Industrial Engineering
Prof. Inderdeep Singh
Department of Mechanical & Industrial Engineering
Indian Institute of Technology, Roorkee

Module - 04
Lecture - 08
Network Analysis – I

A warm welcome to all of you in this lecture on Network Analysis, we have been discussing lectures on Industrial Engineering and network analysis is one of the most important topics of industrial engineering. Network analysis deals with project planning and scheduling and on an overall basis we can say that network analysis is one of the most important tools in project management.

So, different projects are there in our life, for example suppose I want to go from Dehradun to Delhi that is itself a project. It involves numbers of different activities, different activities may be I get ready at my home, then I come out of my home take a auto rickshaw to the railway station or to the bus stand. And thereafter, I take rail train or a bus to go to Delhi, all these small, small activities add up to a complete project.

Similarly in any industry in any organization in any situation, we have different types of projects all the time going on. If you are aware, we seen in the software industry there are people called project leaders, so what these project leaders do, they segregate the complete project into small, small, small different tasks and activities. And then, this tasks and activities are accomplished by their team members and finally, the project is clubbed together.

If I give you another example of a project, we can say building house is very good example of a project, what we are doing in building a house, by piece of land, then we make the foundation, then walls are made flooring is done, roof is there, interior decoration is done. All these activities add up to the construction of the house, so basically that is a project, so building a house is also a project.

Now, each of these activities will have their precedence relationships, these word precedence relationships may sound a bit difficult for you to understand at this moment of time. But with the passage of this lecture, we will see what is the precedence relationship, here in order to understand, in order to give a very simple reasoning for

precedence relationship, I would like to explain that all these activities will have their precedence.

For example we cannot make a roof without making the walls; otherwise it will not be a precedence thing. For example, when the foundation is not ready we cannot erect the walls, so the first thing to be done is the making of the foundation. Then, we will construct the walls, then we will do the roof, then we will do the flooring, then interior decoration will be done. So whenever, we are constructing a house, all these activities have to be accomplished and all these activities hold up precedence of one activity in relation to the other activity.

I mean to say that, one activity cannot be done until and unless it is preceding activity has been accomplished. So, that basically is the crux of the project management and how project management is important in our lives. For example, we have to take a hell amount of decisions like I have limited amount of money available with me.

Now, I have to see that on which activity I should put my money, at what moment of time which activity will be taking place. For example, if you are constructing, if you are making a particular product in your company, so which machine will be dedicated to which particular job at what moment of time that is also falling the under broad umbrella of project management. So, project management is a very, very important tool which every industrial engineer or every mechanical engineer are to know.

So, today in this lecture we will discuss relate topics related to the basics of project management. We would try to understand, what is project management like, what is the history, how we have entered into the arena of projects or the networks may be network analysis. Initially, there were certain tools, which were devised by the researchers and scientist, then these tools made way for the networks. So, we will see that how networks evolved.

We will see how we can represent the complete project in the form of a network, what are the rules to be followed, when a network has to be constructed. And then, we will also see that, how a problem can be solved, when the network is ready, what type of information we can derive, once the network is ready. So, the important thing is that first we have to have a complete idea that what is the project.

Then, we need to understand that which tasks and be divided or how the project can be divided into a large number of tasks which whose accomplishment will result into the completion of the project. Then, how these tasks are related to one another which I have already explained that is the precedence relationships and then, how these can be represented on a piece of pape, in the form of a network.

Then, what are the rules that have to be followed, when we frame the network of a piece of paper, then what are the information or what is the information that we can derive out of this network. And then finally, how this information can be used, by the manager of an organization for carrying out his planning activity.

So also these things, we are going to see today, may be we will have two lectures on network analysis. First we will try to understand what is network analysis and then we will try to solve certain problems, which will be used on the basis of network analysis certain problems which will be using the concept of networks, in order to solve a simple problem. So, let us now start with understanding the networks, now initially let us first basically understand that what do we mean actually by project management.

(Refer Slide Time: 06:48)
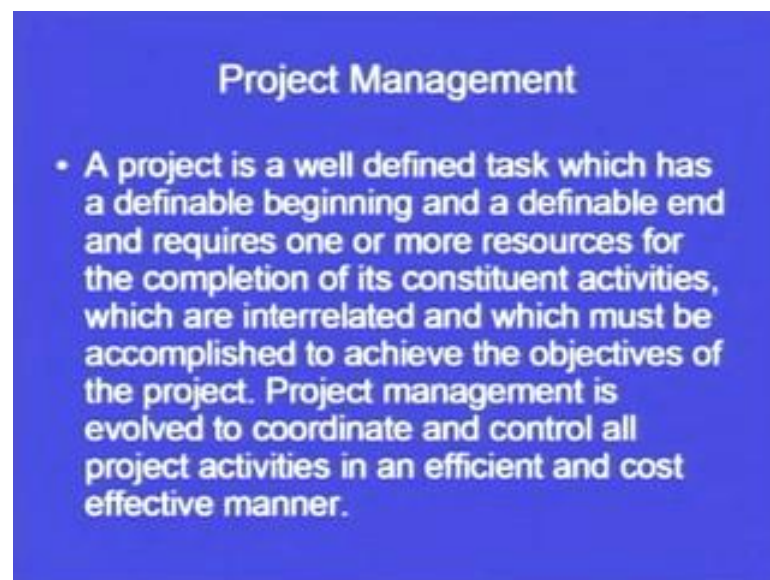
Project Management

- A project is a well defined task which has a definable beginning and a definable end and requires one or more resources for the completion of its constituent activities, which are interrelated and which must be accomplished to achieve the objectives of the project. Project management is evolved to coordinate and control all project activities in an efficient and cost effective manner.

A project is a well defined task which has a definable beginning and a definable end and requires one or more resources for the completion of its constituent activities, which are interrelated and which must be accomplished to achieve the objectives of the project.

