

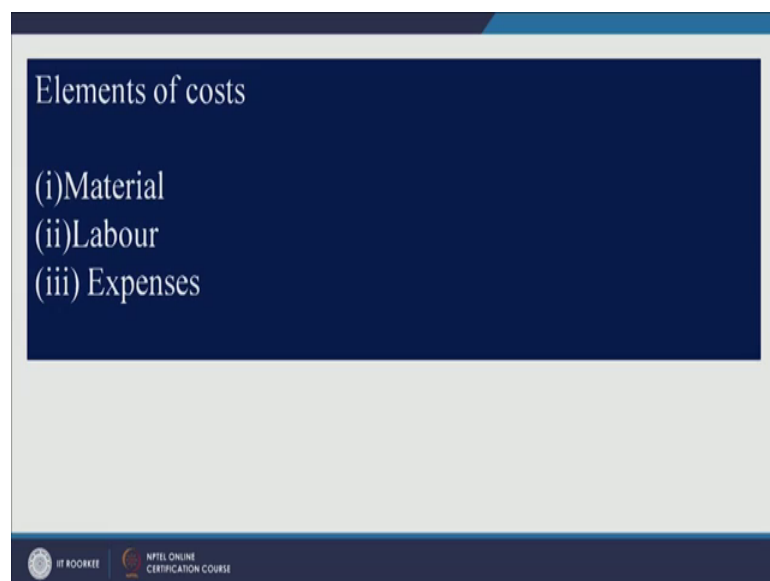
Project Management for Managers
Dr. M.K. Barua
Department of Management
Indian Institute of Technology, Roorkee

Lecture - 47
Time and Cost Relationship

Hello friends, welcome you all in this session. As you are aware in previous session we were discussing about slack float their characteristics and how to find out those 4 types of floats right in this session we are going to talk about time and cost relationship. Whenever you come up with a product or a project generally a product is made up of different cost and we divide those cost into broadly 3 categories it is called labour cost, material cost and overheads right. So, we will look at what is the relationship between duration and cost of a project, weather when we decrease the duration of the project what happens to cost right.

So, we will see all those issues in this lecture. So, generally whenever we crash a project, crash means the process of reducing duration of the project what happens when we crash a project right. Some of the costs are there which would increase some of them would decrease right. So, we will see what are those cost ok.

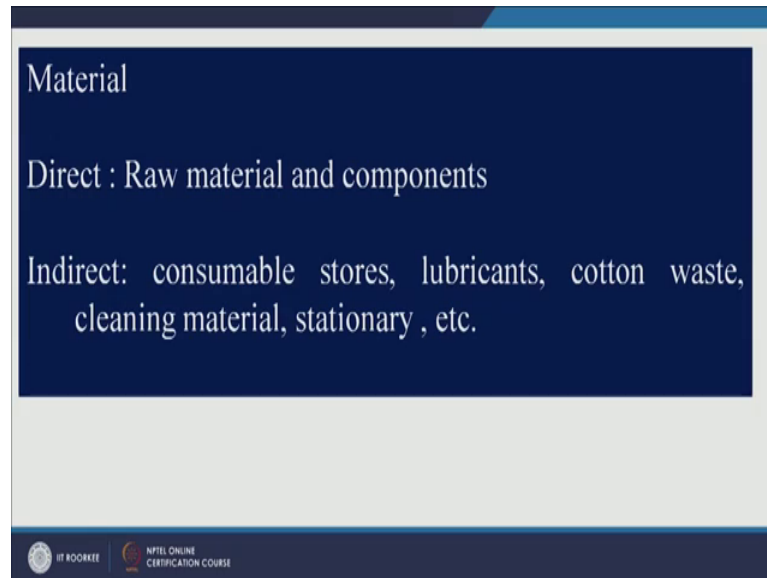
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So, as I said a product is made up of broadly 3 cost; material cost, labour cost and expenses. When you say material cost you have got 2 types of broad categories again I

would say broad subcategories you have got direct material and direct and indirect material right.

