Plant Design and Economics
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Lecture No -21
Cumulative Cash Flow and Profitability Standards

Welcome to module 5 of plant design and economics. In this module we will talk about engineering economics part 3. Engineering economics part 1 and engineering economics part 2 we have discussed about, total capital cost, fixed cost and then various interest rates. Now, in this module we will make use of those tools to perform economic evaluation of projects or economic evaluations of plants.

Now when you decide to build and construct. To build and operate a chemical plant. You also commit supplier funds. So such a decision has to be based on proper economic evaluation of your business proposals. In other words if the business proposals are not profitable you do not accept as proposals and invest your resources. So you need to know various tools to perform such economic evaluations.

So those are the tools we will be learning in this module. Also there will always be alternate uses of your resources. So you will also learn alternate use of resources during this module.

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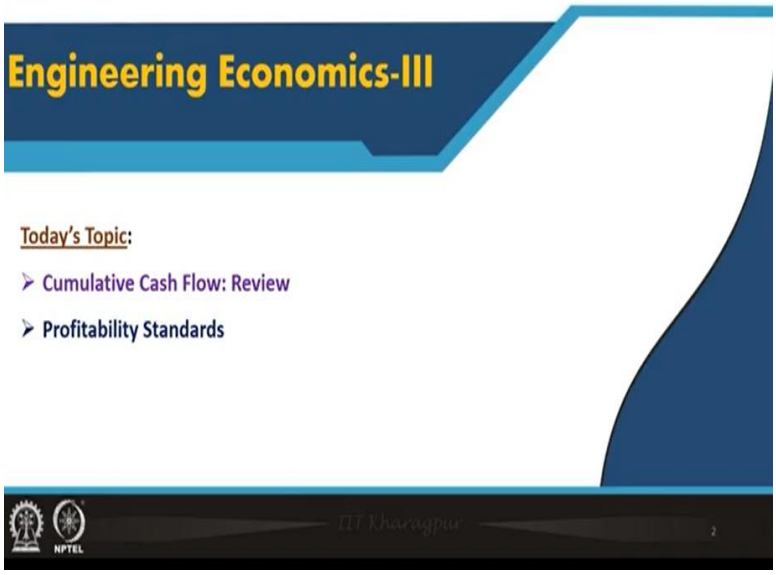

So today we will start with cumulative cash flow. We are briefly talked about it earlier, we will again review this. And we will also talk about profitability standards.

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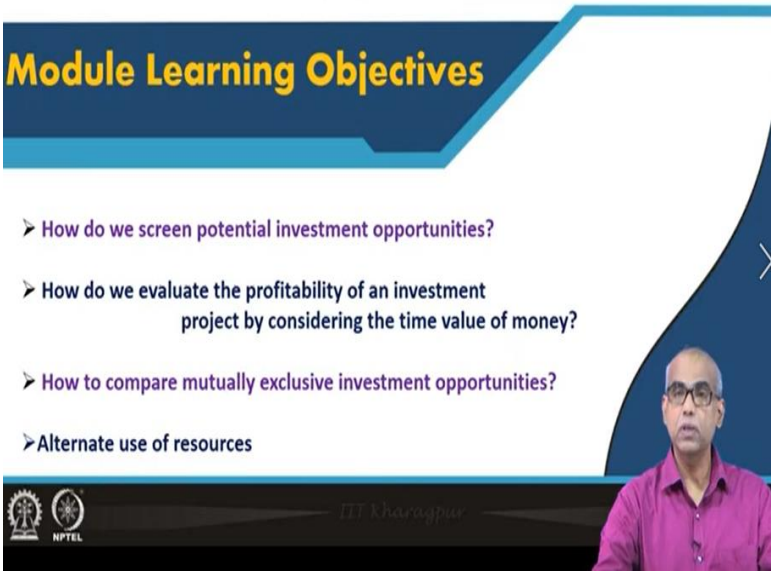

So these are the learning objectives for this module. So after this module you will be able to answer the following questions. How do you screen potential investment opportunities? How do we evaluate the profitability of an investment project by considering the time value of money? How to compare mutually exclusive investment opportunities? And what about alternate use of resources?