Project management is evolved to coordinate and control all the project activities in an efficient and cost effective manner.

So, these four, five lines add up to the complete understanding of project management, so we will try to understand the project management concept from this definition. A project is a well defined task which has definable beginning and a definable end. So, what do we mean to say here is there may be certain project in which there is no end, so that you cannot say to be the project?

For example, I have given you a very brief in example of making a house of building a house. So, building a house is very simple example of a project why, because beginning is also fixed, end is also fixed, the goal is very, very clear that this is the kind of building of this is the kind of home which has to be made. So, it has a definable beginning and a definable end, so it can very easily be called as a project. Now, the next point is and requires one or more resources for the completion of its constituent activities. Now, building a house we have already identified that this can be called as the project, because it has a definable beginning and a definable end.

Now, we require resources for the accomplishment of these activities, now the house building project can be divided into a large number of small, small, small, small activities which I have already told you. Now, each and every activity would require certain resources, it will require certain raw materials like it may require bricks, it may require cement, it may require certain other raw materials like concrete etcetera. So, these are the resources which are required by the individual activities.

Then, we require manpower also we require certain machines certain tools also. So, house building is a project, which can be divided into a number of activities and all these activities further requires certain resources for their accompaniment. So, the second the point is also very, very clear. The completion of its constituent activities requires one or more resources, then which are interrelated and which must be accomplish to achieve the objectives of the project. Already I have explained this thing, that all these activities are interrelated that the completion of one activity.

Results as the beginning of an another activity, so may be activity x is dependent on a x activity y or activity y is dependent on activity z, so there are so many different activities

which are interrelated to one another. So, accomplishment of one with result in the start of the other or the finish of one will lead to the start of the other activity.

So, what I mean to say is that, there is a precedence relationship among these various activities. So, first three points are very, very clear. Just to summarize, because why I am addressing so much on the basics, because this is going to lead you into the complete theory of the networks and the understanding of the networks is the based on this basic concept only.

So, again to summarize this point, a project is a activity or a task which has a definable beginning and definable end. Further the project can be divided into number of small activities and tasks, which requires certain resources for their accomplishment and these tasks or activity, which lead to the completion or the accomplishment of the project are interrelated to one another, which means that they have precedence relationship among one another.

Now, the next point is the project management is evolved to coordinate and control all the project activity in an efficient and cost effective manner. So, the important point to understand here is that, what is the need of project management, I wound tell you one particular thing, that if we have unlimited resources. There is no constraint on the resources, I have huge amount of available with me, I have a huge amount of manpower available with me, I have huge amount resources in terms of machines and equipment available with me. Then, there is no need to do any kind of management, because whatever the need arises, I have sufficient stock of manpower money tools and equipment available which can be put into use.

But that is not the case, most of the time we are always constrained with the manpower that only 100 people are available with me only 10 people are available with me only twenty people are available with me. Sometimes, we have a constrained on the availability of the machines, because the machines are already working on certain other project and we also want the same machines, so that those machines are also not available for us.

Similarly, there may be avail there may be crunch of the money also, we may be facing capital crunch, the money is also not available with us. So, I mean to say is that always there are certain constrains in terms of money, in terms of manpower, in terms of other

resources. So that is why, we need to evolve a technique which would help us to complete our project in the most effective efficient and cost effective manner.

So, project management is evolved to coordinate and control all the project activities in efficient and cost effective manner. So, we have to complete that project within the specified time and in a very, very cost effective manner, then only and that is the only thing that is going to lead the organization in making the profit.

Now suppose, we have to launch a particular product in the market, we have outlined the different activities or tasks which will be completed for the launch of the product in the market. Suppose now, we are not able to complete those activities in the specified amount of time, what is going to happen, the competitor is going up parallel in his activities with our activities.

The competitor, if he is within the time will launch his product before we are able to launch our product in the market. So, what is going to be the scenario, we wound all certain be losing certain amount of market share why, because we have not been able to complete our project within the specified amount of time and the competitor has been able to do so and that is why, he enjoys more market share as compare to our company.

So, a project has to be completed within the specified constraints, in the most efficient and cost effective manner. So, if we will with this particular background, all of you might been able to understand that a project management and a project analysis is one of the most important tools, we should be known to all the engineer and more specifically to the industrial mechanical and civil engineers. So now, we will see certain other intricate things about project management, as well as about network representation. Now, we will see, what are the salient features of a project, already I have told you, what is project management, what is a project; project is made of number of tasks and activities those have to be completed for the accomplishment of the project.
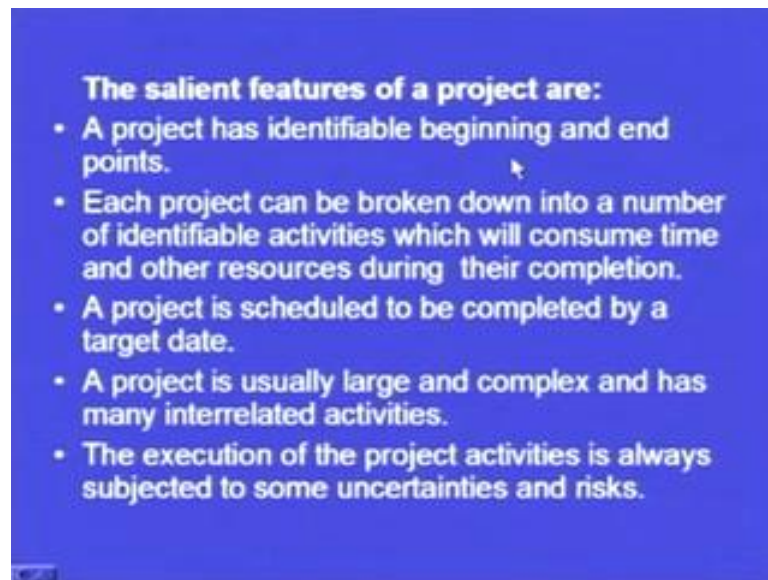
So now, we are going to see what are the salient features of the project? On your screen you can see, a project identifiable beginning and ends points, which I have already explained in the previous slide. Each project can be broken down into a number of identifiable activities which will consume time and other resources during their completion. So, all these salient features are coming from the definition a project or the project management that we have seen in the previous slide.

