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

Lecture - 28
Project Scheduling Using PERT/CPM (Contd.)

Welcome to this lecture.

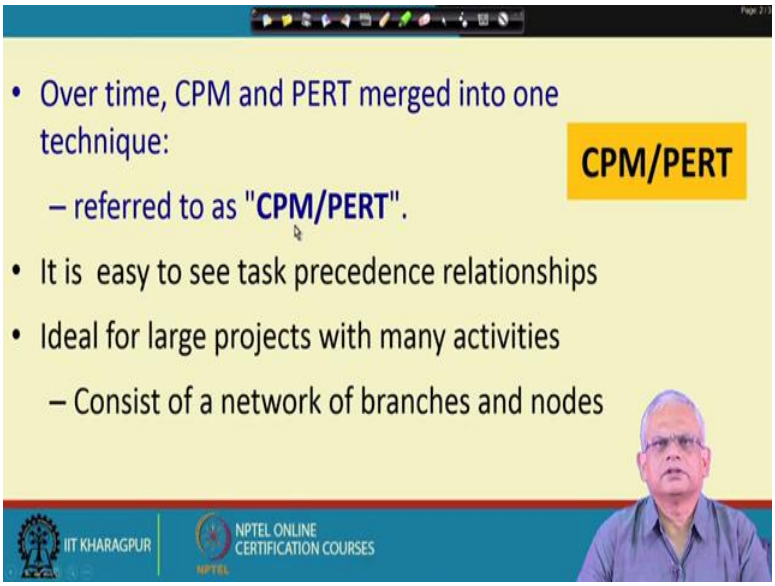
(Refer Slide Time: 00:29)

In the last lecture, we had discussed about PERT and CPM, some very basic ideas. We discussed about PERT and CPM, their origin, the main components of the PERT CPM diagram. We said that these were two very independent techniques used for very different purposes. PERT was used in development of the Polaris missile, where there were lot of uncertainty regarding task completion times is a challenging project; whereas CPM was used by dupont for its chemical plant maintenance activities; which were more or less routine activities even though the activities there are many activities and it was a complex set of activities, but the activity durations where deterministic.

And the critical path method it allowed to compute the critical path, it gave a technique using the task network; how to compute the critical path. But then over the years, both the techniques have evolved; both the techniques are equally capable. Many of the things that were there on PERT is observed in CPM and vice versa and now they have been merged into a single technique. And we will discuss about how these techniques are

being used in project scheduling because this is a important tool for the project manager. The project manager using the PERT CPM can determine the completion time of the project; for each activity can compute the slack time the critical path and so on and that is the focus of this lecture.

(Refer Slide Time: 02:23)



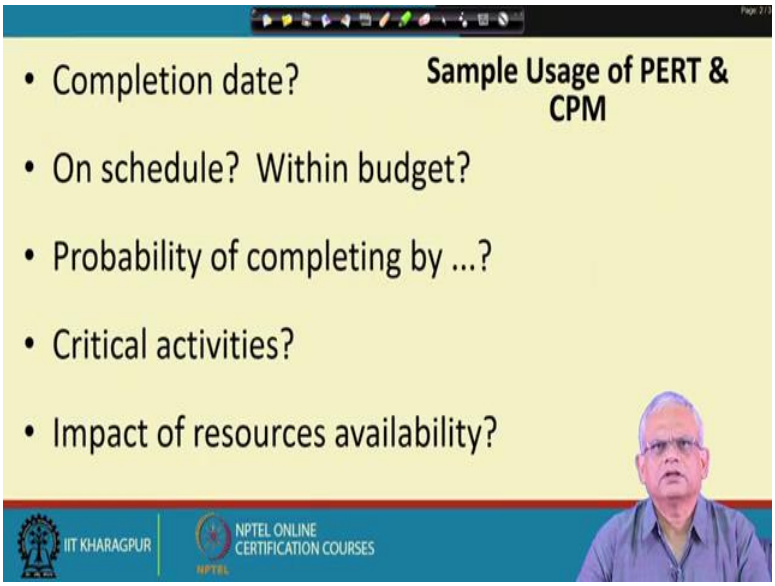
As you are discussing, though CPM and PERT were two different techniques; now they are merged into a single technique and usually in the books and literature this is referred to as CPM PERT.

