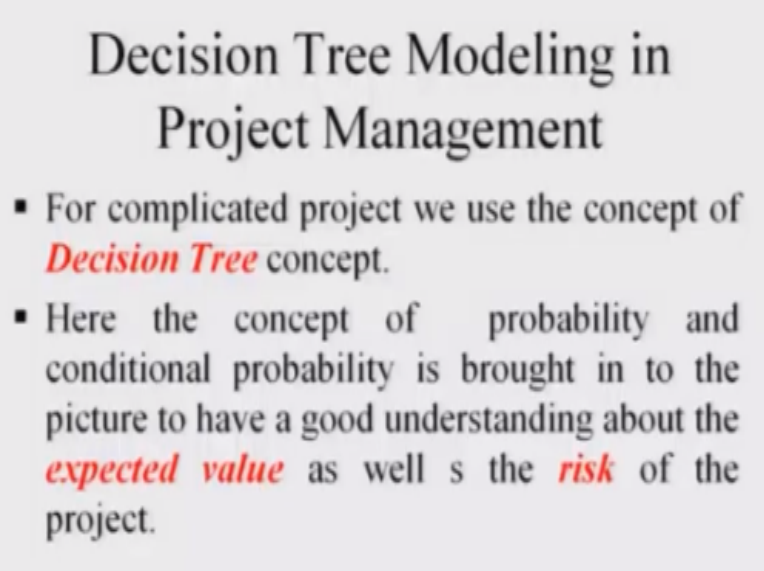


Project Management
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Module No # 2
Lecture No # 08
Solving Project Management Decision Problems

Welcome back I am Raghunandhan Sengupta from IME department IIM Kanpur. So this is the course for project management and today is the eight lecture which is the third session for the second week. So as we are discussing the concept of expected value and how this concept of expected value is used. We will discuss that soon with problems.

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**Decision Tree Modeling in
Project Management**

- For complicated project we use the concept of *Decision Tree* concept.
- Here the concept of probability and conditional probability is brought in to the picture to have a good understanding about the *expected value* as well s the *risk* of the project.

(So for complicated project we use the concept of decision tree so decision tree is basically so called node and arc concept. Node means the concept where you basically have decision being taken at a at a node and arc would basically be connecting the nodes. So we will have the decision tree denoted by node and arc but it can be the other way also like arc and a node.

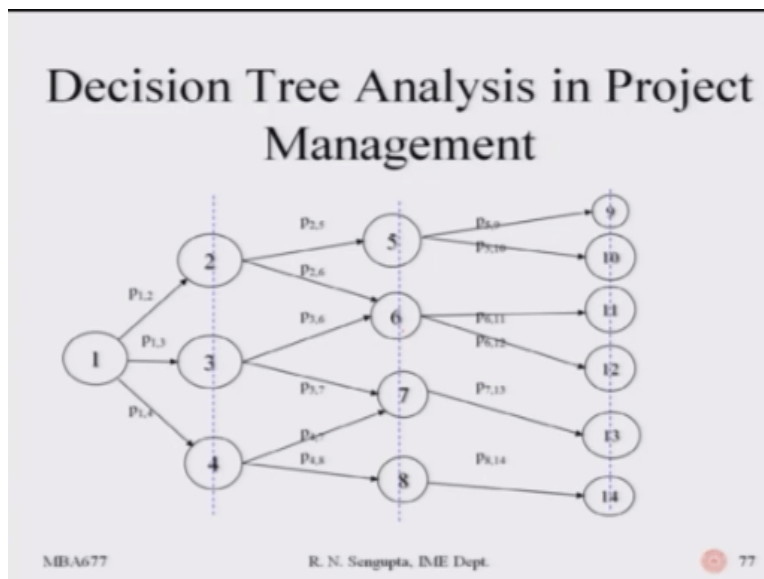
So for any event or any job for a project you can either use the concept of arc and node or node and arc depending on how you are trying to portray the activities. So it may seem at the first go very complicated but very simple how you basically delineate or how to draw the activities either using the node or the arc's. So here the concept of probability for the decision tree the concept of

probability if you remember we had generally discussed the concept of probability the number of days and what is the loss per unit of day for any particular activities is there and how based on that how we find out the overall loss.