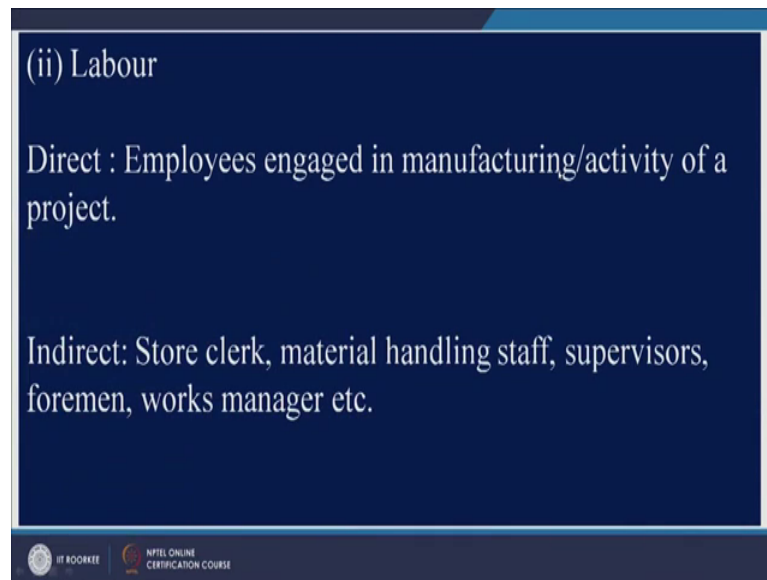
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So, direct material means the raw material which is being used to make a particular product right and different components right. For example, let us say when you make an automobile right. So, you need different types of raw materials is not it? You need let us say I am you need some components of let us say made up of plastic is not it; you have got parts and tubes and all those things right. So, they are nothing but direct materials you also have something called indirect material now indirect materials are those materials which help you in processing of direct materials on a machine right. So, you have got let us say consumable items, you have got lubricants, you have got coolants, you have got cutting light right cotton waste cleaning material stationery and so on.

So, the all these materials are nothing but indirect materials right.

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(ii) Labour

Direct : Employees engaged in manufacturing/activity of a project.

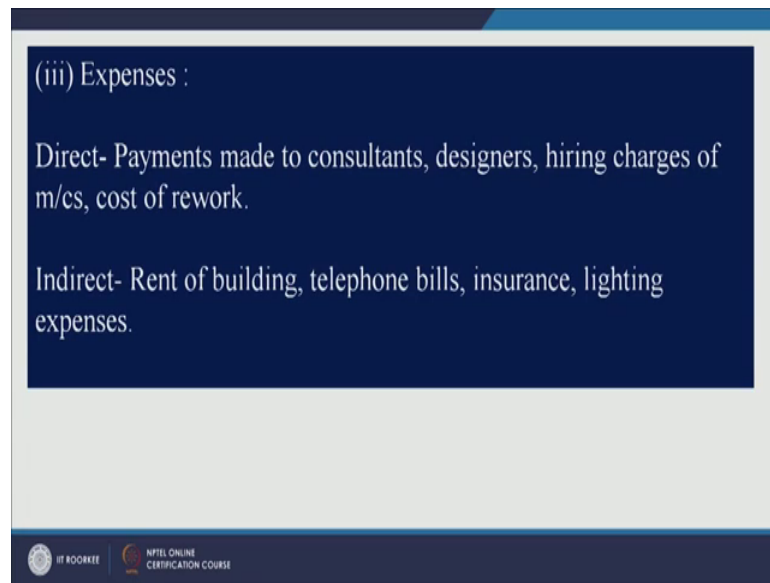
Indirect: Store clerk, material handling staff, supervisors, foremen, works manager etc.

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So, 2 types of materials direct material and indirect material. Similar to material we have got labour also you have got direct labour and indirect labour. So, those employees who are engaged in manufacturing or any other activity of a project they are called direct labours are those employees those workers who actually work on machines right machines are service centre right.

So, they are called direct labour right and there are some people who help these direct labours in producing final product and their like store clerk right material handling staff, your supervisor, your quality control inspector, let us say your manager for men is not it. So, all these employees come under indirect labour. So, you have seen direct and indirect material direct and indirect labour right.