This technique is very useful to the project manager can looking at the diagram easily identify which tasks are precedence; that is which are the tasks need to complete for the task to start. These techniques over the years becomes sophisticated, many tools that are available. When the projects are complicated there are many activities with various types of dependencies then these techniques become useful. If the activity has only, if the project is very simple only 3, 4 activities sequential activities, there is no other precedence and so on. .

These techniques may become a over kill, but then the typical IT projects are complicated. There are many activities there hundreds of activates for large projects and dozens of activities 2, 3 dozens of activities for even moderate size projects which are obtained from the work break down structure. The project manager uses a tool, we will discuss about few tools which you can easily use based on the concepts discussed here.

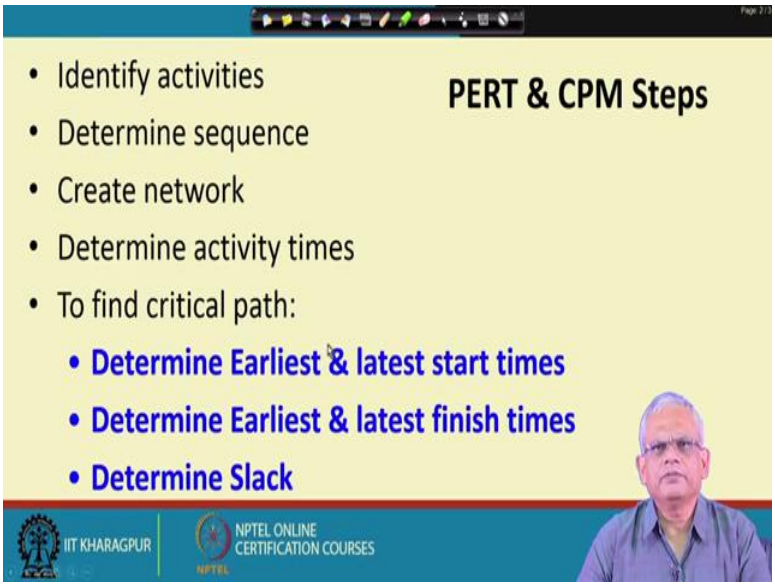
Those tools allow to draw the diagram, the task network diagram and also it automatically computes the critical path; it shows the critical activities, the slack times and so on. But then in this lecture, we will discuss about the main concepts here so that we can effortlessly use the tools.

(Refer Slide Time: 04:39)



Once we develop the PERT CPM network, we can be able to answer that what will be the project completion date. At any time we can also look at the PERT CPM and determine whether it is on schedule within budget. And because these are statistical parameters for the activities can be given; we can as the project manager determine the probability of completing the project by certain date. What are the critical activities? What is the impact of resource unavailability or availability; that is if some developer becomes unavailable what will be the impact and so on.

(Refer Slide Time: 05:39)



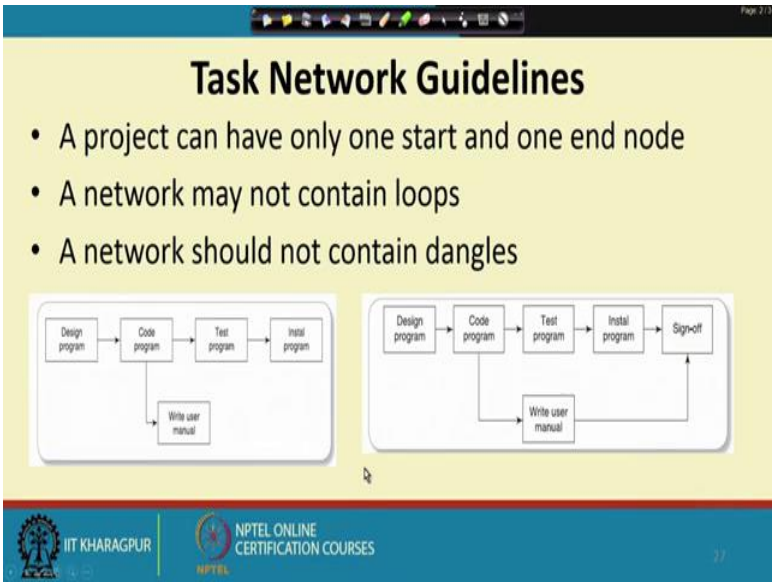
The PERT CPM are used in the early phases of the project planning; these are more generic in nature, we do not really represent the exact start dates. We do not consider intervening holidays, off days, allocation of resources to the tasks and so on.