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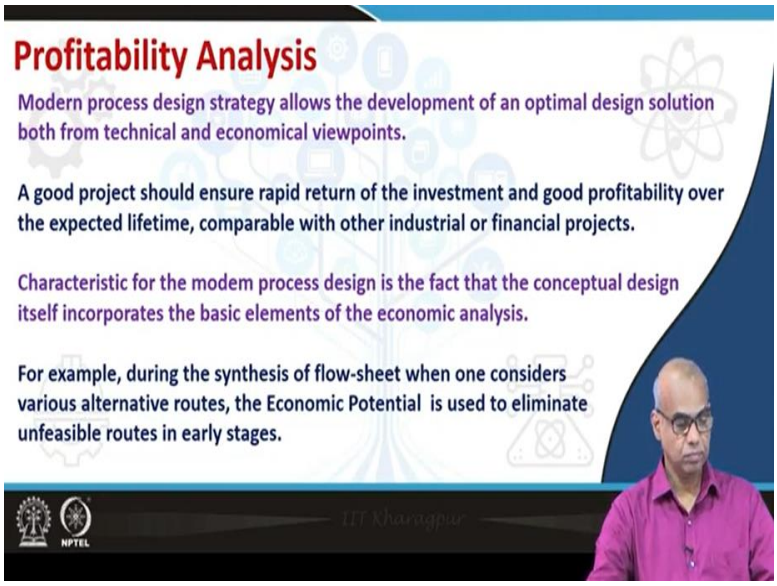

So what do you understand by profitability analysis? Modern process design strategy allows the development of an optimal design solution both from technical and economical viewpoints. A good project should ensure rapid return of the investment and good profitability over the expected lifetime, comparable with other industrial or financial projects. Characteristic of the modern process design is the fact that the conceptual design itself incorporates the basic elements of the economic analysis.

For example during the synthesis of flow-sheet when you consider various alternative routes, the Economic potential can be used to eliminate unfeasible routes in the early stages. So during the synthesis of flow-sheets you come up with various alternatives routes for a particular stage or particular process. At this stage itself you keep in mind the economic potential of such routes so that you can eliminate the unfeasible routes as soon as possible.

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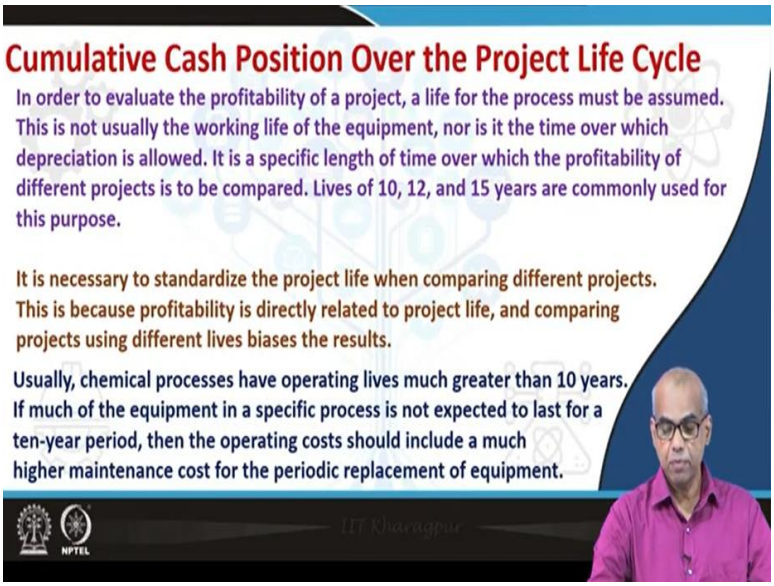

Now we will briefly review the cash flow diagrams or in particular cumulative cash flow diagrams. In order to evaluate the profitability of a project a life for the process must be assumed. Let us say shall we consider 10 years as life of my chemical plant. This is not usually the working life of the equipment or the plant. Nor is it the time over which depreciation is allowed.

In our previous module we have talked about depreciation and recovery period. So by the time we are not mentioning that recovery period here. It is a specific length of time over which the profitability of different projects is to be compared. Typically 10 years, 12 years or 15 years are commonly used for such profitability analysis of different projects. It is necessary to standardize the project life when comparing different projects.