So considering distributions are not known or known whatever it is you can find it out here the concept of probability and conditional probability can be brought into the picture to have a good understanding about the concept of expected value as well as the risk of the project. So let me first highlight two important things how we do that we will consider there in the problem in in the third week or by all probabilities in the last session of this week second week.

So basically is the concept of the probability which is marked here and the consequent in the concept of conditional probability condition on the fact something has happened will try to utilize that later on trying to find out the expected value and the risk of the project.

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So now this is the first very simplistic diagram which I want the students to pay attention because that will give you a fairly or idea how the concept of probability expected value and risk or the variance is used to find out the decision trees overall outcome based on which we can use the concept of expected value to make our decision. So what we have we have the nodes which is number one marked here and based on the work which is being done between one and two say for example you are you have acquired land and after the land is acquired.

So basically you will try to do three type of work one is trying to lay the foundation for the big building which would be say for example hypothetically the work being done from one to two. So this P suffix one two is the probability or the concept of so called probability or condition probability which would come into the picture. So for the areas or the concept of PERT and CPM this probability would be subsumed in the problem in a different sense I will come to that later.

So P12 is the probability for the being done between one and two one and three is basically considered you are trying to clear up the area in and around where the building will be built. So they are simultaneously there is no mismatch that one work has to be done first other has to be done second for the timing for two three and four.

And say for example one and four is the work related to some litigation which would not affect your actual work being done. Say for example there is some litigation regarding the road which is to be build up just outside the building. So if that is a different issue then you can definitely take both of all three of the works one to two one to three and one to four all of them simultaneously.

So up but probabilities are different as mentioned P12 then you have P13 then you have P14 which are the corresponding probabilities. Now remember one thing the probabilities would be different point 1 they can be either unconditional probability or conditional probability point number 2 point number 3 is that the arcs which joins the nodes 1, 2 or joints 1, 3 or joints 1, 4 the length of arc is not to suppose that what is the number of days.

So the number of days would basically be mentioned alongside the probability which we have not done here in this case we will consider that when we going into the PERT and CPM concept but it is basically just to show that there is a linkage between the nodes 1 2, 1 3 and 1 4. So this blue dotted line which you see for the first time this one which is the vertical one is basically a stage of the decision process.

So if you remember that we have been considering the problems from the project management perspective. So they were some acceptant gate and they were some decision gates. So the gates or the stage where you are going to take a decision.

These vertical lines basically that means the first one the second one and the third one basically signifies that if you are standing there what would be your decision based on the overall feedback which you have corresponding to the properties and the so called other set of information's which you have. Similarly considered from 2 to 5 you will go where the probabilities P suffix 2 to 5.

Similarly you will go from 2 to 6, 3 to 7, 4 to 7, 4 to 8 and the corresponding probabilities are given with P with the suffix of the initial node and the final node. Now remember one thing if you consider 6 it would mean that 6 can only start once the work related to joining between 2 to 6 and 3 to 6 all or the both of them as been done why I am using the word all there can be other jobs also which are ending at 6.

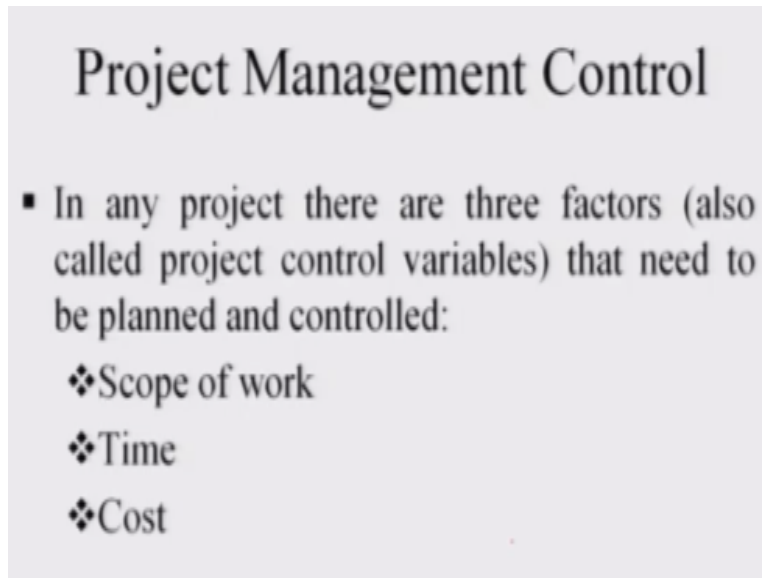
So here in the diagram I only have 2 such jobs it can be others jobs which are coming here say for example there is a job here with basically and sub 6 they can be job here which ends at 6. Say for example 4 and 6 is connected so it may mean and actually would basically give you the information that job 6 can only be done after 2 to 6 is done after 3 to 6 is done after 4 to 6 is done this is just for the information which I want the students to be aware that you can only start the job once is falling jobs which are to be done are finished.