We just develop a very high level plan which is later low level plan is developed by using a Gantt chart. Here for using the PERT CPM, we should have identified the activities using the work break down structure. We should have determined the sequence in which these activities and based on these two; that is what are the activities and their precedence relations, we can create the task network.

And we need to determine the activity times; these are basically estimates and then we represent these and then our diagram the PERT CPM diagram is ready for use. And based on this diagram we can determine the earliest and latest start times, earliest and latest finish times and also determine the slack or the float time.

We first try to understand that the earliest and latest start times; even though these are intuitive, but then with an example we will try to make out what we mean by earliest and latest start times, earliest and latest finish times and the slack.

(Refer Slide Time: 07:39)



But before that we will just discuss some guidelines of developing the task network. As we have been saying that the project scheduling techniques, using the PERT CPM can be easily applied when we have single start and single end node; if we have multiple start and multiple end node it becomes complicated.

And therefore, we will require that we have one single node start node and one single end node; if necessary we will create dummy nodes, dummy start and end nodes. The other rule that we must enforce is that once you draw the diagram there should not be any loops in the diagram. For example, an activity is dependent on one activity let us say A is dependent on B and again B is dependent on A; these things are not very common but then if we have such situation we need to avoid because this will make very difficult to apply the project scheduling techniques that we will discuss subsequently.

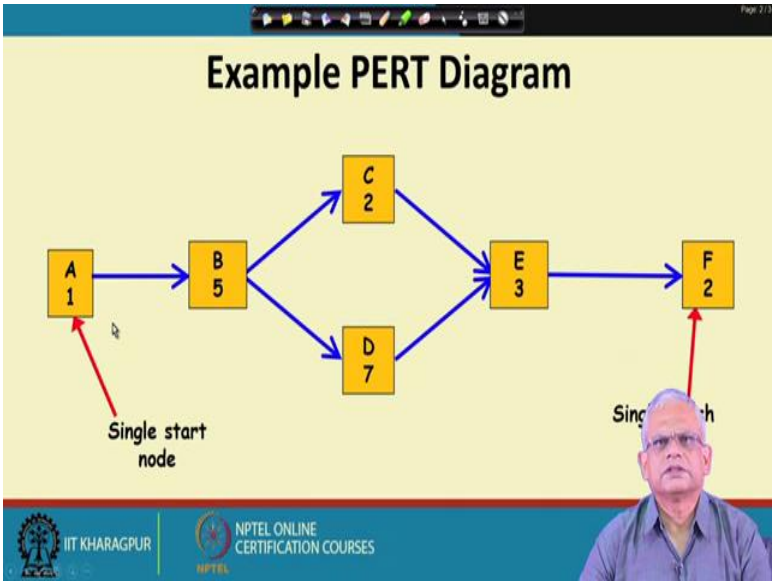
We must ensure that there are no loops in the diagram and also there should not be any dangles. In this diagram, there is a dangling activity here, but then if there is no other activity to be done; we must have end node here and then have this edge connected so that there is no dangling nodes.

If there are dangling nodes then it becomes very difficult to apply the project scheduling techniques. So, these 3 points we must ensure before applying the project scheduling techniques. The first is that the network should have single start and single end node, there should not be any loops in a normal project; loops do not exist.