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Let us look at what are direct and indirect expenses. So, you have got direct expenses let us say payment and made to consultants right designers hiring charges of machines cost of rework and so on right. So, expenses like these come under direct expenses category and you got indirect expenses like rent of building insurance premium your telephone bills lighting expenses security expenses and so on right. So, all those expenses come under indirect expenses. Now after looking at all these 3 materials, labour and expenses we classify that a project is consists of 2 type of cost and will call them as direct cost and indirect cost.

So, direct labour direct material direct expenses will form direct cost, and indirect material indirect labour and indirect expenses would form indirect cost. So, every project will have 2 types of cost and those cost are direct cost and indirect cost right.


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Crashing of a Project

Crashing : Process of reducing time of the project.

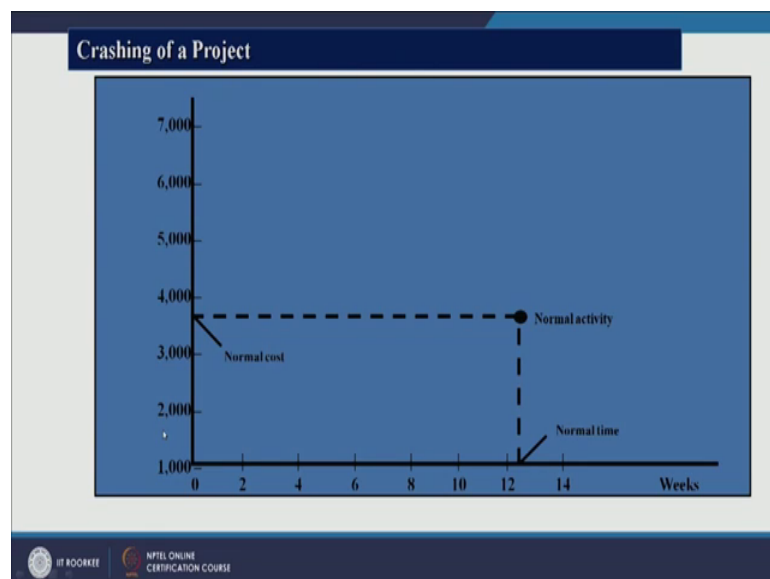
Direct cost: Cost of resources required to for an activity (men, material, etc).

Indirect cost: Indirect costs associated with material , labor and expenses.



So, direct cost cost of resources required for an activity. So, again you can just some of all those 3 direct you know direct labour, direct material and direct expenses similarly You have got indirect cost right.

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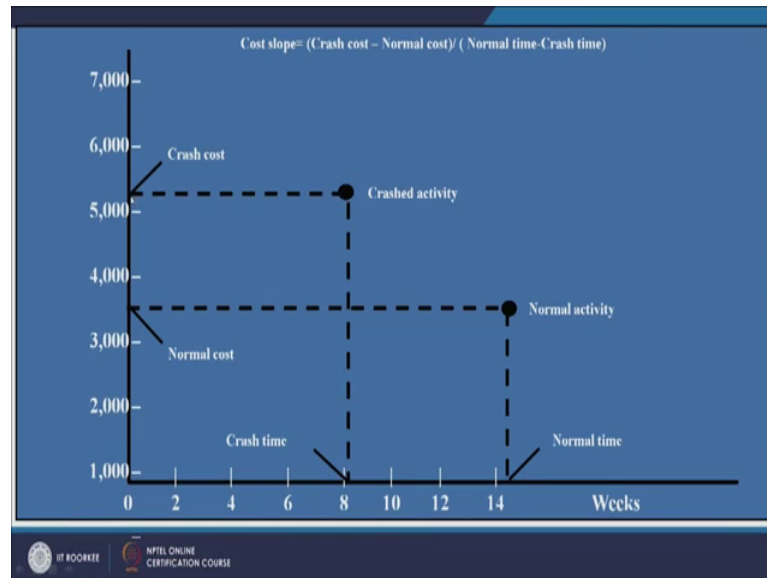


Now let us look at this slide now in this slide and there is a project is normal time is let us say 12.5 days 12.5 weeks.

So, project is your complete in at in 12.5 weeks and it is cost is let us say 3800. So, this is called normal time and this is called normal cost and this is normal activity right. So,

the moment you try to reduce this particular activity things will change right cost will change time will also change right. So, this is normal time of an activity and this normal cost of an activity right. Now your reducing duration of the activity, the moment you reduce duration of activity from let us say 14.5 weeks to let us say 8 weeks it is cost has gone up to let us say 5200 rupees.