So, first point is the project should have identifiable, beginning and end points which I have already explained to you. Each project can be broken down into a number of identifiable activities, which will consume time and other resources during their completion. I have already explained, what are the other resources? These resources can be in terms of tools and equipment in terms of certain machines. So, these are the other resources.

Third point is a project is scheduled to be completed by a target date. Already I have given you, one example of lunching of product in the market; if that scheduled date is not met we are going to lose a certain amount of market share in the business. So, if the market share is lost in business, it will result into huge amount of losses to the company. So, whatever target date is fixed, we have to comply with that target date. A project is scheduled to be completed by a target date now that target date is fixed; if we exceed the target date then it is going to be a loss to the company.

A project is usually large and complex and has many interrelated activities, which has already been explained that all the activities and tasks, which makeup the complete project are interrelated to one another. And, there exists certain precedence relationships among the different activities which have to be represented in the form of a network logic that we will see in the subsequent slides.

Last point or the last salient feature of a project is the execution of the project activities is always subjected to some uncertainties and risks. We cannot say that the project, we have planned in such a way and everything will go according our plans only which is not possible. Always there will be certain breakdown in the machines, certain breakdown in the smooth flow of the process, sometime people or the workers may not turn up.

So, the planned work for that particular day, when there is mass absentees will carry forward to the another day, so all these things are the risks and the complexities in the project. So, the project completion is a very dynamic process and every other day we will be facing a large number of problems.

So, project management will help us to identify and to rectify these problems with certain tools, where are a part of project management, for example the project is lacking behind the scheduled date. Now, scheduled completion of the project is on suppose 31 of December, we are left with 15 days to complete the project. But, the activities which require more than fifteen days to be completed, now what can be done, only 15 days are left for the scheduled completion of the project.

And, there are many activities which are running behind schedule and which cannot be completed before 31 of December. Then, we are left with no other option either to get the scheduled date relaxed of it may be we can say that 31 December we will not be able to complete this project, so what can be done? So, 15 days additional time should be provided. So we can say that we will be able to complete this project by 15th of January.

But if that is not in the contract, then, we have to complete the project positively by 31 of December, how that can be done. Now we will see that, which are the activities in which are running before schedule and where are activities which are running behind schedule; So, we can release certain resources from those activities, which are ahead of their schedule and put those resources in the activities, which are behind the schedule, so that their progress can be speeded up.

And when their progress will be higher, at higher rate they will work, then the time for completion will automatically comedown or we can outsource some of the activities, so that we are able complete the project by 31 of December. If we are not able complete the project by 31 of September, then it will invite a huge amount of penalty from our vendor or from our customer. So, we do not want to pay that penalty, so we will do our best to avoid that penalty, so that we are able to meet the target date.

So, in order to avoid penalty, we may have to spend some more amount. In order to speed up the process of completion of those activities which are behind schedule? So, why these activities are behind schedule, these are because of the 5th point or the last point on your screen the execution for the project activities is always subjected to some uncertainties and risk.

So, whenever there are certain uncertainties and risks involved that project activities may get delayed. And, this delay will result in the overall completion delay in the project, so overall completion of the project will get delayed. So, these are some of the silent features of the project.

So, if we are able to manage all these features properly, if we are able to manage the interdependence among the activities properly, if we are able to manage the uncertainty and risks properly. Then, we will certainly be able to complete the project within the stipulated time and with the allocated resources.

Otherwise, if we are not able to complete the project, within the stipulated time with the allocated resources, if we are spending something more on the allocated, something more, then the allocated resources, then that will add up to the cost of the project. So, we do not want that the cost of the project should be increased, so whatever resources we have allocated, those resources should be able to complete the project within the timeframe. So, that is what we require.

