Plant Design and Economics
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Lecture No -23
Profitability Analysis (Contd.)

Welcome to lecture 23 of plant design and economics. In this module, we are talking about economic evaluation of projects. In our previous lecture we started discussion on various methods of profitability analysis. In this lecture also, we will continue our discussion on profitability analysis. So we will start with different other methods on profitability analysis.

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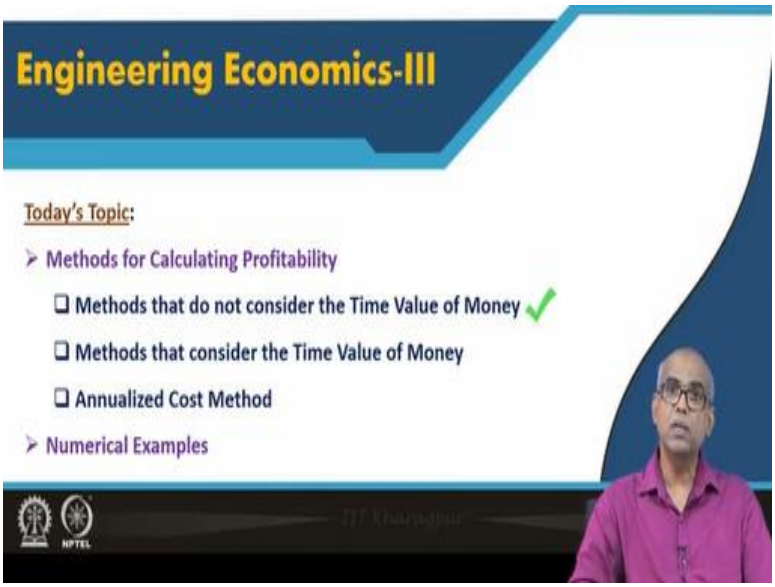

So in our previous lecture, we will talk about the methods that do not consider the time value of money. So today we will consider first, the methods that consider the time value of money, we will also talk about some variance of these methods and also take several numerical examples.

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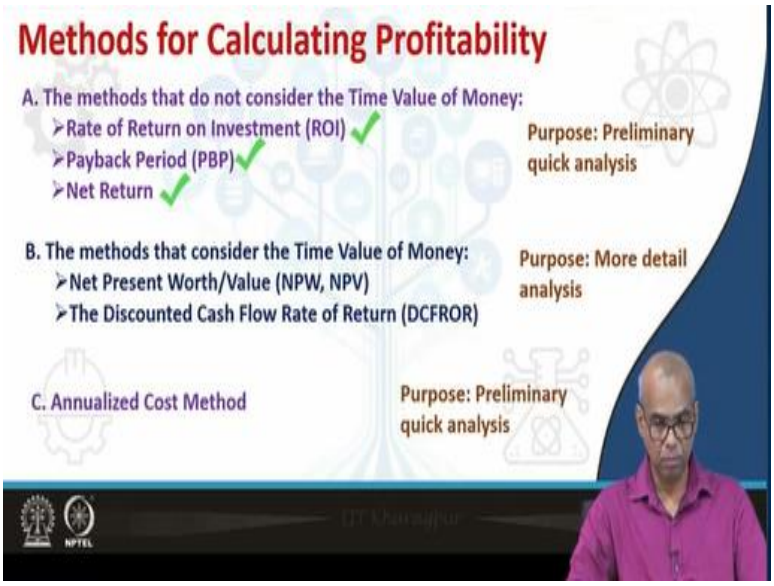

So we have already completed methods that do not consider the time value of money under these we discussed rate of return on investment, payback period, we will call that simple payback period because there is another payback period which is known as discounted payback period, we will discuss that briefly and net return. Now the methods that do consider the time value of money are net present worth or net present value and the discounted cash flow rate of return. So we will discuss these two methods with examples.

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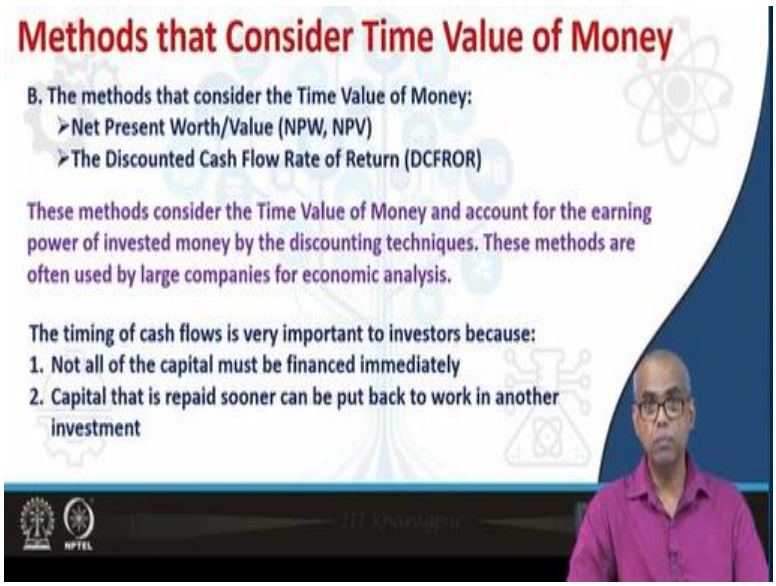

The methods that consider the time value of money account for the earning power of invested money by the discounting techniques. Such methods provide more detail analysis for economic evaluation of projects and are often used by large companies for their economic analysis. It is

important to take care of time value of money, because not all of the capital must be financed immediately.

Also capital that is repaid sooner can be put back to work in another investment. So it is important that the timing of the cash flows are taken into account.