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So, what is happening here? Then we reduce the duration of the activity the cost goes up right. So, this is relationship now when I say cost goes up which cost it is the direct or indirect? It is the direct cost which goes up right, but the indirect cost will decrease. So, with the reduction in duration of an activity the direct cost increases and indirect cost decreases there is direct proportional there is direct relationship between duration of the activity and indirect cost. If duration of the activity you know increases the indirect cost will also increase if duration decrease then indirect cost will also decrease right, but within with direct cost the relationship is inverse right inverse means when you reduce the duration of the activity you will have to put some more resources and because of that the direct cost will increase right.

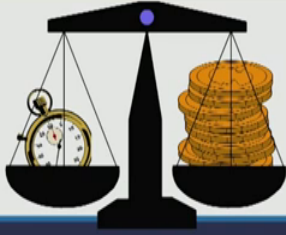
So, there is something called cost slope cost slope is nothing but the change in cost with respect to time. How much cost is changed due to change in time? So, crash cost divide minus normal cost right divided by normal time and crash time. So, you need to

remember this particular equation right this formalize cost slope the change in cost with respect to time right. So, let us look at what this relationship.

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Time-Cost Relationship

- ✓ *Direct costs increase as project duration decreases*
- ✓ *Indirect costs increase as project duration increases and vice versa*
- ✓ *Reduce project length as long as crashing costs are less than indirect costs*

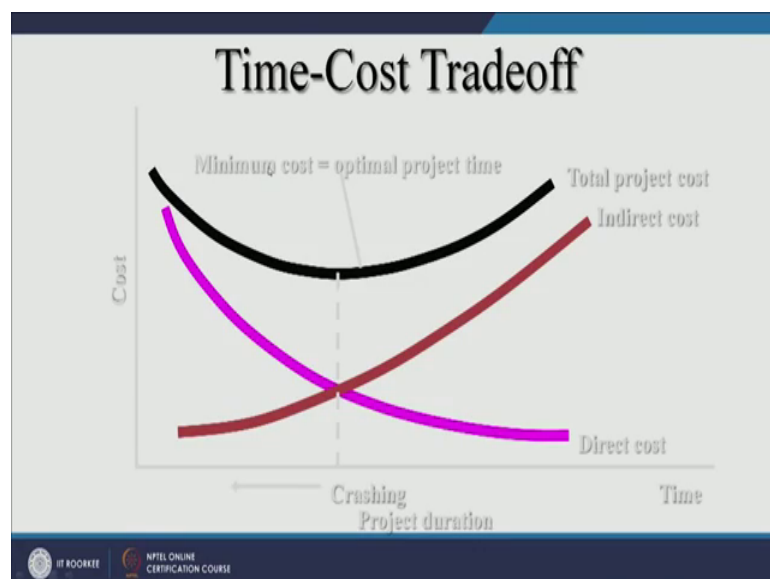


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Direct cost increase as project duration decreases indirect cost increases project duration increases and vice versa right reduce project length as long as crashing cost are less than indirect cost.

So, you should try to reduce the duration of the project as long as the crashing cost are less than indirect cost right.

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So, this is basically trade of between these 2 costs. So, and this is on x is you have got time right on y axis you have got cost right. So, when you reduce the duration of the project from this side to this side here direct cost increases right just see this curve is not it. And when increase the duration of the project indirect cost increases with the decrease in duration of the project indirect cost decreases right. So, this point where these 2 curves intersect is optimum cost point right are the minimum cost and this nothing but total cost curve right.

So, total cost curves is indirect cost curve plus direct cost curve; so you will get this type of total cost curve right. So, whenever we try to reduce the duration of the project you need to follow certain rules, how to reduce which activity should be reduced. So, let us say I will be you have already discuss that there is something called slope change in cost with respect to change in time. So, let us say in a project there are let us of activities and let us say one of them is painting. So, if you are reducing this activity then definitely the direct cost will increase and indirect cost will decrease right.