Now, let us come to the history, how project management has evolved. Initially there was Gantt Charts n this axis we can say this is y axis activities are there and on x axis days are represented. So, you can say 4th day 8th day 12th day, then may be 16th 20th 24th day and on y axis we have activities. So, we can say activity, if will start on day 1 and it will continue till day 4, then activity b will start which will take may be till 12th day this will be going. Then d will start d and b are parallel activities they both can start on day 4 and similarly activity c will only start when this activity is completed. So, all these activities can be represented on a time scale, so this is one kind of representation of the activities on a piece of paper.
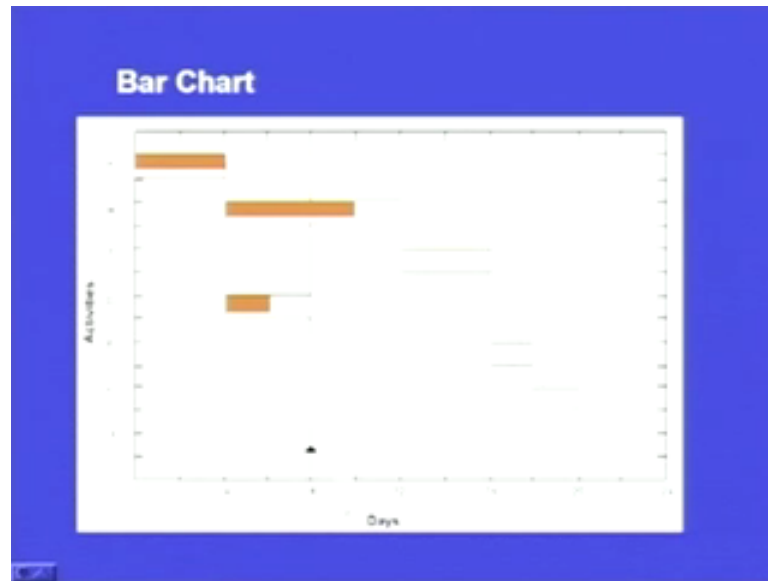
Then, we have Bar Charts in Bar Charts also on x axis, we see we have days and on y axis we have activities. Now these activities you can say are represented here in the form of bars. And, these some activities and maybe we can say on day 8th, what is the completion; how much work has been completed and how much work is left to be completed.
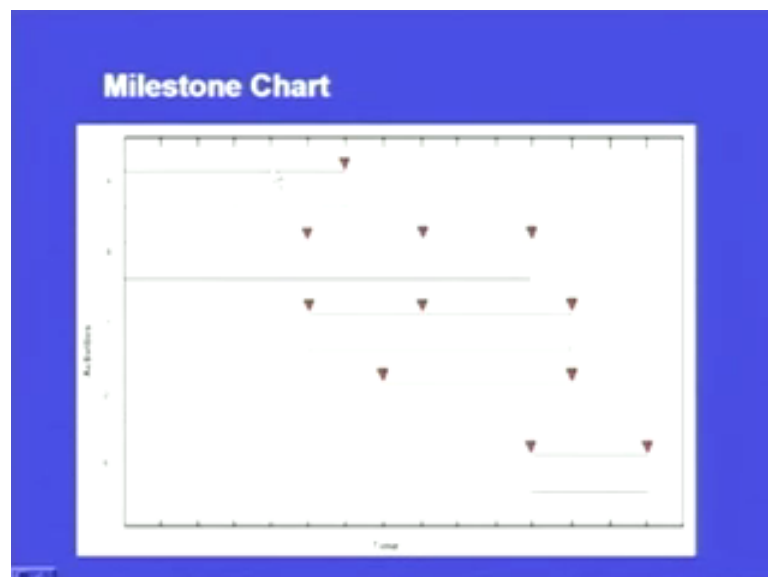
Now, similarly we have Milestone Charts, why we are seeing all these charts, because this is the way the networks have been developed, so initially these were the tools which

were use for project scheduling and project planning. But now, the networks are finding wider application as compare to these charts.

Now these the Milestone charts, now Milestone we know that, this is indicator of some certain amount of completion of activity. So it will indicate that this much amount of work has been completed and this much amount of work is left to be completed for the accomplishment of a particular activity and further resulting into the completion of the project.

(Refer Slide Time: 24:08)
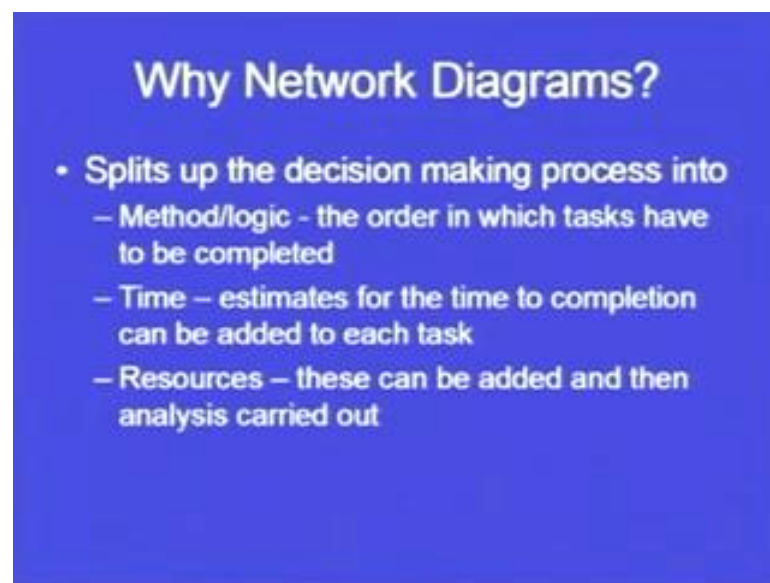
So, when all these tools are available, what is the need for going for network diagrams; So, network diagrams basically spits up the decision making process into method logic, the order in which tasks have to be completed. So, the interrelationship is one of the most important catch points of the networks.

Already, we have seen whatever we have discussed in this lecture, that most of the activities are interrelated to one another and this interrelationship has to be incorporated into the network diagram. So, networks are very easily adoptable to this type of an interrelationship behavior between the various activities. So, this splits of this decision making process into method or logic, the order in which tasks have to be completed. So, that order is always fixed, starting from the beginning till the end there will be so many activities and all these activities will be interrelated to one another.

Means this activity cannot start, until these two activities have been completed or these two activities cannot start until this activity has been completed. So, that kind of interdependence or interrelationship between the activities or what we call is it as the precedence relationship between the activities is incorporated very easily in the form a network diagram.

Then, time estimates for the time to completion can be added to each task. So, we can say that which activities can take place parallel, which activities can go at parallel rate which activities will be successor, which activity will be predecessor and how much time will be required, what will be the total project completion time, what will be the individual activity completion time. So, all those things can be incorporated in the form of a network.

Similarly the resources, these can be added and then analysis can be carried out. Now, for example, let me explain, a project consists of 10 different activities, now all these 10 different activities when completed will result in the completion of the project. Each and every activity requires certain number of men to complete that activity.

Now suppose, activity 1 2 and 3, they require 4 persons per day and all these activities are starting on day 1. Let me repeat, activity 1 2 and 3 are starting on day 1 and all of them require 4 people per day. Now, what will be the requirement for the first day manpower requirement, manpower requirement will be 12 people will require on the first day, if no other activities schedule for that day. And now suppose, we have a constraint of 10 people available, we require 12 we have 10.