Again coming back to then you have basically the nodes 5, 6, 7, 8 again there is a decision stage where you will take a look at all the overall feedback which you have for the project and make a decision here correspondingly again you go from 5 to 9 or 10, 6 to 11 and 12, 7 to 13 and 8 to 14 here just for simplicity I am not considered the thirteen is being affected by 6 or 13 is being affected by 5.

So those two concepts are not there if there were so obviously 5 would have joined 13, 6 would have joined 13 and you would only be able to start 13 once the jobs on the activities is

connecting five thirteen six thirteen and seven thirteen all are over. So again the probabilities which are given P suffix five comma nine till P Suffix eight comma 14 are the corresponding probabilities which denotes the suffix denotes the initial job and the final job or the initial activity, final activity or the initial stage or the final stage whatever it is.

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Project Management Control

- In any project there are three factors (also called project control variables) that need to be planned and controlled:
 - ❖ Scope of work
 - ❖ Time
 - ❖ Cost

In any project there are three factors also called the project control variables and they are needed or required for planned and controlled concept to take into decision the scope of the word what is the scope of work like what are the boundaries based on which the work could be done or the project would be undertaken so on and so forth.

What is the time scale based on which you are trying to do the work because if you remember I did mention when we started off the concept of project management that time is one of the most important factor based on which the decision is taken about the relevance of the project and whether and that set of activities are important or not.

And obviously later on we will see the concept of cost or the concept of how what is the schedule that would also come into the picture where rupees or dollars or euros or yen's whatever it is will be considered in order to take a decision whether that project is at all related or whether some set of scheduling can be done using some extra cost in order to reduce the time.

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Project Management Basic Planning Technique

- Open creative techniques: Exploits the creativity in organizations seeking new and non-traditional solutions. They are based on experts that are motivated to creative thinking. The most widely used technique is brainstorming.
- Forecasting techniques: This method is based on development trends over time. Under this there are two methods which are: *explorative techniques* and *normative techniques*.
- Organization development methods: In this method we try to involve the whole or a special part of the organization in creating ideas. One of the best known techniques is the *Strength Weakness Opportunity Threat* (SWOT) analysis.

Project planning basic planning techniques would basically have the open creative technique the forecasting technique have the open creative technique the forecasting technique and the organizational development techniques. So in the open creative technique you basically uses the creativity in organizations seeking new and non-traditional solutions as that based on the new and non-traditional solutions you will be able to find out that what is the overall way the project should be handled.

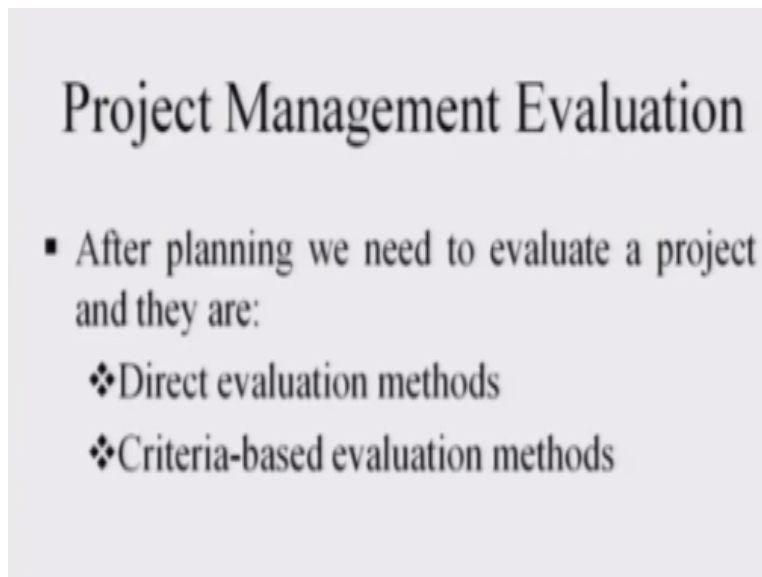
The most widely used technique is the brainstorming sessions where people from the different areas of work who are involved with the project basically they sit down together give their feedback on different aspect and all the salient points are basically gone into the details are based on all the feedback which you have the overall team gets the best set of feedbacks or the best set of solutions of best set of see for example techniques we should be taking up to complete that project management work.