This is because profitability is directly related to the project life. And comparing projects using different lives will bias the results of your analysis, so it is important that is standardize the project life when you compare different projects. Usually chemical processes have operating lives much than 10 years. If much of the equipment in a specific project is not expected to last for 10 year period, then the operating costs should include a much higher maintenance cost for the periodic replacement of the equipment.

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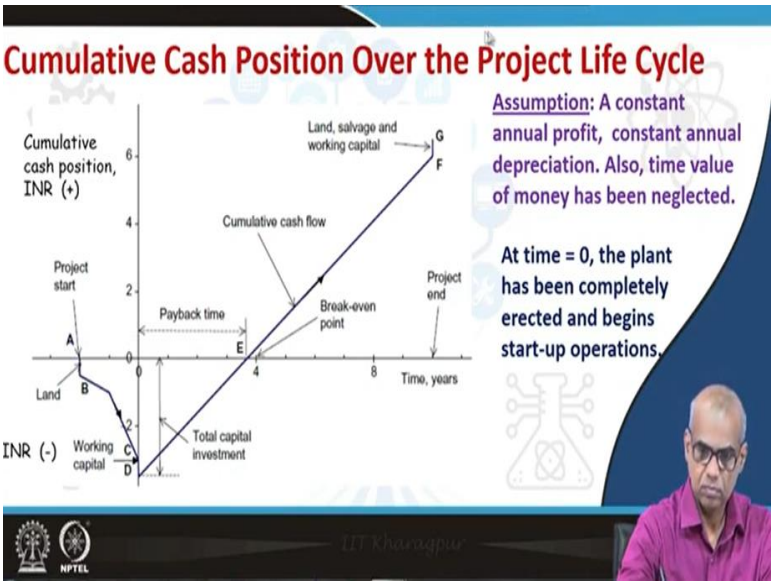

Now what is now see is the cumulative cash flow diagram of a new project. On the horizontal axis we write years, around the vertical axis we put cumulative cash position. Note that the cumulative cash position takes both positive value as well as negative value. Now the project starts at the point A. And goes to different stages from A to B, B to C, C to D then E then finally ends at F. So this is the life of the project.

And against the life of the project what you are plotting on vertical axis is the cumulative cash position of the plant. Now there are certain assumptions that goes when developing this cumulative cash flow diagram. For example, we have assumed the constant annual profit, a constant annual depreciation also the time value of money has been neglected in this particular diagram.

Note that this is time 0 and this is the time when project starts. So time 0 represents the time when the plant has been completely erected and it begins startup operations. So, this is the period over which you buy land, you put your capital investment, fixed capital investment as well as working capital investment. You do the startup operation and time 0 point size with the time at which the operations start and the plant sells the products and revenue is earned.

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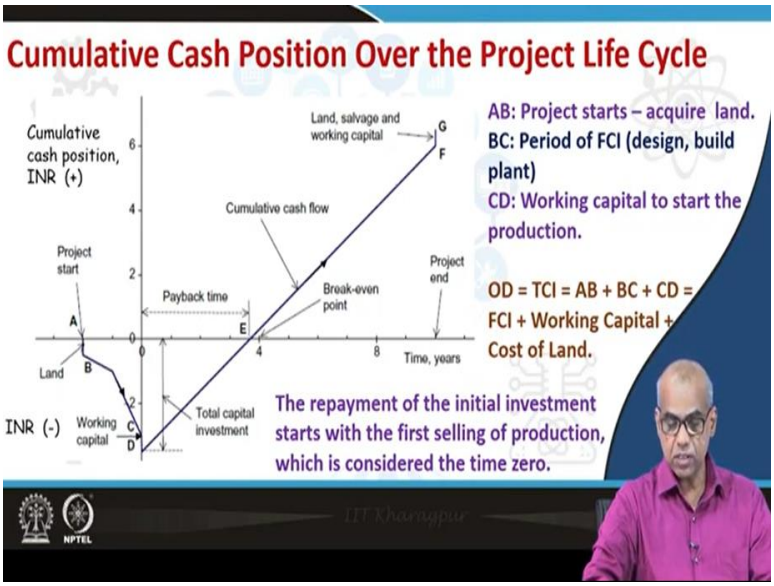

So once again the project starts at point A with the purchase of the land. So you acquired land for the project and the project starts with the purchase of the land. Then from point B to point C represents the period over which you have invested your fixed capital. So this fixed capital goes for the design of the plant as well as construction and building of the plant.