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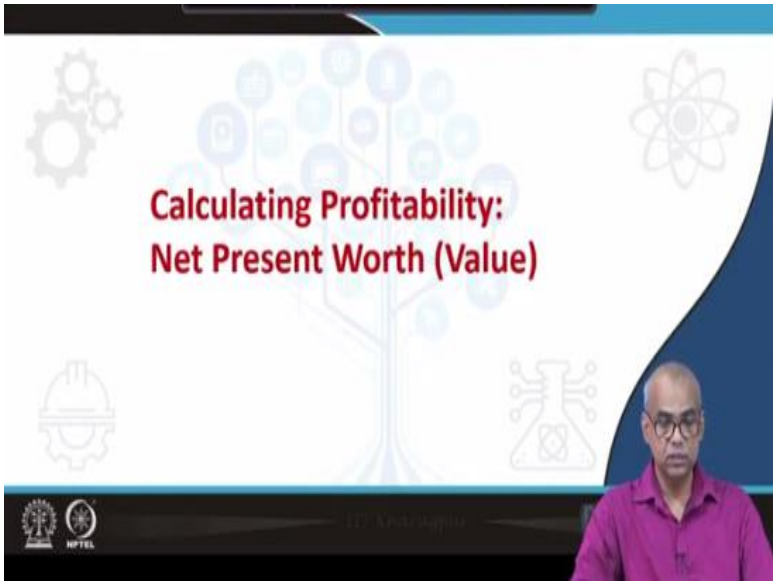

So we start with how to calculate profitability using net present worth analysis or net present value analysis.

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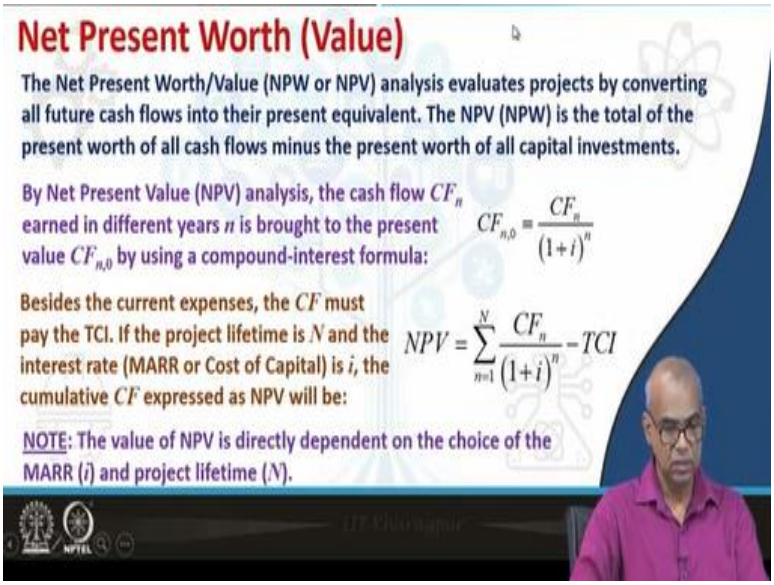

The net present worth or net present value generally known as NPW or NPV analysis evaluates

projects by converting all future cash flows into their present equivalent, the net present value or NPV is the total of the present worth of all cash flows minus the present worth of all capital investments. So by definition the NPV is the total of the present worth of all cash flows minus the present worth of all capital investments.

By net present value analysis the cash flow are in different years n is brought to the present value by using compound interest formula and you are familiar with this equation. So this equation is nothing but, P=F by 1+ i to the power n. Besides the correct expenses the cash flow must pay the total capital investment. So, if the project lifetime is capital N and the interest rate which may be the minimum acceptable rate of return or cost of analysis will be represented by i.

Then the cumulative cash flow expressed as NPV will be all the cash flows converted to the present worth minus the total capital investment. So this is the mathematical expression for the net present value. Note that, the small n represents years here and we started with n equal to 1 to n equal to N. The value of NPV is directly dependent on the choice of the minimum acceptable rate of return which is i, as well as project life time which represented here as capital N.

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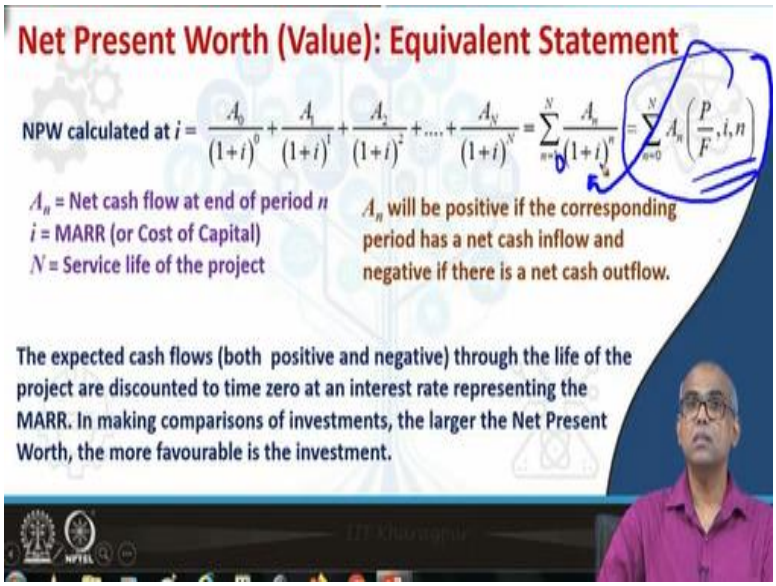

Now, we can also make an equivalent statement about NPV, the net present worth are NPV can

be calculated at interest i as A0 by 1+i to the power 0 + A1 divided by 1+i to the power 1 and so on and so forth up to year N. So, which is summed as n=1 to N it should be actually n=0 to capital N, because we are also including A0. Now, An is the net cash flow at end of period n, i is the minimum acceptable rate of return or cost of capital and N is service life of the project An will be positive, if the corresponding period has a net cash inflow, that means it has an income.

And negative, if there is a net cash outflow that means that is a cost. So if we consider that, then we can compactly the write as this, note that this is n equal to 0 to N. Now, this is right again in terms of P by F factors. Now P by F factors is nothing but 1 by i to the power n, the expected cash flows both positive and negative through the life of the project are discounted to time 0 at an interest rate representing minimum acceptable rate of return.