So, reduce how to select an activity for reduction of it is duration just look at this slope which has got the list slope. So, if there are 3 activities in a project reduce or the select that activity for reduction for which the slope is least right. Now there is one more point whenever you reduce the duration of critical activity, then only the duration of project reduces. So, there is no point generally there is no point to reduce the duration of non critical activities speakers they will they will not affect the duration of the project right.

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Rule 1: Crash only those activities whose **slope** (increased direct cost/unit time) is more than **indirect cost per unit time**. Now suppose **painting** is not a critical activity. Then the overall project duration would not decrease by decreasing activity time for painting as project duration is the sum total of duration of critical activities.

So, we reach the second rule for crashing.

Rule 2: Crash only those activities which **are on critical path**. There are many activities which are critical in a project, which qualify the second rule. There may many of them which follow the first rule as well. Now the question arises which activity should be preferred for crashing. This is given by third rule. Rule 3: Preference should be given to the activity with the **least slope**.

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So, what you should do? First of all select those activities which are critical and which have got least slopes right. Now if there is a tie for critical activity right.

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There may be situations where two or more critical activities have the **same** slope.

Then we should use a subsidiary rule.

Subsidiary rule 1: Preference should be given to the activity with the **least additional** cost in the situation when there is a tie between slopes of critical activities.

Another situation can be seen when there is **more than one critical path**. Then we can use another subsidiary rule. Subsidiary rule 2: Preference should be given to **common activity** on the critical path if there is more than one critical path.

In the absence of any qualifying activity, which is common to all the critical paths, we should stick to the rule of **lowest slope** amongst all critical activities

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So, you know have a situation where 2 or more critical activities have same slope then what to do? In that case preference should be given to the activity with the least additional cost in the situation when there is a tie between slope of slopes of critical activities. So, select that activity which adds list to the cost right.

Now, you know have a situation where there are more than one critical path. Now if you have got more than one critical path it means it is possible that you may have a common critical path initially and then different critical paths. So, try to reduce the common critical path first, select that activity for crashing right. So, these are couple of rules which should be followed whenever you go for crashing of a network right. So, we will take this example and we will try to solve what is the optimum schedule.

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Example: Find optimum schedule.

Activity	Normal		Crash	
	Time ^a	Cost	Time	Cost
1-2	4	100	1 (up to 1 day)	130
1-3	3	140	1	160
1-4	3	200	1	240
2-5	5	100	2	200
3-6	2	50	1	80
4-6	10	150	9	180
5-6	7	200	5	250

Indirect cost = 50 per day.

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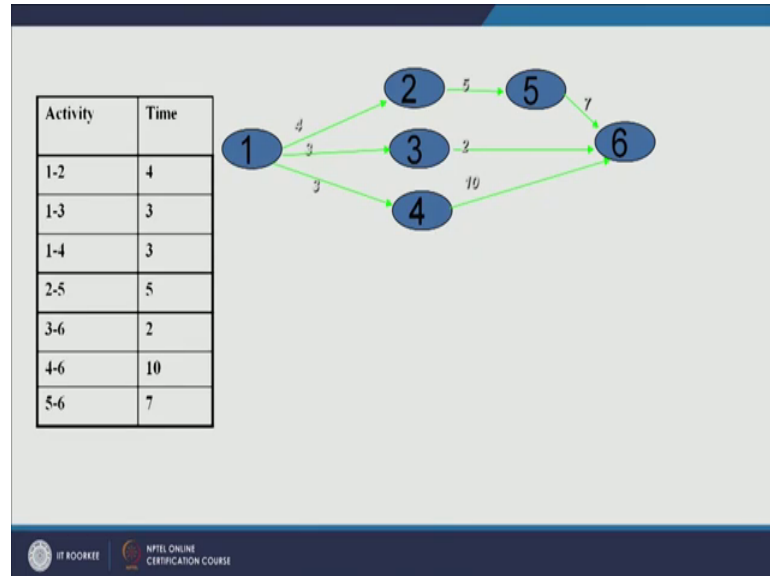
So, you have to find optimum schedule of this project the normal time of this activity one 2 is 4 days and it is cost is hundred rupees. For activity one 3 normal time is 3 cost is 140 for activity 5 6 normal time is 7 cost is 200.