So, what we can do, we have to reschedule one for the activities, otherwise 12 people are require 10 people are available and 10 people will not able to perform the work of 12 people. So, I mean to say is that project networks will help us to reschedule the activities in such a way. So, that the manpower constraint is incorporated into the scheduling process.

So, when we will relax one activity we will relax one activity, so that it will be accomplished at a later stage. And, we will only plan for the two activities and 4 persons per activity means 8 persons will be required and one activity will be relaxed towards the right may be it can be accomplished at a later stage.

And, we will find out activity using the critical path, that if the activity is not lying on the critical path it can be relaxed, so what is critical path; that also we are going to understand today. So here we need to understand is that a networks we can incorporate the concept of time, we can incorporate the concept of resources as well.

So, resources in terms of manpower I have given an example, there may be other resources in terms of machines required, there may be other resource in terms of certain equipment required. So, all those things can be incorporated in the network and when this network is ready it will be helping us in solving a large number of management related problems or on a nutshell I can say a large amount of planning related problem.

So, the construction of the network and then the analysis of network is one of the most important tasks in network analysis. So, in this slide we have seen that networks are helpful in incorporating the logic into the network or into the program, then it can incorporate the time, it can incorporate the resources.

So, basically it becomes a complete entity in itself for a complete program in itself in which we have the interdependence among the activities that time required for each and every activity. And, the resources required for each and every activity and then these can be optimized accordingly.

Now, we come on to another important aspect that is the network representation. Just to summarize in 3 or 4 lines, what we have discussed till, now is that project management is very, very important. A project consists of a large number of activities or tasks whose accomplishment will lead the completion of the whole project.

Each of these tasks and activities require certain resources, these resources can be in terms of money, in terms of manpower in terms of machine and equipment and all these activities are interrelated to one another that is they have certain precedence relationships with one another. And, we have seen that why networks are important, these networks are important, because in by representing the complete project in form of a network.

We are very easily able to incorporate the logic in bit or the interdependence among the activities. We are easily able to incorporate the time aspect in the project and we are very easily able to incorporate the resources aspect into the project.

So, when this complete program or the complete project is ready, we can do the network analysis which will be helpful to us in planning or in scheduling. So, we can plan that at what moment of time which machine will be required, how many people will be required, what amount of money will be required and we schedule the activities accordingly. So, now we know that network is a very important tool and now, how to represent the data whatever is available with us in the form of a network. There are certain points we will see each and every point one by one.

(Refer Slide Time: 31:15)
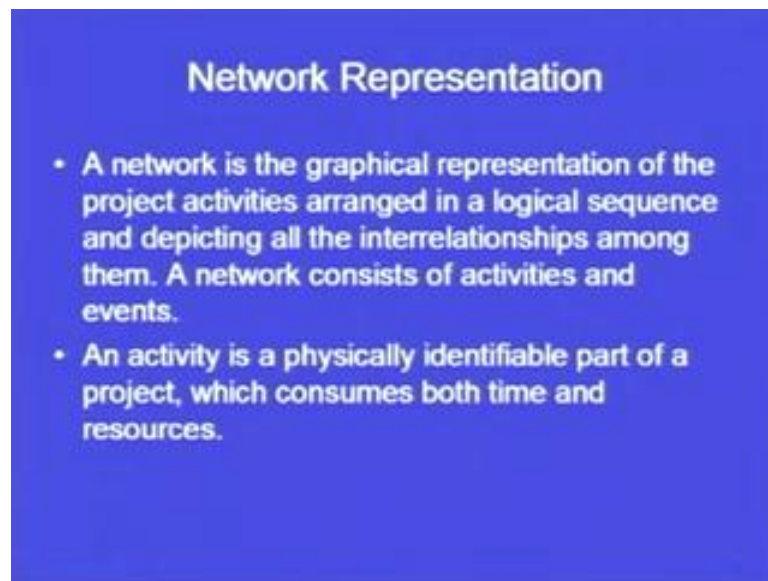
So, network representation on your screen you can see, a network is the graphical representation of the project activities arranged in a logical sequence and depicting all the interrelationships among them. A network consists of activities and events, so once again I will read it network is the graphical representation, graphical means that on a piece of paper, we will be drawing a certain kind of drawing which will be representing the complete project. It will be in the form of nodes and arrows that we will see subsequently that, how the network would look like.

Network is the graphical representation of the project activities, each and every activity will be represented by an arrow, and arrow will be having head and a tail. So, a network is the graphical representation of the project activities arranged in a logical sequence, so logical sequence means in the precedence relationship manner or logically means their interdependence will be represented in the form of a network.

So, logical sequence will be used in order to place the activities at their respective places in the network diagram. And, depicting all the interrelationships which I have already explained among them, networks consist of activities and events. So, a network consists of simple activities and events, so this how network will look like that, we will see in the subsequent slide. So basically, what we are doing here is, the complete project is divided into a large number of activities.

And, each and every activity will be represented by an arrow and in a logical sequence or in with the precedence relationship into mind. Keeping in mind that precedence relationship these activities will be placed at their respective places.

An activity is a physically identifiable part of a project which consumes both time and resources. This I have already explained two times in today's lecture only that an activity is a physically identifiable part and it will consume both time and resources. So, every activity will require sometimes, may be if you are drawing network in terms of days, we will say every at every activity will require certain amount of days to be completed.