In making comparisons of investments the larger the net present worth, the more favorable is the investment. So once you calculate the NPV then the NPV is large it is favorable. So when we have multiple proposals to evaluate economically you compute the NPV value for each and every proposals, and you will accept that proposal which has the largest NPV or net present worth.

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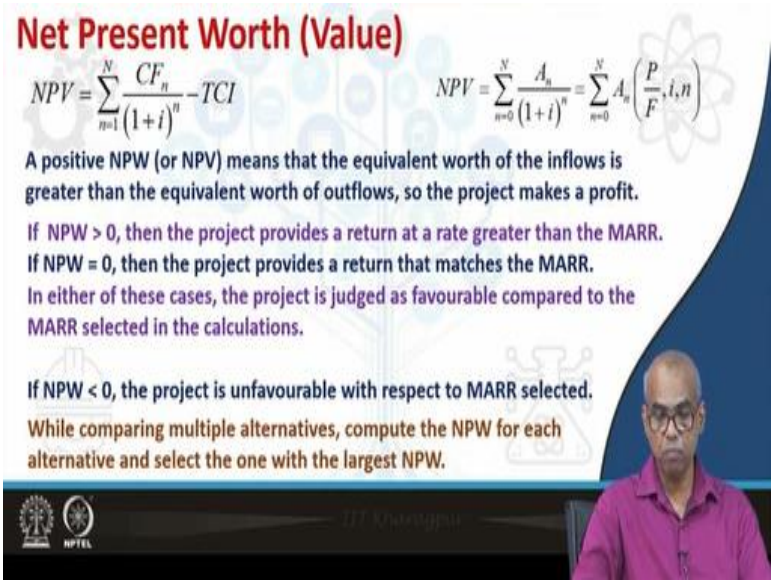

A positive net present worth or net present value means that the equivalent worth of the inflows is greater than the equivalent worth of outflows, so the project makes a profit. So if you are

evaluating a single business proposal, you can accept the proposal if the NPV value is greater than 0. If NPV value is equal to 0, then inflows matches out flows, so it is indifferent. Now NPV greater than 0 it means that the inflow is greater than the equivalent worth of out flows.

So the project makes a profit and it is acceptable, so NPW is greater than 0, then the project provides the return at a rate greater than the minimum acceptable rate of return that you have selected. If NPW equal to 0, then the project provides the return that matches the minimum acceptable rate of return but in any case NPW greater than 0 and NPW equal to 0, are judged as favorable compared to the minimum acceptable rate of return selected.

If NPW is less than 0, the project is unfavorable with respect to the minimum acceptable rate of return that you have selected. So while comparing multiple alternatives computes the NPW for each alternative and select the one with the largest NPV or NPW.

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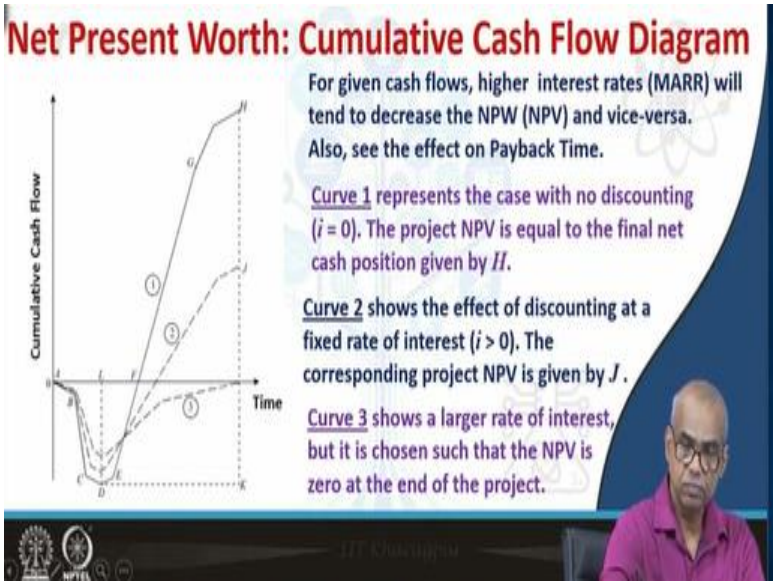

Now look at this cumulative cash flow diagram, for a given cash flows higher interest rates, that means the minimum acceptable rate of return will tend to decrease the NPV and vice versa. So if the rate of interest decreases, NPV will decrease, sorry if the rate of interest increases the NPV will decreases. So if you go on increasing the interest rate NPV can be negative. Now, there are three curves, 1, 2 and 3.

So, look at curve 1 first the curve one represents accumulating cash flow diagram with no discounting, that means the rate of return i is 0 here, the project NPV will be is equal to the net cash position, which is given by the point H on the cash flow diagram. Now, let us take a case where I have increase the rate of return, I have increase the rate of interest i, so minimum acceptable rate of return has been increased.

So curve 2 represent such a case where you can see the effect of discounting at a rate of interest, which is greater than 0. Now, you can see the project NPV is depended by point J has decreased from by point H to this value, so it has decrease by this quantity. Now, if we further increase the rate of interest you will get a position represented by curve 3, where the rate of interest is so chosen that the final NPV which 0 at the end of the project.

So this figure shows that increasing value of rate of interest your NPV decreases, and you can have an rate of interest, NPV will be 0 exactly at the end of the project. If you further increase rate of interest NPV may be negative. Also, look at as you go on increasing rate of interest, the payback period increases. So the payback period also increases with higher interest rates.