Now, you see the rates are different. The rate at which you spend money is different. Initially it is less because design phase and then when you start building the plant there will be heavy flow of cash. So you rapidly invest money to your business venture. Now when you come to point C you have constructed the plant. Now you need money as working capital to start the production. So CD represents the working capital to start the production.

So the total capital investment will be the fixed capital investment, working capital + the cost of land. So, this entire cost is total capital investment. Now at point D your operation starts, point D corresponds to time t = 0. So your operation starts, products are sold in the market and the company starts earning revenue. So the repayment of the initial investment starts. It will start with the first selling of production.

And this happens at time t = 0 corresponds to the time when your plant has started its operation it is earning revenue and repayment of the initial investment has started at the same time.

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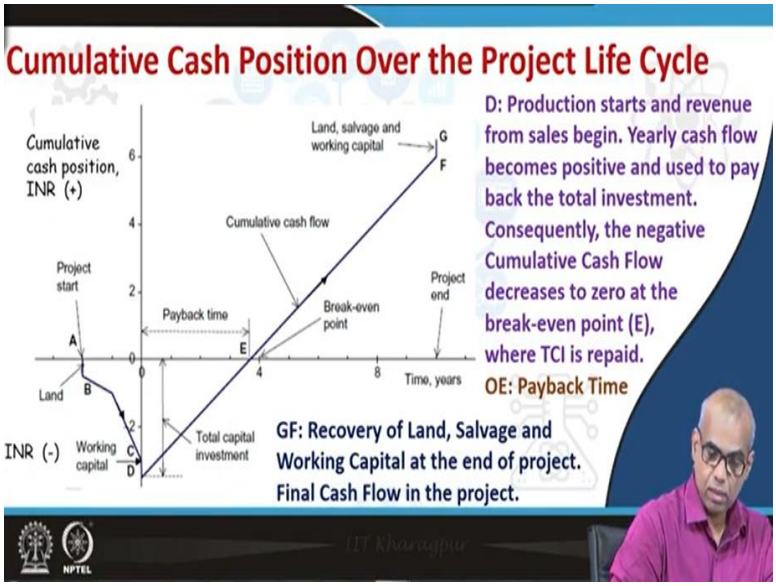

Now upto point D, you had a negative cash flow. Because you were only investing capital to your business, you have not started earning revenue. Now after point D or starting with point D production starts and revenue from sales begin. So yearly cash flow becomes positive and this is used to pay back the total investment. So now after point D your yearly cash flow has become positive.

Note that the slope has changed but the cumulative cash flow is still negative. But as time progresses, you earn more and more revenue and the negative cumulative cash flow decreases. And when you come at time represented by E there will no more be any negative cumulative cash flow. The cumulative cash position will be exactly 0. This is the point where you have completely repaid the total capital investment.

So point E represents the break-even point. So point E represents the break-even point at which you have completely repaid the total capital investment. So the time over which it is done namely OE is known as payback time. Now beyond time represented by point E that means when you have crossed the breakeven point you start making profit. So here you are making profit.

When you come to time corresponding to point A your project ends. At the end of the project, you will recover your invested working capital so you will completely empty your inventories,

you will collect all receivables and thereby you will recover your working capital, you will get the salvage if any and also you will recover the land. The land can be used whatever way you want, maybe for another business venture.

So GF will correspond to the final cash flow to the project which comes in the shape of recovery of land, salvage and working capital. With this the life or the entire life of this particular plant ends. So what is the profit that you made? You made the profit represented by this and what was your investment? This was your total capital investment.