Some activities may be completed in 3 days, some activities may be completed in 5 days, and some activities may be completed in 10 days. So, each and every activity will require certain amount of time for completion, similarly, each and every activity would require certain resources for its completion. So, resources may be in terms of manpower in terms of machine. So, each and every activity would require time and resources, but there are certain activities do not require any time and resources, what are those activities, that will seen in the subsequent slides.
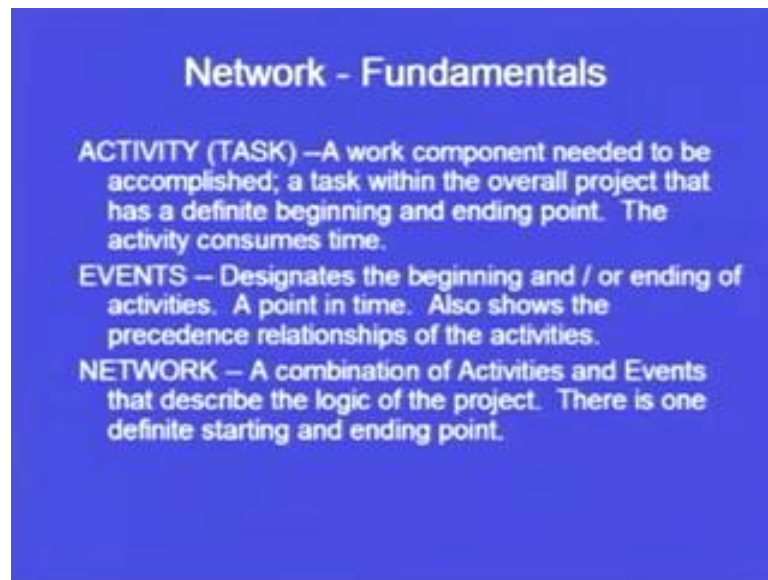
Now, network fundamentals mean an activity or task a work component needed to be accomplished. A task within the overall project, that has defined or definite beginning and ending point. The activity consumes time, this I have already explained, why I am repeating all these things again and again, is because these form the basis of network construction and once the network is ready. Then, we do the network analysis for the help of the running activity or for scheduling the project in the best possible cost effective and most efficient manner.

So, activity by now I think everybody might have understood that, what do we mean by an activity, now what is a event? Event designates the beginning and or ending of the activities a point in time. So, this is a point in time and at a particular event, we will say that so many numbers of activities have been completed and this event has taken place. So, this is any point of time in the whole network.

So, designates the beginning and or ending of activities already I have told a point in time, also shows the precedence relationships of the activities. So, it show precedence relationship of the activities, now what I mean to say here is, that when a event has taken place.

It means certain activities have converged to that event and then certain activities are starting from that event. Now, this event is turning out to be a node at which certain activities have been completed and the other activities are starting. So, the precedence is
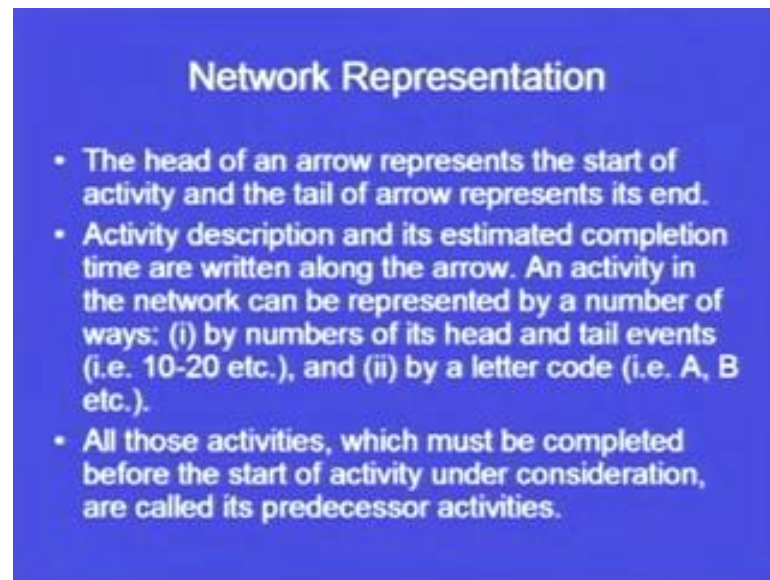
set that these activities cannot start until and unless this event has happened, because this event is resulting out to be a culminating point of certain activities which were running through and they have completed at this event.

And at this event, certain other activities are starting to take place, so this will also tell one of the nodes or one of the logic points in the network. Then, what is a network a network is a combination of activities and events that describe the logic of the project. Now total network, I have already told, it is a representation of all the activities in context of their time resources as well as their interdependence of the precedence relationships.

So the combination of activities and events, that describe the logic of the project. So, logic basically means the precedence relationships, the interrelationship among the various activities. So, there is one definite starting and ending point.

So, already we know that a project is a combination of tasks and activities, which have identifiable beginning and identifiable end. So, only there will be one start point of the project, one end of the project in between there will be large array activities that would be taking place. And, all the accomplishment of all these activities will finally, lead to one point which will be said as the project completion. So, basically every network is made up of nodes activities and events, so events will be placed on the nodes and activities will be represented with the help of arrows. So, that is the simple network diagram.

So, already I have told the head of an arrow represents the start of the activity and the tail of the arrow represents its ends. So, we can say head of an arrow and a tail of an arrow, so we means from the start to the beginning arrow will be represented. So, depending upon what type of activity, what type of network diagram we want to have, we can have activities on the arrows we can have activities on the nodes or AON or AOA. So, that type of that we are not going to go into that much depth related to the network diagrams, but we need to understand the head of the arrow represents the start of the activity and the tail of the arrow represent its end.

Activity description and its estimated completion time are written along the arrow. So, on the arrow we can write that this much is the time required for this activity that networks we will see. But, we are presently and try to understand is a representation of the complete logic of the project in the form of network diagram.

So, the complete project is there, activities are there, how those getting represented in the form of a network diagram that we are trying to understand here. Activity description and its estimated completion time are written along the arrow.

Now on the arrow, we can write the name like activity A comma, how much time would be required, may be 3 days suppose. So, A comma 3 on the arrow will represent that this activity is activity, the name of this activity is A and this would require 3 days for completion, there can be other data also which can represented on the arrow. In terms of

may be the manpower required for a accomplishing this activity or the kind of tools required for a accomplishing this activity, all that data can be represented.