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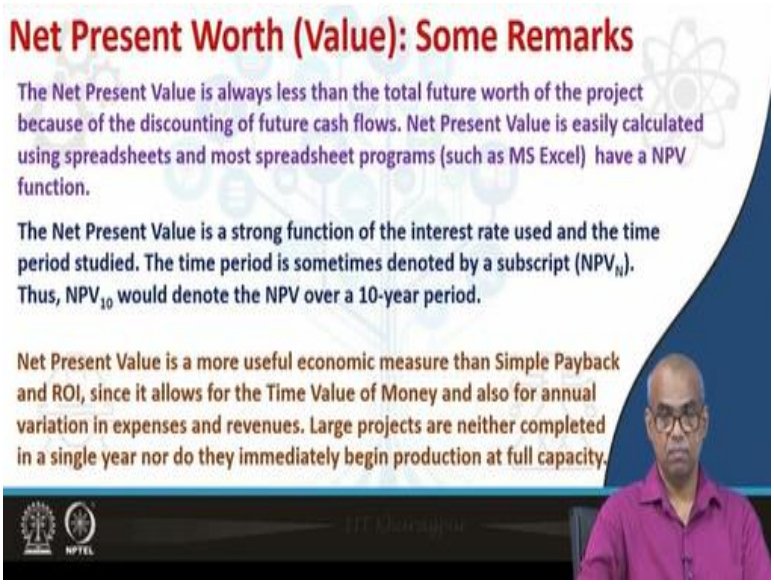

Now here are some remarks about the net present value, the net present value is less than the total future work of the project because of the discounting of future cash flows. Net present value is easily calculated using spreadsheets and most spreadsheet programs such as Microsoft

Excel have a NPV function. So you can make use of the NPV function of the Microsoft Excel and can compute net present value of a cash flow diagram.

Net present value the strong function of the interest rate and the time period studied the time period is sometimes denoted by a subscript N, so NPV subscript 10 would denote NPV over a period of 10 years. Net present value is a more useful economic measure than simple payback and return on investment. Since it allows for the time value of money and also for annual variation in expenses and revenues, this is important to take care of time value of money as well as variation in expenses and the revenues that may occur from one year to another.

Large projects are neither completed in a single year nor large projects immediately begin production at their full design capacity. So it is important to take care of time value of money as well as annual variations in expenses and revenues.

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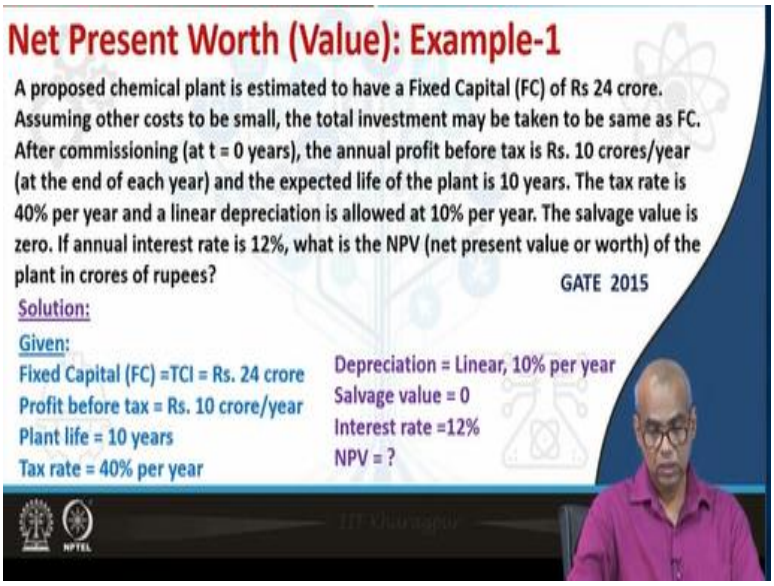

Now, let us take an example on net present value, a purposed chemical plant is estimated to have a fixed capital of rupees 24 crores. Assuming other cost to be small the total investment may be taken to be same as fixed capital. After commissioning at t=0 years, the annual profit before tax is rupees 10 crores per year at the end of each year and expected life of the plant is 10 years.

The tax rate is 40% per year under linear depreciation is allowed at 10% per year, the salvage value is 0. If annual interest rate is 12%, what is the NPV of the plant in crores. So let us first see what are the information that are given, fixed capital which is also same as the total investment for the plant is given as 24 crores rupees. Profit before tax is 10 crore per year. Plant life is given as 10 years; tax rate is 40% per year.

Depreciation is linear and charges that 10% per year. There is no salvage value, 0, interest rate is 12%; we have to compute NPV, net present value.

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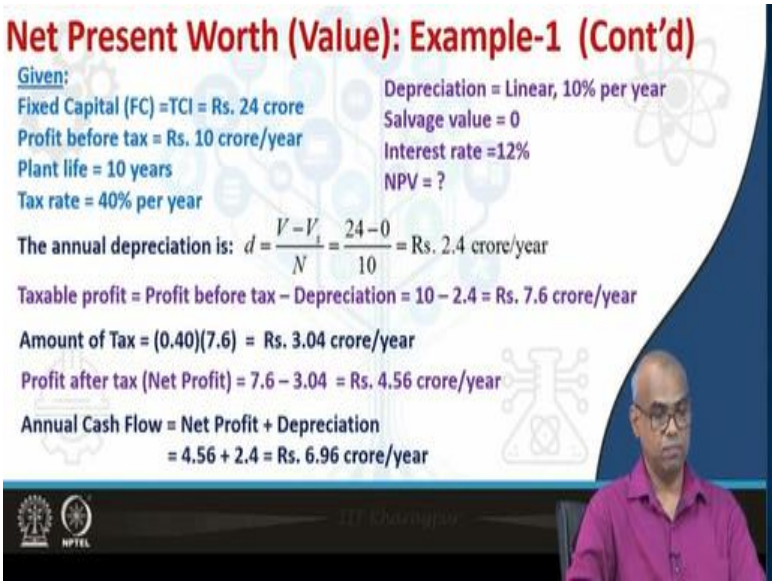

So first find the annual depreciation, which is V-Vs by N. So the fixed capital minus salvage value divided by plant life, so is computed as 2.4 crore per year. So what will be taxable profit? The taxable profit will be the profit before tax depreciation, so depreciation has to be subtracted that is the tax incentive. So 10-2.4 and you get as 7.6 crore per year. So now what will be the amount of tax? That will be 40% of 7.6, so you get 3.04 crore per year.