The forecasting technique can be either exploratory technique on one normal and techniques so they are basically developed over time. So say for example you want to forecast that what would be sales of the moped or you want to find out that what would be the average price based on which you can sell a certain product whether an air conditioner whether the fridge or a car whatever it is.

So you have different type of mathematical and qualitative techniques based on which you can take a decision for the forecasting concept which you are going to use and under the organizational development methods you have the strength weakness opportunity and threats SWOTS analysis. So many of you we have done that concept of sort when is basically for any decision or any project to be taken all the strengths of that project or the project work or the activities all the weaknesses who are the competitors.

What are the environment based on which the work is to be done what are the threat perceptions whether the technology would be absolute and all these things are basically analyzed on a detailed and my new skill such that based on those feedback for the SWOT analysis and whatever other techniques you will be able to utilize the brainstorming can also be utilized compliment to this SWOT analysis or forecasting techniques can be use as that you get the best solutions by combining all the different techniques which are there at the end.

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The slide has a light gray background. At the top, the title 'Project Management Evaluation' is written in a large, dark, serif font. Below the title, there is a bulleted list. The first bullet point is a square symbol followed by the text 'After planning we need to evaluate a project and they are:'. Below this, there are two more bullet points, each preceded by a diamond symbol. The first diamond bullet point is 'Direct evaluation methods' and the second is 'Criteria-based evaluation methods'.

After planning we need to evaluate the project and they are basically the direct evaluation methods then the criteria based evaluation methods. Criteria based evaluation method would be say for example we want to reduce the time what do you want to have basically an optimum time based on which the project would be finished or do you want to basically utilize the resources in such a way that you would be not be utilizing more than say for example twenty crores for the project whether the time is important or not important may not be very relevant to the problem.

But in general we will see that in maximum on the project management techniques which are use in the practical sense there the overall feedback is taken related to the time spent on that work that overall amount of money spent on their work different types of machines and equipment's spent on that what different about of human resources being utilized so everything is considered such that you get the best benefit for you for that project considering that you will be utilizing different resources at different levels of usage.

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Project Management Evaluation

- Technical evaluation could be related to functionality, quality, reliability, etc.
- It is often necessary to measure these factors in economic units.
- The most commonly used direct evaluation methods are:
 - ❖ Check list
 - ❖ Pair wise ranking

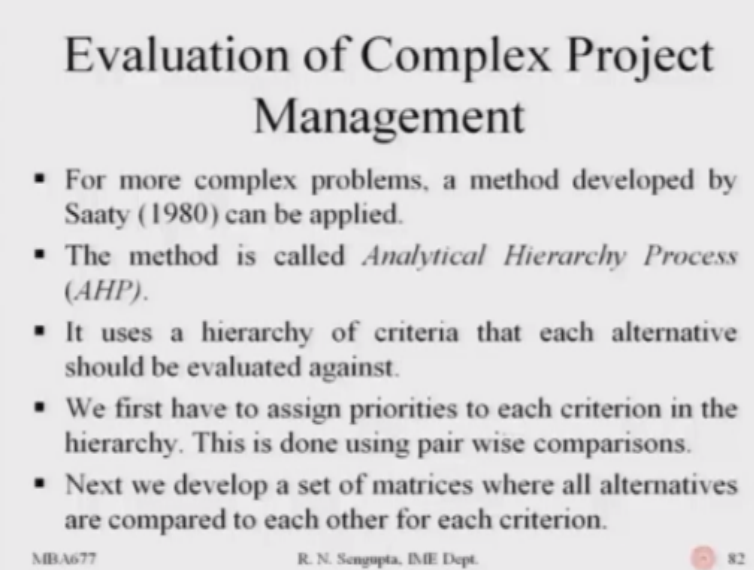
Technical event could be related to continuing with project management evaluation techniques. Technical evaluation should be related to functionality the quality the reliability so how reliable the overall analysis has been whether there would be any change in the cost structure how sensitive is the cost of say for example input material to the overall cost of the project.