So, normal time and normal cost right crash time when you take activity 1 2 is normal time is four, but you can reduce up to one minute or one day right. So, this is it is crash time and crash cost is 130. It means what is happening here when you reduce the duration of activity one to from 4 days to one day, cost as increased from 100 to 130 right. So, this is crash time is nothing but up to this these times you can reduce these activities, it is not like that you can reduce activity one to by one days it is not by one day it is up to one day right you cannot reduce after at.

So, which you look at indirect cost indirect cost is 50 rupees per day, and view already verified that the moment you reduce the duration of the project indirect cost will decrease and direct cost will increase right. So, you need to keep reducing duration of the

project and less and an till this to cost are equal right and that would be the optimum cost point. So, let us look at this question and we will solve this question.

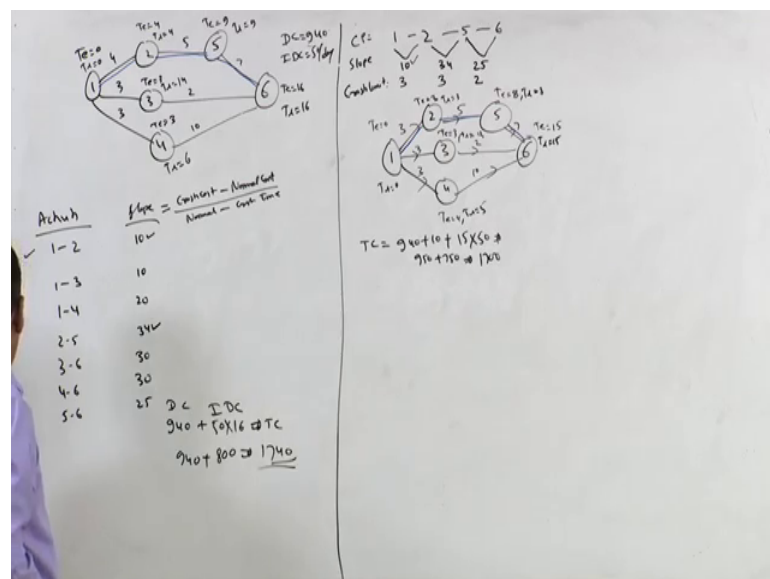
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So, you have got this network have in 6 nodes and there are 7 activities.

So, let me go on network first 1 2 3 4 5 and 6 these are different activities

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So, activity one 2 it is duration is 4 3 3 it is 5 2 and 10 and this is 7 right. So, let us first find out for this question; what is the slope, right. So, let us find out slope. So, first of all

for finding slope you need to know normal time normal cost crash timing crash cost. So, I will calculate for all this activity. So, activity one 2 right it is slope is 30 by 3; that means, 10 why 30 by 3 because it is crash cost is 130 normal cost is 100.

So, 130 minus 100 what is for is what is the definition of slope? It is crash cost minus normal cost divided by normal time minus crash time is not it. So, for first activity slope is 10, for second activity slope is for second activity which is activity one 3 right slope is also 10. Now it is very simple calculation right you have got for second activity you have got crash cost as 160 normal cost 140. So, 160 minus 140 divided by 2 right this is point right for one 4 slope is 20, for 25 slope is 34, it is 33.33. So, I have taken it has 34 right 36 for 3 6 it is it is 30 for 4 6 it is 30 for 5 6 it is 25. So, for all these 7 activities we will calculate slope right.

Now let us find out what is the total cost of this particular project. If you look at this question then the total cost the total normal cost of this project can be calculated by adding this particular column right. So, let us find out what is that normal cost 100 plus 140 240 440 540, 540 plus 200 740 plus 200 940. So, 640 is the direct cost. So, initially direct cost is direct cost is 940 and we have been given in direct cost is rupees 50 per day right 50 per day or per week whatever is the unit right. So, it is 50 per day.

So, let us find out what is the total cost of this project. So, for finding out total cost of the project what you need to calculate first of all you will you should know how much time this project is taking right and to know how much time this project is taking you need to calculate critical path and what is the value of t at this point right. So, let us look at Te here is 0 Te is 4, Te is 3, Te is 3 right Te is 9 here right from this side t would be 5 from here it would be 13. So, 9 plus 7 it is 16. So, Te is 16 here. So, what is the total cost of the project initially it is 940 direct cost plus indirect cost what is indirect cost? 15 into 16 days, right.