Profit after tax or net tax will be then 7.6- 3.04 the amount of tax that you have paid 3.04, which is rupees 4.56 crore per year. So now you get the annual cash flow, so annual cash flow will be the net profit plus you add the depreciation, we have discussed that depreciation is a cash inflow to the crore per year. So 4.56 + 2.4, which gives you 6.96 crore per year, so you have an annual cash flow of rupees 6.96 crores per year.

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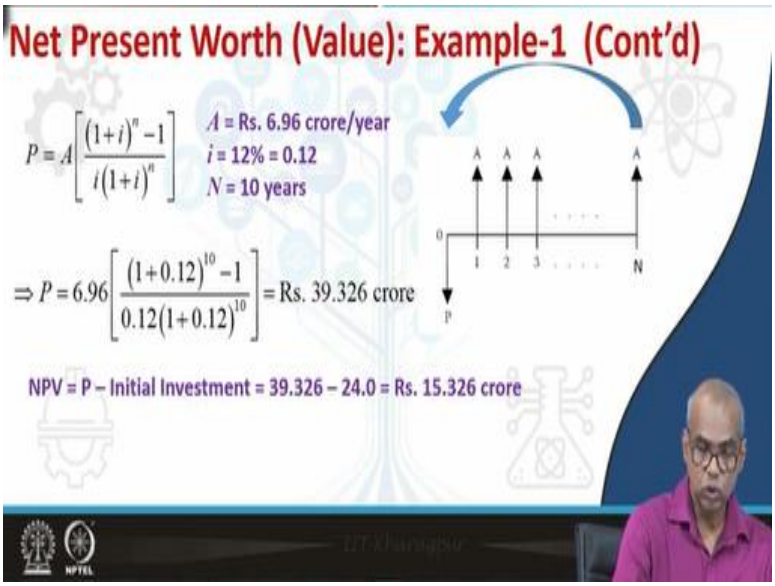

So now we have a situation where the cash flow diagram can be schematically represented like this. So you have an equal payment series for N=10 years and equal payments A is 6.96 crore every year, interest rate is 12% that is 0.12, so all these A's next to be converted to the present worth P. So for such uniform payment series, we know the formula, which relates P and A. So if you now substitute all this quantities, what you get P as 39.326 crores.

What will be the net present value? You have to substract this 39.326 crore from the initial investment must be substracted 39.326 crore, so 39.326 crore is the present worth of all A's, from there to subtract the initial investment of 24 crore. So the net present value is 15.326 crore.

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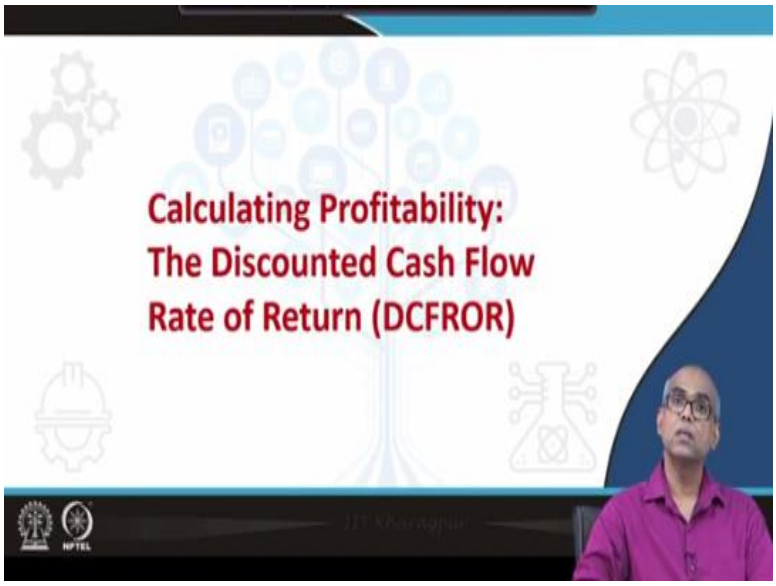

Next we will discuss another method of calculating profitability which takes into account the time value of money. This is known as the discounted cash flow rate of return.

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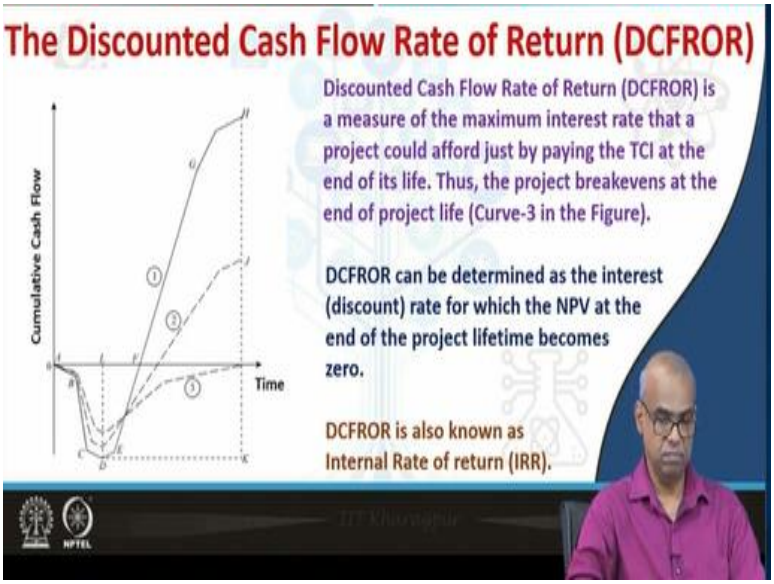

Again, look at the cash flow diagram look at the curve 3, so curve 3 represents a cash flow diagram corresponding to a rate of interest which makes the cumulative cash flow = 0 at the end of project life. Discounted cash flow rate of return is a measure of the maximum interest rate that a project could afford just by paying the total capital investment at the end of its life, thus the project break evens at the end of project life.