Of course, there can be iterations like let us say there is a coding and testing; testing starts after coding, but then there are bugs may be detected. But and then the coding has to be done again and that if we try to represent will become a loop. And once there are loops in the diagram we cannot apply the project scheduling techniques, it become very difficult.

And therefore, these we should avoid by having coding followed by testing and then we can have bug correction, a separate activity not coding and that way we can break the loops. And also there should not be any dangling activity like this and if that is the situation that we have some problem description; then we have we have to have a arrow connecting it to the end node.

(Refer Slide Time: 11:17)



This is one of the simple PERT diagrams, there is a single start node, single end node and each node is labeled with the name of the activity. And there is a duration with each activity and here in this example we are using week 1 week, 5 week, 2 week as a duration, but there can be you can even use this for days or months and so on. And a critical path here; in this project if we look at this that one of the path here from start to end is A, B, C, E, F, another path is A, B, D, E, F.

On this path, the time taken is 6 plus 2; 8 plus 3, 11 plus 2; 13, but on this path we have 1 plus 5, 6 plus 7; 13; 3; 16 to 18; so this is the longest path. From this diagram, we can say that the project duration is 18 weeks because that is a longest path here. And this one

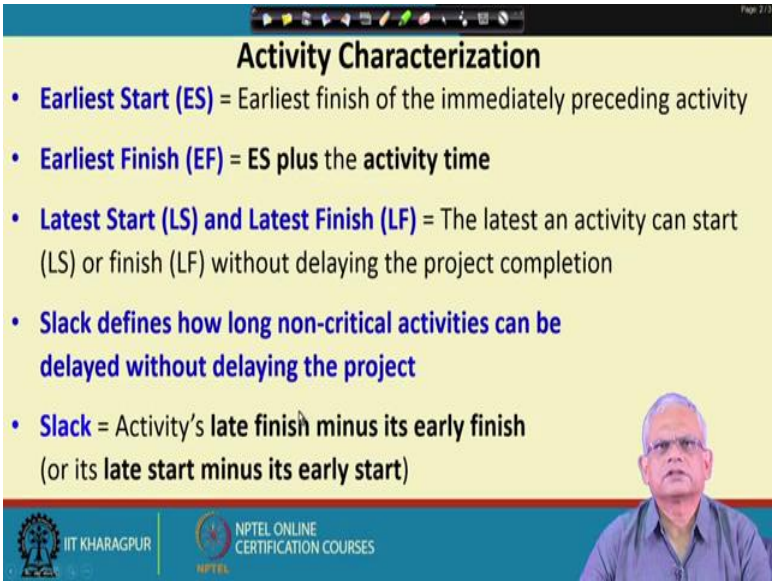
A, B, D, E, F is the critical path because any delay to any of these activities on the critical path will delay the project. Whereas, the activity that are not in the critical path for example, C can get delayed little bit without effecting the final project schedule.

So, that is the intuitive idea and we will discuss the project scheduling techniques using which we will compute the earliest start, earliest finish, latest start, latest finish; the slack times the critical path. But for this we really do not need such a simple diagram we can easily compute even without using the technique that we are going to discuss. It becomes easy that to see here that there are two paths here and one path is the critical path takes 18 weeks to complete. And the other is non critical path and that takes 15 weeks to complete, but A and B are critical activities because they are on the critical path.

Similarly, E and F are also critical activities, but C is not a critical activity is a non critical activity. And the project manager has some laxity here or slack time or float time which you can exploit advantage so that the project gets completed on time. He may redistribute resources, take out men power allotted to C activity and deploy in another activity which is getting delayed, so that the project overall project completes on time.

So, there is a single start node, the single end node and this is the critical path. And the CASE tools the project management tools that are available many are open source easily downloadable tools, where you can draw such diagrams and that would indicate the critical path using a red color or something.