So, this is this to this would be total cost right. So, in this way you can initially calculate total cost right. So, now, let us move on to process of crashing this network right now what is the first tool first tool is if you really want to and what is critical path here anyway let us calculate Tl also right. So, Tl is 9 Tl is 4, Tl is 0 and Tl here is 6, Tl here is 14. So, this is your critical path right this path is critical path. So, if you want to reduce duration of this project then you need to reduce one of these activities along critical path.

So, your critical path is what? Your critical path is one 2 5 and 6. So, I have to select one of the critical activities to reduce duration of the project. So, which activities should be selected.

So, first of all we should write over here what is the slope. So, you have got to 1 2 5 and 6 right. So, what is the slope of activity one 2 cost slope of activity one 2 is 10 right. So, write 10 here is not it what is the slope of 2 5? Slope of 2 5 is 34 right and what is slope of 5 6 it is 25 right one more point you should write here is called crash limit. Crash limit is the limit up to which you can reduce duration of the activity for example, normal duration is 3 sorry normal duration is 4 for activity 1 2 and crashed duration is 1. So, crash limit is 3. So, you can reduce the duration of activity one to from 4 to 1. So, crash limit is 3. So, crash limit is 3 here for activity 2 5 what is cash limit? For activity 2 5 crash limit is 5 minus 2 it is 3.

Similarly for activity 5 6 for activity 5 6 crash limit is also 2 right. Now we know that the least slope is for activity 1 2 right. So, we select activity one 2 for reducing it is duration right. So, we will reduce duration of activity one to by one day, now this is a process in which and we will be reducing duration every time by one day, we cannot reduce duration of activity this particular and duration of activity 1 2 by 2 days or 3 days why? Because the moment I reduce duration of this activity by one day there is a possibility that one more critical path might have generated and when you have got more than one critical path to reduce the duration of the project, you need to reduce both the path simultaneously.

So, that is why we are taking care that we should not have we should not have more than one critical path generated the moment you reduce it from we reduced by more than one unit right. In fact, in several books you will find that authors have reduced this activity by 3 days directly. It is possible to reduce this activity by more than one day, but we will have to check some other limits and we will have to check free float limits, we have to check that while reducing there should not be any path which is getting generated and also you are crushing it right. So, that should not happen.

So, what we are doing it we are selecting activity 1 2 and reducing it is duration by one day right. So, this is activity 1 2 let us reduce it is duration by one day. So, 1 2 3 this is 3 this is 4 5 and 6 right. So, what we have done let us make this activity as 3 right all other

activities will remain as it is right 5 2 10 and 7 let us find out how t is and Ta. TLS t is equal to 0 Te is equal to 3 Te is equal to 4 Te is equal to 3, Te is equal to 8 and Te is equal to 50. So, what has happened here? The total time has decreased by one day and the total cost which is going to up is by 10 rupees, but. So, our direct cost has increased by 10 rupees and indirect cost has decrease by 50 rupees per day right.

So, what about what is the total cost here let us find out total cost for this also 940 plus this is 800 right this is 17 40 right this is the total cost for 16 days, what is the total cost here total cost here is 940 it will remain as it is now this will be 940 plus 1 right. So, 59 50 right by plus 1 9 40 plus this 10 rupees extra right plus indirect cost is 15 into 50. So, this would be total cost; so 950 plus 950 plus 750 right. So, this would be 1700 is not it. So, total cost has decreased is not it.

Now what is the next step? Let us find out critical path first of all because we would like to further reduce in the duration. So, Tl is 15, Tl is 8, Tl here is 3, Tl is 15 minus to 13, Tl here is 5 and Tl here is 0 right. So, critical path is what which path is critical path this is your critical path right.

So, let me stop here for the time being we will continue solving this particular equation let me remind what we have done here in this session we have discussed different types of cost and what is the relationship between direct cost and time and indirect cost and time. So, we will continue with this session in next lecture.

Thank you very much.