Note that, when this cumulative cash flow becomes 0, at the end of the project for curve 3 at

that point of time you payback the entire total capital investment. So that is the time where breakeven of the project happens. So you are basically paying back just the total capital investment at the end of the project. So the discounted cash flow rate of return determine as the interest rate for which the NPV at the end of the project lifetime becomes 0, the discounted cash flow rate of return is also known as internal rate of return.

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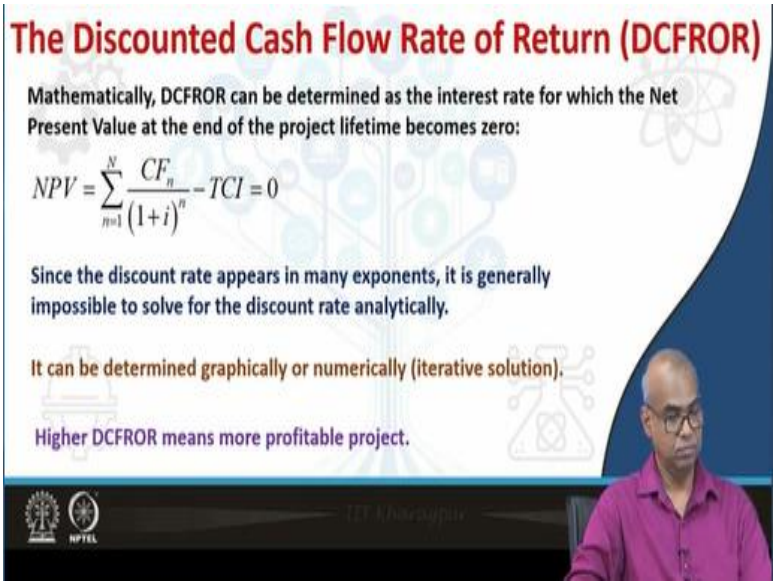

Mathematically the discounted cash flow rate of return can be determined by setting the expression NPV=0. Now if you look at this equation the discount rate appears in many exponents in the denominator is a highly non-linear equation, it is generally impossible to solve this equation analytically. So, usually, I have to solve it numerically or graphically. So when you solving it numerically an iterative procedure has to be adopted.

Now the higher discounted cash flow rate of return will mean more profitable project. So when you compare two alternatives, business proposals for investment and if you have to compare on the basis of discounted cash flow rate of return. You will choose that proposal which gives you higher discounted cash flow rate of return.

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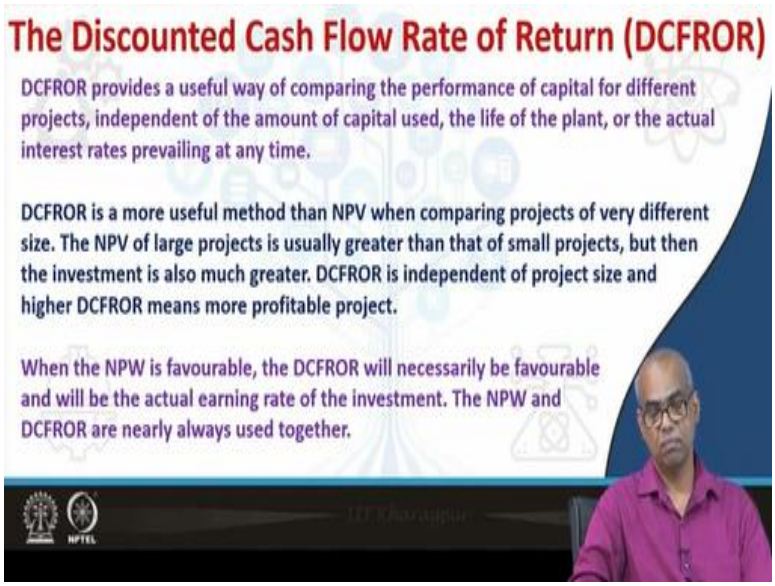

Here are some remarks about discounted cash flow rate of return, discounted cash flow rate of return provides a useful way of comparing the performance of capital for different projects independent of the amount of capital used, the life of the plan or the actual interest prevailing at any time. Discounted cash flow rate of return is more useful method than NPV when comparing projects of very different size.

The NPV of large projects is usually greater than that of small projects, but then the investment is also much greater. The discounted cash flow rate of return is independent of the project size and higher discounted cash flow rate of return means more profitable project. When the NPV is favorable, the discounted cash flow rate of return will necessarily be favourable and will be the actual earning rate of the investment.

Note that NPV is favourable when NPV is greater than 0 and the discounted cash flow rate of return is defined that which gives cumulative cash flow equal to 0. So NPV is favorable the discounted rate of return will definitely be favorable and this will be the actual earning rate of the investment the NPV and the discounted cash flow rate of return are nearly always used together.