(Refer Slide Time: 15:17)

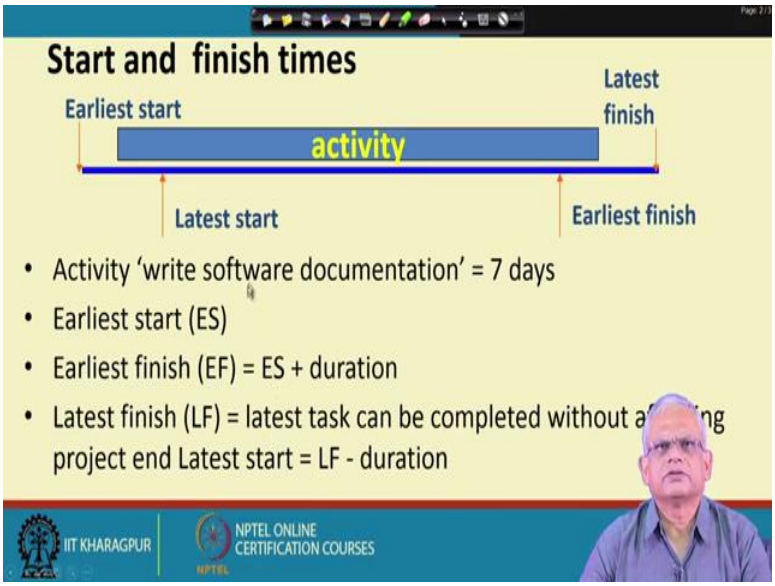


Now, let us see the activity how they are characterized on a PERT CPM chart. One is the earliest start, the earliest start that is the earliest time that a task or a activity can start is the earliest finish time of the preceding activity; only after the preceding activity completes the task and start. Therefore, the earliest start of an activity is the earliest finish of the preceding activity.

Similarly, the earliest finish of an activity is the earliest start time plus the activity time; very intuitive that earliest start is the time by which the preceding activity completes and then if everything goes well; it will start in earliest start plus the total duration of the activity which we call as a earliest finish time.

Similarly, we can define the latest start and latest finish; the slack or the float time it defines how long a non critical task can be delayed without effecting the project. And from this definition all the critical activities have zero slack time the slack is the activities latest finish time minus its earliest finish time; we will discuss these with help of an example that will make it clear.

(Refer Slide Time: 17:11)



Let us look at this diagram, here the preceding activity can complete by this time and here in the PERT chart; we do not give calendar dates we just give numbers here 10, 20 and so on; which later during the resource allocation, we give the exact dates there here we do not give dates we just give numbers.

The earliest start may be a number which is a date and then this is the activity time, but then the latest finish is here. And then this plus this is the slack time or the earliest finish minus earliest start minus activity that gives the slack time. The earliest finish time is the earliest start time plus the duration.

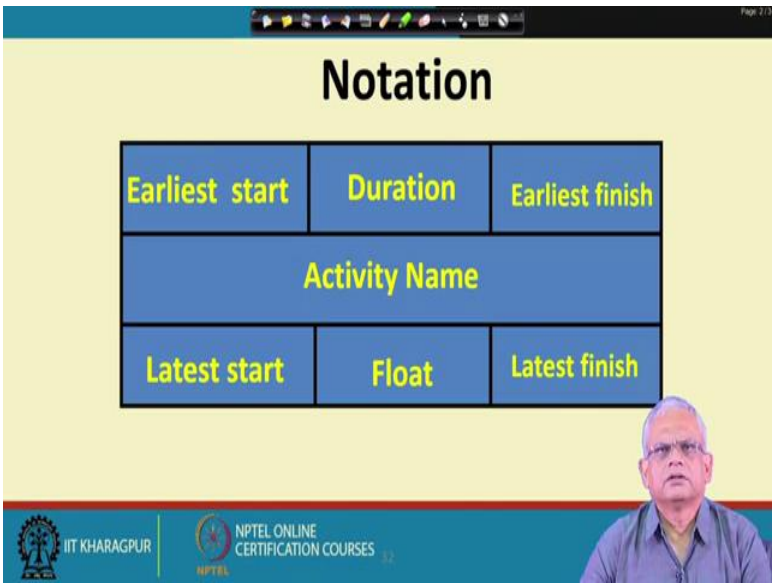
$$\text{Earliest finish (EF)} = \text{ES} + \text{duration}$$

So, that is earliest start time plus the activity time that gives the earliest finish time;

$$\text{Latest start} = \text{LF} - \text{duration}$$

the latest finish time minus the activity time that gives the latest start time.

