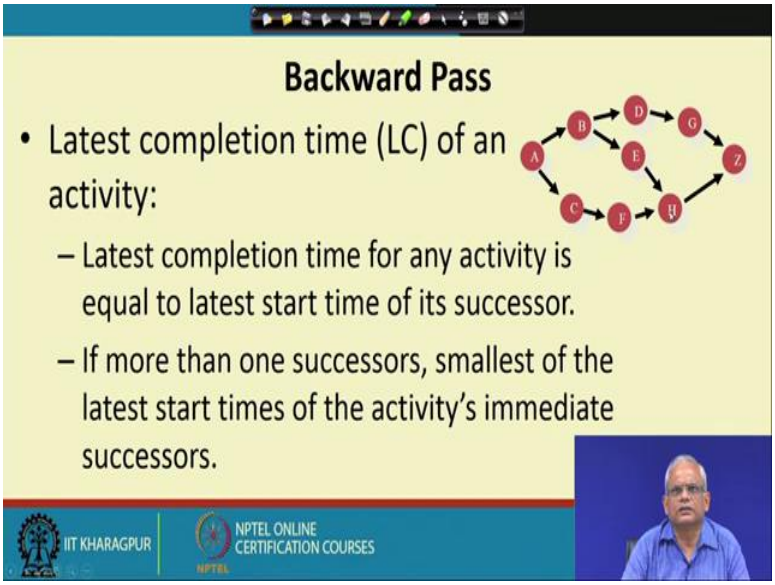
Now, let us look at the forward pass, this is the first activity using which we will compute some of the attributes. In our task network the first task will always be starting at day 0, that is end of day 0 or day 1 and then we will work forward following the chain. We will assign the earliest start date to an activity which is equal to the earliest finish date for the previous activity. We will take an example and explain how we do it, we will take a task from left to right and we will set its earliest start date which is equal to the earliest finish date for the previous. So, any task here, we look at the earliest finish date for the previous task and the earliest start date of this will become earliest finish date of the previous task.

But, then if there are more than one previous task, let us consider the example of H which has two previous task E and F then we will take the latest finish time of E and F.

The implication of this is that H can start only after both the tasks complete, even if E starts earlier H cannot start. H will start only after E and F both complete and therefore, we have to consider the latest time between all the preceding tasks to set the start time for H. This is just an example, if certain task the earliest finish time is day 7 and another task where the earliest finish time is day 10 and both are the predecessors of this task, then this task cannot start until day 10.

So, this task will complete at the end of day 10 and this task will start at the end of day 10 or that is beginning of day 11. So, we have to consider the letter of the two preceding tasks and set the earliest start time to be that. So, forward pass is simple, let us take some example and then we will see how to use this.

(Refer Slide Time: 24:35)



Once we have done the forward pass, we will have to do the backward pass. In backward pass we start from the last activity and here we compute the latest completion time of the activity which is equal to the latest start time of its successor. We now look at the successor of a network, successor of a task. So, if we look at B ok, let us look at a G then we look at what is the latest start time of H Z, latest start time of Z and then we set the latest completion time of G. The idea is that until if we find that Z needs to start on some date, G has to complete by that date.

So, using that concept we use the backward pass and then if there are more than one successor, the smallest of the latest start time of the activities immediate successor has to

be put. Let us look at the case of B, B has two successors D and E; now if D has certain latest start time and E has certain latest start time. Then we have to take the smallest of this two D and E and make that as the latest completion time of the B. Or, in other words B must complete before E can start let us say E has the smallest completion time let us say D has 10 and E has 7; then B has latest completion time must be 7 otherwise E cannot start again.

Here in the backward pass the rule is simple, we will take an example to consider the forward pass and backward pass. You can see the rule is extremely simple, we can do for very small or moderate sized the task networks. But, then as I was mentioning earlier nowadays there are many tools. We will discuss some of these tools, where the computation of the characteristics of the project are done automatically. The one that we do by backward pass, sorry forward pass and then followed by backward pass, identification of the critical path these are done only on press of a switch, press of a button.

So, but then it is important to understand the technique that they use to compute forward pass, backward pass and then identification of the critical path and for small task network. So, you do not even have to use a computer, we can just draw it by pen and paper and within a minute or two we can compute the task characteristics. We are almost at the end of this lecture; we will stop here and continue from this point in the next lecture.

Thank you.