So consider that you are using steel if the prices of the steel has the huge amount of effect on the project then any small amount increase or decrease of the price of the steel would have the huge amount of impact for the project. So these things should be considered it is also man often necessity to measure these factor on the economic units such that based on the economic factors if you remember in in in the last or last to last class I am we did discuss that of the problem where per unit decrease in in overall cost or the loss was say for example two thousand rupees.

So those economic factor should also be considered in in the problem in order to find out the overall cost of the project the most commonly used direct evaluation matters or the check list and pairwise rankings are that based on the pair was ranking you can make a decision whether the project should be delay.

So obviously for the pairwise ranking we will consider what are the different techniques or expected value and variance concept or if required you can use different combinations of the moments to take a decision whether the project actually viable and whether is feasible yes or not.

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Evaluation of Complex Project Management

- For more complex problems, a method developed by Saaty (1980) can be applied.
- The method is called *Analytical Hierarchy Process (AHP)*.
- It uses a hierarchy of criteria that each alternative should be evaluated against.
- We first have to assign priorities to each criterion in the hierarchy. This is done using pair wise comparisons.
- Next we develop a set of matrices where all alternatives are compared to each other for each criterion.

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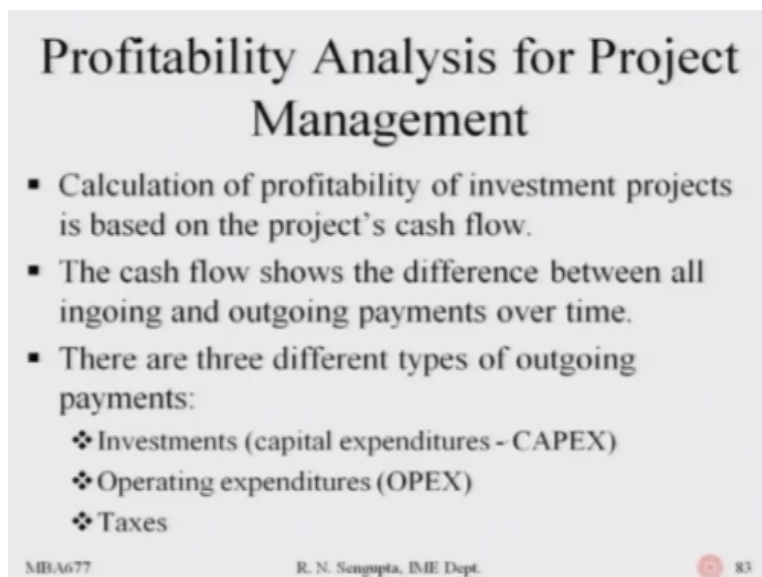
For more complex problems a method was developed by SAATY in nineteen eighties basically called the analytical hierarchy process AHP and a bigger scope of this AHP is the analytical network process also developed by SAATY in the nineteen eighties and nineteen nineties and in the early nineteen nineties. So in the identical network process you basically try to analyze the whole project or a work as a network.

So there are if you remember in just a few slides back we have the decision tree that was the was a very simplistic decision tree in the network there would be loops and feedbacks. Such that you will consider the overall project as a network and basically take a decision based on that so where probabilities and condition properties come into the picture in analytical hierarchy process there are hierarchies based on the hierarchy.

So there is no feedback loop in the sense feedback loop what I mean is that that for the hierarchy which you are below there are no arrows again leading back to the upper hierarchies but in analytical network process there are feedback loops or feedback arrows such that you have to take that into consideration when trying to basically analyze the AMP network while in AHP network or the diagram you do not have the concept of feedbacks.