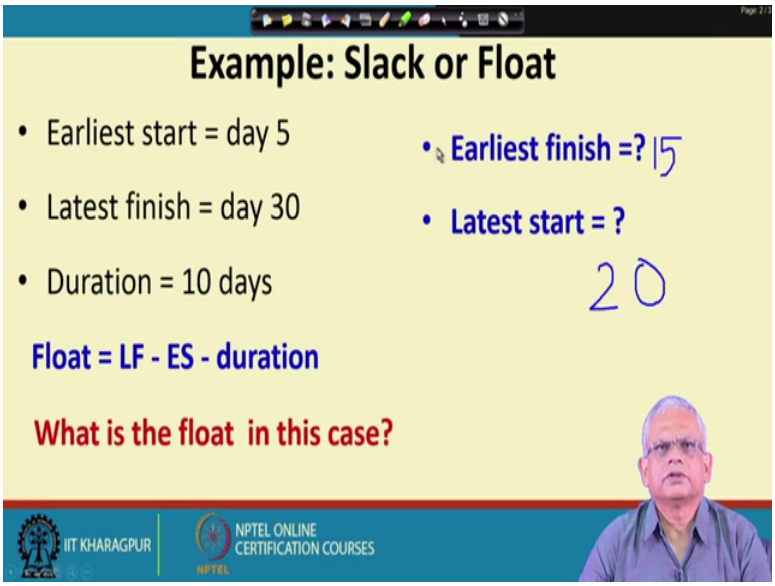
(Refer Slide Time: 18:49)



For each activity, we use this notation each node in the task network will have such a notation; where we have the activity name or the label of the activity, what is the duration earliest start, earliest finish, latest start, latest finish and what is the float time available.

This has lot of information here for every activity for the project manager; you can know that whether it is a critical activity or not. Whether it is what is the amount of float that is available, what is the duration earliest start earliest finish and so on; so there is lot of information on every node of the diagram.

(Refer Slide Time: 19:49)

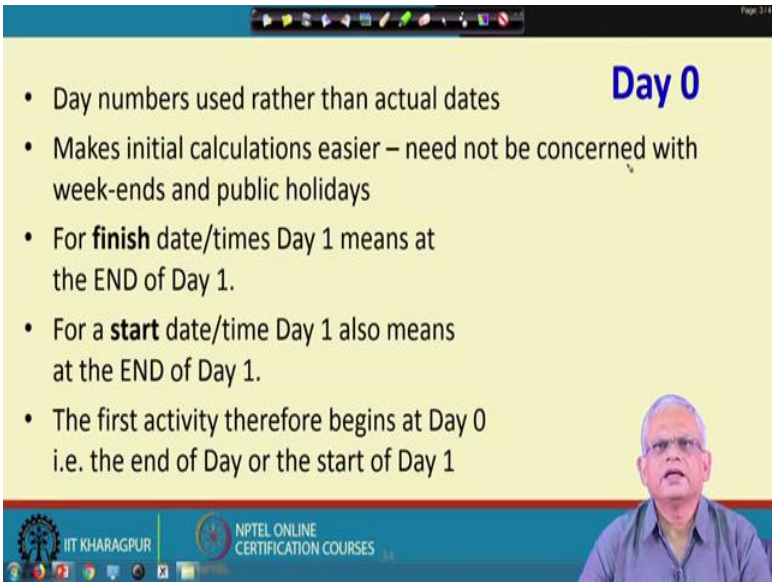


Now, let us look at an example; for a certain activity the earliest start is day 5 and the latest finish is day 30, the duration is 10 days. And we want to know; what is the float, what is the earliest finish and what is the latest start?