An activity in the network can be represented by a number of the ways. By number of its head and tail events like 10 20, so suppose the head event is 20, tail event is 10. It means 10 20 can be represented or letter code, already I have given an example activity can represented by its name may be the name may be A or the name may be B or all the activities may be named like A, B, C, D, E, F, G may be if there are seven activities we can go to seven alphabets and all these alphabets will be representing the activities.

So, activities can represented either by the head and tail events in the number of head and tail event and it can also be represented by the alphabets such as A B C D. Now, all those activities which must be completed before the start of activity under consideration are called predecessor activities.
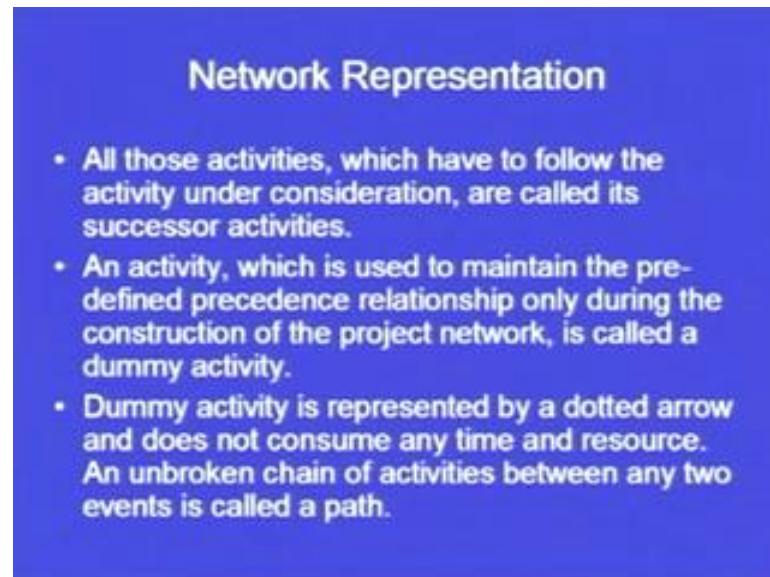
Now suppose, activity C is the dependent upon the completion of activity A and B. Now, A and B are ought to be completed before C can start, so A and B will become the predecessor activities of activity C. Same thing is there on your screen, all those activities which must be completed before the start of the activity in our case, this is A and B. So, A and B must be completed before the start of the activities C, so C is under consideration or called predecessor activities.

So, just again to summarize, an activity has to be started and there are certain activities which need to be completed before the start of this activity. So, the activities which are needed to be completed before, the start of known activity are called predecessor activities to that activity. In our case, A and B are the predecessor activities for activity C, also it means that C cannot start until and unless A and B both have been completed. Then, all those activities which have to follow the activity under the consideration are called its successor activities.

Now in our example, successor of A and B is C, because C is following the completion of A and B. So, all those activities which have to follow the activity inter consideration are called successor activities, so C becomes automatically it becomes the successor of A and B. So, when A and B will be completed at a particular event, then C will start and C will be the successor of A and B.

There can be number of other examples in which we can explain that these are the successor activities and these are predecessor activities. So, I think with the example of A B and C, I have been able to make it very, very clear that what is the successor activity and what is a predecessor activity.

(Refer Slide Time: 42:40)

Network Representation

- All those activities, which have to follow the activity under consideration, are called its successor activities.
- An activity, which is used to maintain the pre-defined precedence relationship only during the construction of the project network, is called a dummy activity.
- Dummy activity is represented by a dotted arrow and does not consume any time and resource. An unbroken chain of activities between any two events is called a path.

Then, a network representation an activity which is used to maintain the predefined precedence relationship, only during the construction of the project network is called dummy activity. Now, the concept of dummy activity has been introduced in the construction of the project or the network representation.

Already in the course of this lecture, I have told you that there are certain activities which do not require any time and resources. Now, these are the activities, which are called as the dummy activity, so what is the need of the dummy activity in drawing the project network. Now, dummy activity basically is an activity which is used to find out the logic and to represent the logic inside the network. Sometimes there may be a conflict in drawing the network, we are not able to very easily represent the logic or the precedence relationship or the interrelationship among the various activities, following the rules of the network diagram.

So, in those cases sometimes we may have to incorporate the concept of dummy activity. So, we will see that what is the dummy activity, where it is very, very useful; I will explain this with the help of an example, when we see the rules for drawing the network.

But till now we can very easily understand this point, that a dummy activity is a activity which do not require any time and resources and it is drawn or it is incorporated or it is required in drawing the project network, in order to satisfy the logic or the precedence relationships among the various activities. Dummy activity is represented by a dotted arrow and does not consume anytime and resource which already I have explained. An unbroken chain of activities between the two events is called a path.

Now, between the two events if there may be different paths, then a unbroken chain of activities between the two. On your screen you can see an unbroken chain of activity between the two events is called a path and there is a method called critical path method that we will discussing in the subsequent slide. Till now what we are discussing is the representation of the complete project in the form of a network. And, what are the things that are required, when we construct a network for the subsequent analysis. Now, here you see, now we are going to discuss the rules for drawing the network diagram. There are certain rules, that have to be born in mind when we draw the network.