In AHP uses the hierarchy or criteria that each alternative should be evaluated against we first have to assign priorities to each priority in the hierarchy this is done using the pairwise comparison and based on the pairwise comparison you take you do that job. Next we developed a set of matrices for the hierarchies where all the alternatives are compared to each other for each criteria based on that we take a decision.

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Profitability Analysis for Project Management

- Calculation of profitability of investment projects is based on the project's cash flow.
- The cash flow shows the difference between all ingoing and outgoing payments over time.
- There are three different types of outgoing payments:
 - ❖ Investments (capital expenditures - CAPEX)
 - ❖ Operating expenditures (OPEX)
 - ❖ Taxes

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So the probability analysis of the project management is done such that the calculation of problem profitability of the investment process is based on the projected cash flow. So you will try to basically find out what is the present value of the cash flow what is the future value of the cash flow.

What is the concept of rate of return here you will be using is it continuous compounding is it simple interest is it say for example compound interest or you will try to find out whether the

interest rates or the evaluations of the cash flow would be based on a monthly basis or a yearly basis and if at all if the interest rates are fluctuating.

So you have to take into consideration whether you are able to do your work considering the average value of the interest rate or you have to be still consider some distribution for the interest rate based on that you need to do the work the cash flow shows the different between the ongoing projects and the payment sequence which are there. So say for example if you are trying to basically analyze different projects.

So one good method would be try to basically compare the internal rate of return IRR of the projects and basically make a decision that what is the rate of return on the project based on which you can take you are positive or negative. Another method can be say for example rather than going into the IRR if it is difficult to for you to calculate you just find out the expected value.

So in that concept of expected value those the concept of probability what is the overall feedback of the rate of return for the cash that would be considered in case see for example the expected rate of return of different projects are same or there is some uncertainty that you are not aware of what is the expected rate of return of the project then you will try to basically find out that what is the variance of the project.

So higher the variance obviously you would not take a decision based on that fact that as the variance is higher. There are three different types of ongoing outgoing payments you have the capital expenditure concept. Where all the project would be considered on capital budgeting concept and one is the operating expenditures concept and there they will consider the concept of tax coming to the picture and so and so henceforth.

So obviously time value of the money along with the tax concept along with the concept of IRR arcs and so on and so henceforth whether the money is there on as taken as loan or whether it is a liability of different types would be considered in order to find out that overall what is the monetary value of the project.

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Cost calculation in Project Management

- Consider
 - C_0 is the initial cost of the project
 - r is the interest rate for the project calculated per year
 - n is the time in years
- Then the total price is given by $S = C_0(1+r/100)^n$
- If they are to be calculated on a yearly basis we have $C_i = C_0(1+r_i/100)^i$
- Hence total cost is $TC = C_1(1+r_1/100)^1 + C_2(1+r_2/100)^2 + \dots + C_n(1+r_n/100)^n$

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So consider this C_0 the initial cost of the project so there as R is the interest rate for the project calculated per year so I am basically considering the R as interested per annum in a very simplistic sense and consider it is deterministic and where N is the number of years for which will be finding out value of the project then the total price would be given but his formula which is basically here.

So which means that if the price of initial cost of the project is is SC_0 then the total price would be given based on the fact that R is the interest rate calculated per annum very simplistically and then it is basically found out percentage wise. What you will do that for each value for each year increase the value in increasing to this. So if you have hundred rupees the and the interest rate is ten rupees then consider a very simple example and this is the just best way of trying to basically make the students understand.

If you put understand if you put hundred rupees in the bank the bank pays ten percent such that is the rate of interest for the investment which is doing and after one year you will get basically get one hundred and ten rupees. So if you again put that a hundred rupees not for now one year for two years then if simple interest concept is there. So it would be calculated by one hundred and ten rupees for the first year ten rupees for the second year and so on and so henceforth.

So if you consider one of the simplistic methodology how you find out the overall value of the project it would be calculated because this is the increase in the value of the money which is the money which you had in the initial stage. So hence the total price would be given by S which is by this formula if they are able to be calculated on a yearly basis.

So obviously it will happen that the per year calculation would come into the picture. So this I would be basically mean that it is for either one year or two years or three years whatever it is. So does not mean only one so because if it is for one year then my calculations will be based on a time frame such that at P is equal to zero.