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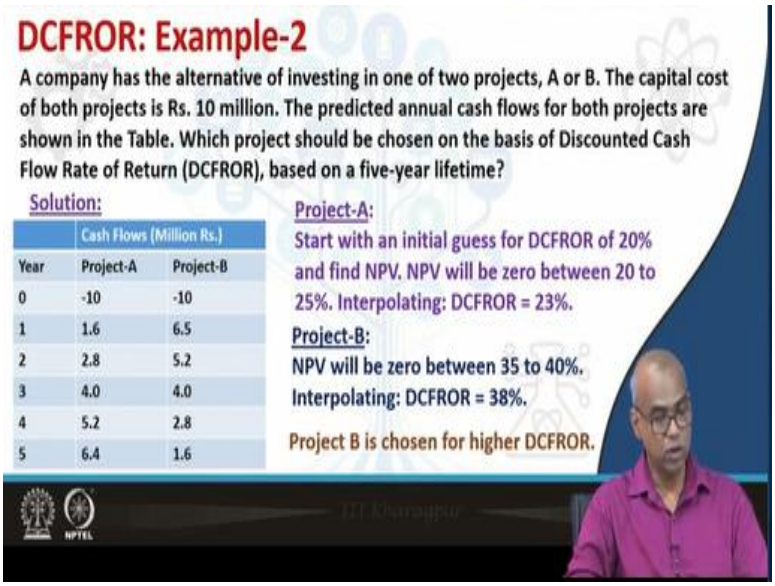

So now let us take an example, on this method, a company has the alternative of investing in one of two projects A or B, the capital cost of both projects is rupees 10 million. The predicted annual cash flows for both projects are shown in the table; which projects should be chosen on the basis of discounted cash flow rate of return, based on a 5 year life time. So you have a 5 year life for the plan for the project, both the projects are 5 year lifetime and the cash flows for the both the projects are given.

So, we will find out discounted cash flow rate of return for project A as well as project B and then we will choose the one which has higher value for discounted cash flow rate of return. Now, we will just discuss that the method we will require iterative solution. So, I will give you the outline of the method how to solve it. So, please complete it yourself. Let us start with project A; you start with an initial guess for the discounted cash flow rate of return.

So let us start with the guess value of 20% and find NPV, NPV will be 0 between 20% to 25% that you will see when you compute, note that as you increase interest rate, NPV value will decrease. So when you switch from positive value to negative value for two different interest rates, you know that the NPV will be 0 somewhere in between these two interest rates. So this will happen for project A within 20 to 25%.

So let us say by interpolating we consider the discounted cash flow rate of return as 23%.

Similarly you repeat for project B and you will see that NPV will be 0 between 35 to 40% and by interpolating we estimate the discounted cash flow rate of return is 38%. So 38% is greater than 23%, so project B is chosen for higher value of discounted cash flow rate of return.

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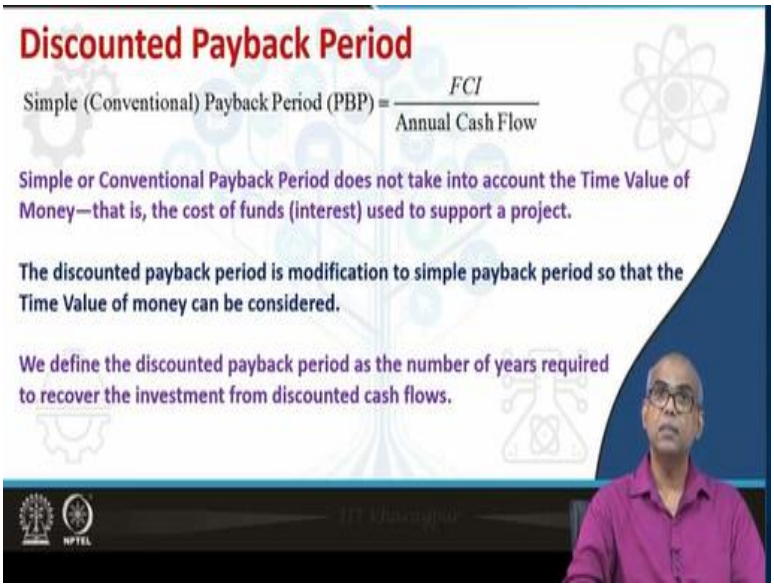

Now we have discussed simple payback period. Let us now discuss discounted payback period or discounted payback time. Now discounted payback time is a modification of the conventional simple payback time and this modification is done so that, the time value of money can be taken into account. The simple or conventional payback period is defined as fixed capital investment divided by annual cash flow.

Now simple or conventional payback period does not take into account the time below money that is the cost of funds or interest used to support a project. The discounted payback period is modification to simple payback period so that the time value of money can be considered. So we define the discounted payback year as the number of years required to recover the investment from discounted cash flows.

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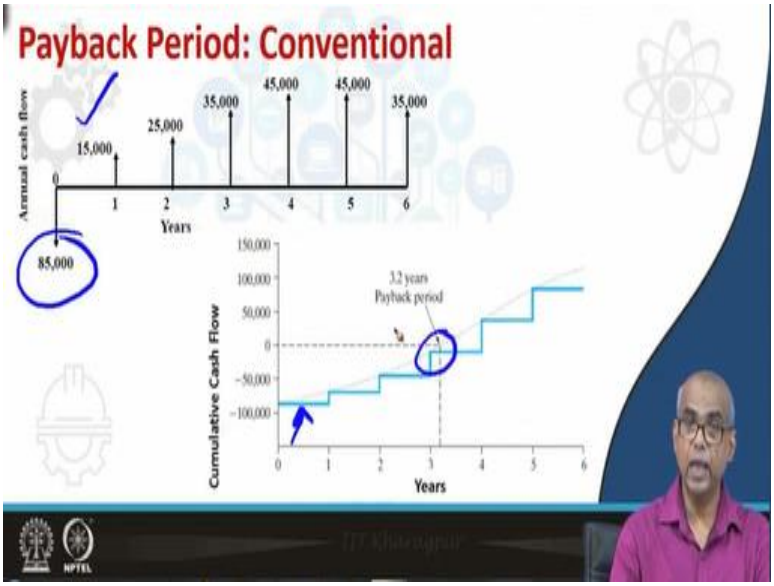

Now, we look at this figure let us consider this cash flow diagram. Now for this cash flow, we can find out the payback period by making a plot of cumulative cash flow against years, number of years and the payback here will be that year where the cumulative cash flow is 0, note that these stairs represents the cumulative cash positions. So initially, you have a cost of 85,000, so this is -85,000 cash flow and at the end of year 1 and you have 15,000 as positive cash flow.