 (Refer Slide Time: 45:32)
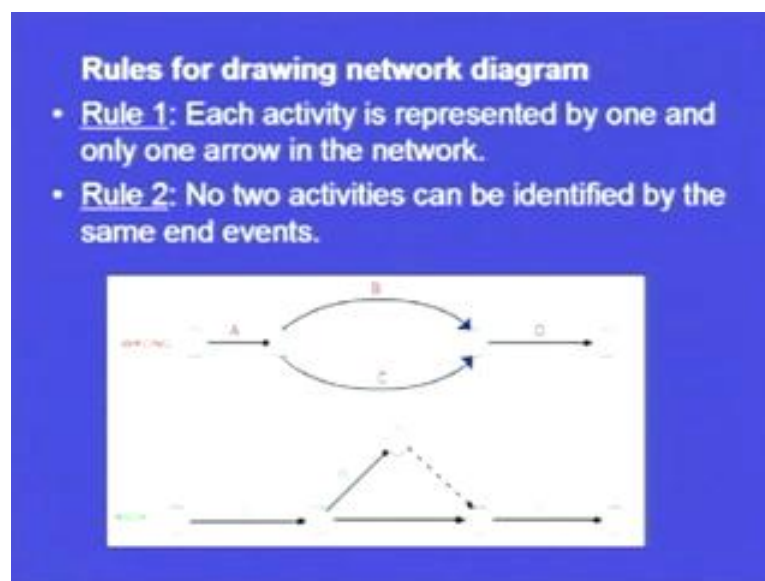
So, you see the rule number one on your screen, each activity is represented by one and only one arrow in the network. So, we cannot say that if certain precedence relationships have to be satisfied activity A can start from one node and it is going here also and it is going to some other node also. So, each and every activity is represented by one and only one arrow in the network.

Now, let us first see, what are the arrows and what are the nodes. Now, see in this although it is wrong, but let me explain with this diagram, now this is A this arrow is representing activity A. So, here only the names of the activities are given, we can also incorporate the time and other resources into this nomenclature in place of A, we can write A comma 3.

So, this will become this activity is activity A and it will require 3days for accomplishment, so A comma 3, this is a representation of activity A. This is a representation of activity B, this is a representation of activity C and this is a representation of activity D. Now suppose, this is a complete project, it is beginning here and it is ending here. So, it has a identifiable beginning and identifiable ending and there are four different activities which are resulting into the completion of the project.

Now, each and every activity would require certain amount of resources to be completed may be certain time to be completed. So, if time is also incorporated, we can find out the longest path that would result in the completion of the project, so why this is wrong this is wrong, because no two activities identified by the same end events. This is also a rule that have to be followed in construction of the network diagram.

So first rule says, each and every activity has to be named independently, each activity represented by one and only one arrow in the network. So, A cannot have two arrows only one arrow will be representing the activity A, similarly, only one arrow will be representing the activity B, one arrow will representing the activity C and One arrow will representing the activity D there cannot be two arrows representing the activity D that is a first rule.

Second rule is not two activities can be identified by the same end events, now in this case if you see why a wrong is written here. Because, activity B and C are having the same end events, no two activities can be identified the same end events. So, here all activity B and C are having the same end event which is not possible according to the rule of constructing the network diagram.

So, this has to be modified how it has to be modified that is the right network which is shown here in green activity A B C D. Now, why this type of network was drawn, what could be the precedence relationship here, you can scratch you mind a bit, you will find that the precedence relationship here says that activity D cannot start. Activity D cannot

start, until activity B and activity C are completed. So, that is the kind of logic that is the kind of precedence relationship that is the kind of interrelationship among the various activities, so activities of concern here are B C and D.

Now activity D cannot start until B and C have been completed, so this is the logic which has to be incorporated in the form of a network. But here, according to rule two this is the correct network, so we have to modify this network a bit. So, how it is modified, we incorporate dummy activity like this, this is a dummy activity this is represented by a dotted line.

Now, why this activity has been represented like this, because in order to satisfy rule number two. Also it may so happen, that activity D is dependent on both B and C and with this diagram, this logical precedence has been incorporated. Because, B is also getting completed at this event, C is also getting completed here and then only D is beginning.

There is another very good point which I wound like mention here is that there may be an activity, say I call it at activity E. Already we have activity A B C D and there is another activity that is activity E. Now suppose E depends on the completion of activity B, if we have to incorporate activity E in this network, from where activity E will start activity E will start from this point and we can represent it like activity E is going in this direction.

So, what would be the problem, if you think over it, activity E is dependent on the completion of activity B. But, it is also becoming dependent on the completion of activity C which is not the logic, which is there in our network. E is only dependent on the B and it is not dependent on the C, so by incorporating a dummy activity here what we have done is, we have solved two problems.

First is that we have now obeyed rule number 2 in which no two activities can be identified by the same end events. So, rule number 2 is also obeyed and activity E start from here and activity E when it starts from this point it has nothing to do with activity C.

Now, E if starts from here, it is only dependent on activity B and it is not at all dependent on activity C. Now, D is dependent on B and C and E is only dependent on activity B, so

this dummy activity has solved certain logical precedence problems which could have been there. If the use of the dummy activities wound not have been prevalent in the construction of the network.

So, rule 2 has been followed now here in this particular network, so right network is shown and dummy activity has been incorporated to follow rule number two. As well as the further modification also I have told that affectivity is only dependent on B, it can start from here and it will have nothing to do C.

But, if you start it from here then it would automatically B and C wound become the immediate predecessors of activity E which we do not want. So, I think most of you might have been able understand, why dummy activities are used and what is the use dummy activities in satisfying the logical precedence in the networks.

So with this, we come to the end of this lecture on network analysis one. Although we have started the discussion regarding the rules, but the rules could not be completed in today's lecture which we will be covering in the subsequent lecture on network analysis two. In which we would also be solving certain problems related to project, we would be drawing certain project or project networks and we will see that how calculations can be done for these networks.

So, we have today established, what is project management, we have established networks as very important tool for solving problems of scheduling and planning in context of project management, we have seen that, what are the silent features of a project; we have seen that how a project can be represented in the form of network. And then finally we were trying to study certain rules which have to be followed in the construction of network diagrams. So, I look forward to the next lecture in which we will be discussing certain other details related to network analysis.

Thank you.