I put my money at T is equal to one year which is three sixty five days or twelve months or fifty two weeks whatever it is I take out their money considering the example which I gave for the bank and based on that I will try to basically half overview that how the project would be doing if I basically try to analyze the project with respect to the investment in the bank.

If it is for two years then what I do is that I invest the money and the money stays in the bank account for two years then the calculations would be based on the fact that $I = 2$. Now this R I give which you will find it is different than R if you remember that R is the fixed value of interest rate for the long duration on time but if the R is changing which is stochastic then I obviously have to use R_1, R_2, R_3, R_4 depending on which time frame I am going to consider.

But a very simplistic way on a very simple sense R is the average or all the R_i values considered they see for example there for ten years then what you will simply do is that find out the sum of all arc R_1, R_2, R_3 till R_{10} divided by ten then you find out the value of R . Hence the total cost of the project would be the first term would be the cost of the other project or the value of the project after one year similarly if you consider if go into the second year thus the terms the bracket R_2 is the interest rate for the second year and the this square means two years.

Similarly if you go down the line this N Suffix is basically the interest rate R_N is the interest rate for the N eth R and N is basically with the number of year calculation is you are doing. Now if you come to the value of C_1, C_2, C_3, C_4 basically they mean the value of the overall the cost of

the project which is basically either decreasing or increasing depending on whether depreciation is there or not there per year.

So if C_1 is the overall cost of the project it means that C_1 is basically the value at the beginning of year one and then based on that you calculate what would be the value of the project after the end of the year one that is beginning of the second year. So that would be calculated as given in the first term here just highlighting it once more. So this is the value then if I go to the second year beginning of the second year till the end of the second year or the beginning of the third year this is the value.

So on and so henceforth I calculate so if I try to draw it in the diagrammatic sense what we have is this line time line this is the which I have say for example input is happening and these are the payback which is happening and each gap which you have is one year. So say for example the input example the input cost is I with a suffix zero which means that is happening for the time period when $T = 0$.

So I am measuring along this horizontal line or T time so this means $T=1$, $T = 2$, $T = 3$ so and hence so forth. So at $T = 0$ which is I_0 is the initial cost and consider this is C_1 , C_2 , C_3 , C_4 which are the payback from the project. So if I want to compare that is actually good decision to take that overall decision for investing in that project what I will do is that I will calculate all the values of C_1 , C_2 , C_3 , C_4 at time $T = 0$ add up all of them whether positive or negative as it does not matter because if it is negative it will basically bring down the overall value.

So these are the so called returns which you are coming to my pocket this (I_0) (26:03) is the value of investment which I have done and if I want to compare I will find out the simple difference between the time value of the money for C_1 , C_2 , C_3 , C_4 so on and hence so forth and compare if I_0 if there is difference so there are such different type of project with different cash flows. I will basically find out the value of the positive and negative return sum them up at time $T = 0$ and compare the different projects at the same time.

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Cost calculation concepts in Project Management

- Discounting factor
- Net Present Value (NPV)
- Fixed Discounting rate (r)
- Variable Discounting rate (r_t)
- Internal rate of return (IRR)
- Payback time
- Return on investment
- Discounted return on investment

So the concept used for the calculating the project value would be the discounting factor the net present value the fixed discounting rate the variable discounting rate the internal rate of return if you remember the payback time the return on investment concept the discounted rate of return on investment and so on.

So I will come in trying to discuss all this problem of discounting factor and net present value expected discounting concept variable discounting later on. So what generally apart from considering the qualitative concept if you slowly go through the slides you will understand that we have from quantitative perspective till now which is basically the eighth lecture which is going to end with another two or three minutes.

We have considered the concept of decision tree which means we will definitely do a decision tree problem in another one of within one or two classes plus we will also consider the concept of expected value and how decision trees and expected values can be combined and then we will try to find out the net present value concept of the money the IRR concept discounting factor concepts such that this whole set of bullet which are there in front of me they would be considered using very simple examples later on in the third week.

So we start of PERT and CPM we will definitely try to cover these problems using very simple quantitative values are there you can give a good idea to the students how the can be utilized and

also we will come up with the concept of very small assignments which need to be done by the students and submitted as per the norms of the NPTEL course have a nice day and with this I will end the eight lecture thank you very much.