The earliest start is 5 that is the preceding activity can complete by day 5 and then only this activity can start and the duration is 10 days. And therefore, the earliest finish will be 15 because the earliest start was 5 and it takes 10 days the earliest it can finish is by 15. The latest finish is 10 days; sorry on day 30 the latest finish is on day 30 and the duration is 10 days and what is the latest start time? For the task to finish at most on 30 day, we must start it by 20 day 20 because it will take 10 days from then and it will complete by day 30.

So, the latest start time is the latest finish minus duration which is 20; one way to compute this float or the slack time is to have the latest start minus earliest finish which is 5 days. So, we can compute the float in this case.

(Refer Slide Time: 22:17)

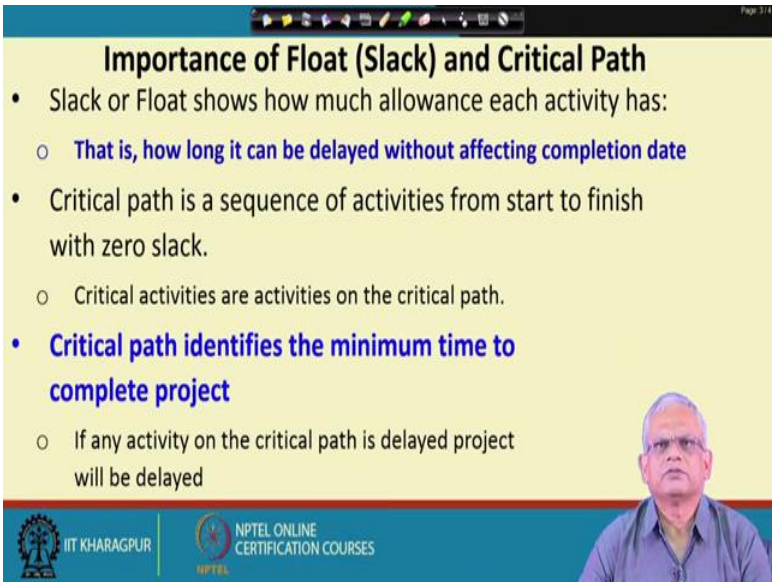


Now, one thing need to mention here that what is the day 0 for a project. We said that in the PERT we do not use really calendar dates, we do not consider which are the intervening holidays what exact date it completes here we just write days. It starts on day 0 and ends on some day; these are numbers rather than the actual dates.

This helps us in a high level scheduling where we ignore what are the intervening weekends public holidays and so on. In a lower level scheduling which we will do using a Gantt chart will take those into consideration. And here the notation is that the finish on day 1 means end of day 1 and also the start of day; the start date is day 1; that means, end of day 1 that is the notation here that if a project finish is on day 10, then it is end of day 10.

If a project start is on day 10 that is at the end of day 10 and from here; we can imagine that the project start date is day 0 that is end of day 0 or that is the start of day 1. So, that is the notation we will use the day 0 is end of day 0; start of day 1 and for every other day also we will use the finish date is end of that date and the start date is also end of that date.

(Refer Slide Time: 24:39)



Now, let us look at the importance of the float or slack and critical path for a project manager. The slack is how much flexibility or float that activity has and this implies how long it can get delayed without affecting the project completion date. It is a very important thing for the project manager to know helps in redistributing the resources.

But then the activities that are there on the critical path are the critical activities and they have zero slack; that is the project manager has to be extremely careful with the critical activities; cannot really take out any resource from a critical path because it will get delayed. But then if for some reason the activity on a critical path is getting delayed that is a critical activity is getting delayed. And the project manager has to bring in man power from non critical activities and see that the critical activities are not getting delayed for the overall project schedule to be met.

Another thing that we must note is that the critical path identifies the minimum time to complete the project. If we can identify the critical path on a very complex task network, then we can sum all the activities there activity times and that will give us the minimum time by is the project will get completed or the project completion time; that is the best case project completion time. And the project manager will meet that time will try to meet that time that is the sum of the activity times and the critical path.

We are almost at the end of this lecture, we will take some examples and then based on the concepts developed and we will discuss a technique by which we can use the PERT CPM to compute the various parameters per project. We will stop at this point.

Thank you.