So the cumulative position will be it -85,000+15,000, which is -70,000. So this is -70,000. So this way, you draw the cumulative cash flow corresponding to year, different years and then take the payback period where the cash flow becomes 0. So you get the payback period is 3.2 years. This is simple or conventional payback period.

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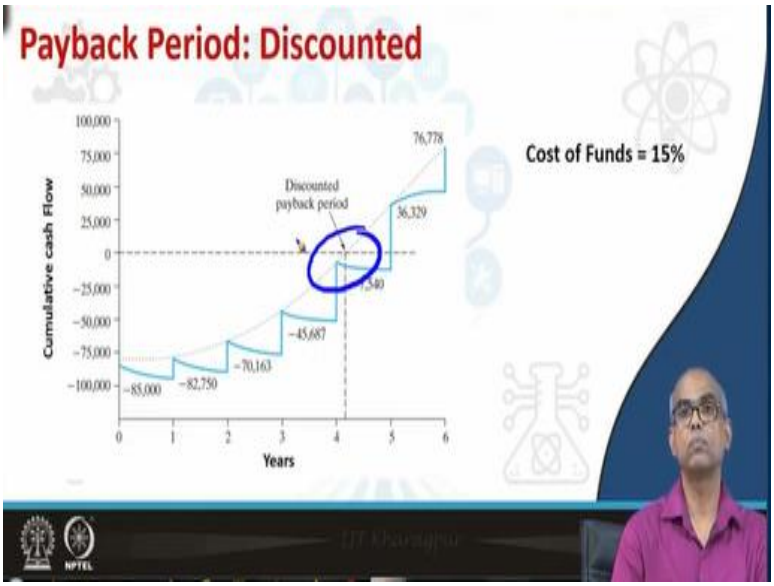

Now consider the discounted payback period, so you have to consider the cost of funds. So one rate of interest has to be considered, let us consider the cost of fund at 15%, so now the cash flows will be discounted. Again, you draw the cumulative cash flow against years and again the payback period is given as the years at which the cumulative cash flow is 0.

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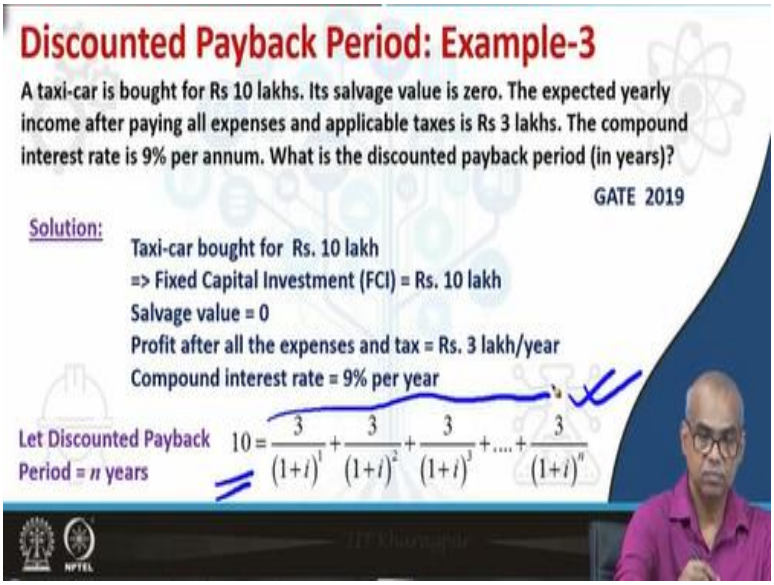

So, let us take an example on discounted payback period. A taxi car is bought for rupees 10 lakhs. It is salvage value is 0, the expected yearly income after paying all expenses and applicable taxes is rupees 3 lakhs, the component interest rate is 9% per annum. What is the discounted payback period in years? So taxi car bought for rupees 10 lakhs, the fixed capital investment there is rupees 10 lakhs, there is no salvage value.

Profit after all the expenses and taxes given as rupees 3 lakhs per year and the compound interest is given as 9% per year. So if we considered the discounted payback period is n years, then basically these 10 lakhs will be equal to sum of this series. So you have to find out for which value of n, this is sums up to 10 lakhs.

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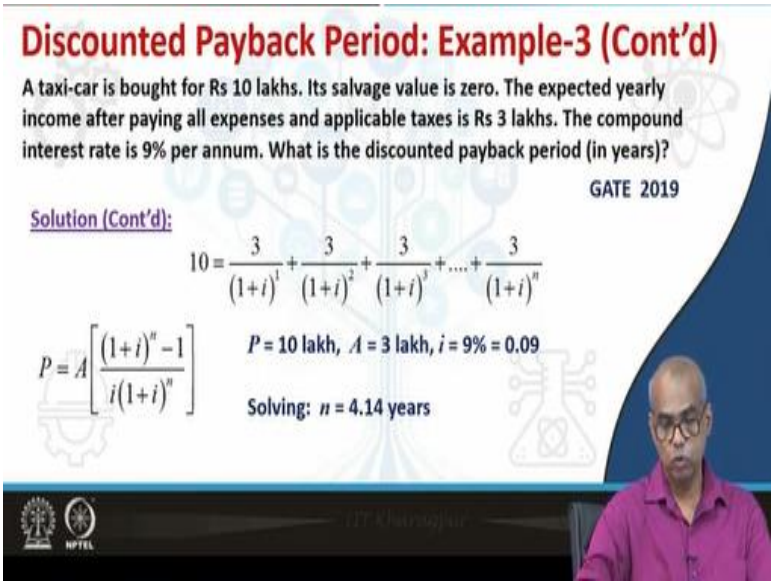

So now you know, this is an uniform payment series and the formula is note to you can make use of this and can find out n. So P is 10 lakhs here, A is 3 lakhs and the rate of interest i = 9% = 0.09%. So if you solve for n, it will be 4.14years. So with this we stop our discussion lecture 23 here.