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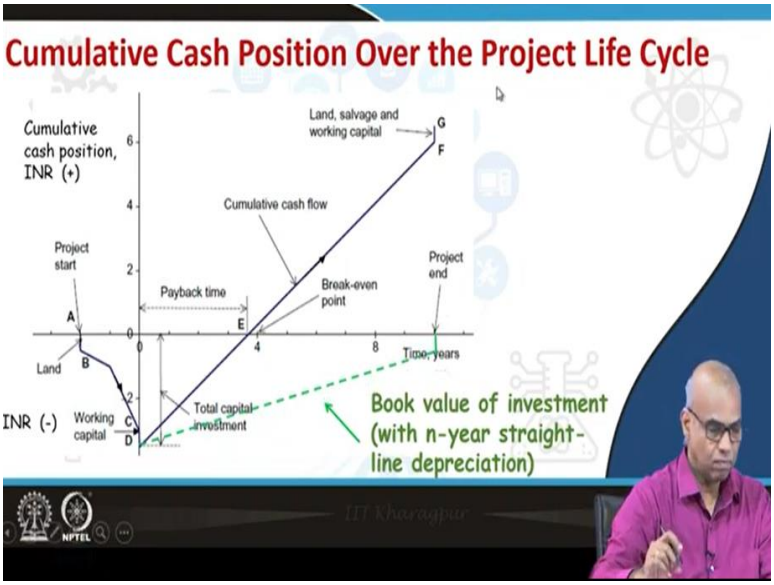

Now in this figure using the dotted green line we represent the book value of investment with n-years-straight-line depreciation. Note that this salvage value is subtracted at the end of the project life and then you consider a straight line depreciation. So this line represents the book value of investment.

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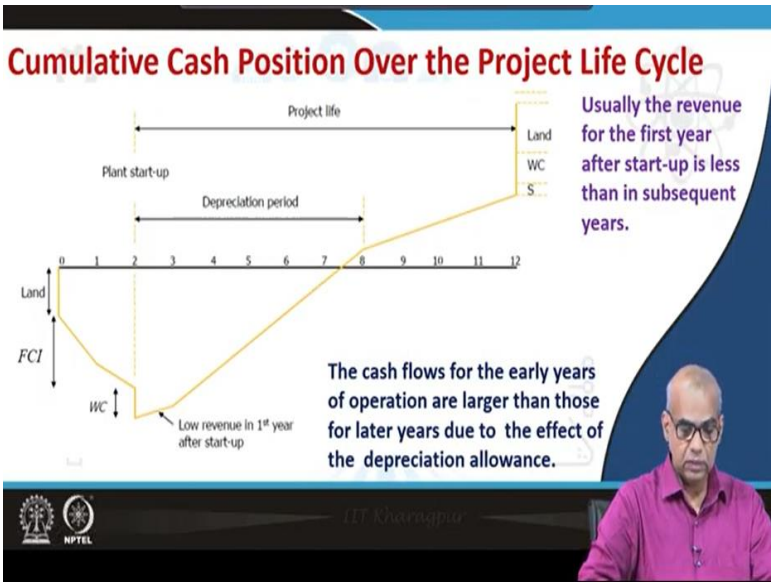

Now this is a slight variation of the cumulative cash flow diagram that you have seen in the earlier slides. What are the differences? Note in this part, so do you see any difference? Usually the revenue for the first year after startup is less than in subsequent years. So you see that there is a difference in the slope. This is because immediately after start up, your project or plant will not will not operate at its maximum design capacity.

It may take at least one year from the start up to run at its full design capacity. So usually the revenue for the first year after startup is less than subsequent years, so that is what is shown by different slope there. There is one more point, in our previous module when you talked about depreciation we have discussed that once the capital investment is recovered that means when you have charged completely the depreciable amount there will not be any more tax benefit due to depreciation.

So this at this time you have completely recovered the capital investment that means depreciation stops here. And that is why you see another change in the slope of the cumulative cash position. Also the time 0 is indicated differently in this diagram, but here these are the two points which we wanted to make clear. So the cash flows for the early years of operation are larger than those for later years due to the effect of depreciation allowance.

So beyond this point you no more get any tax benefit or allowance due to depreciation, because

you have completely recovered the depreciable capital investment. So the cash flow now decreases beyond the depreciation period.

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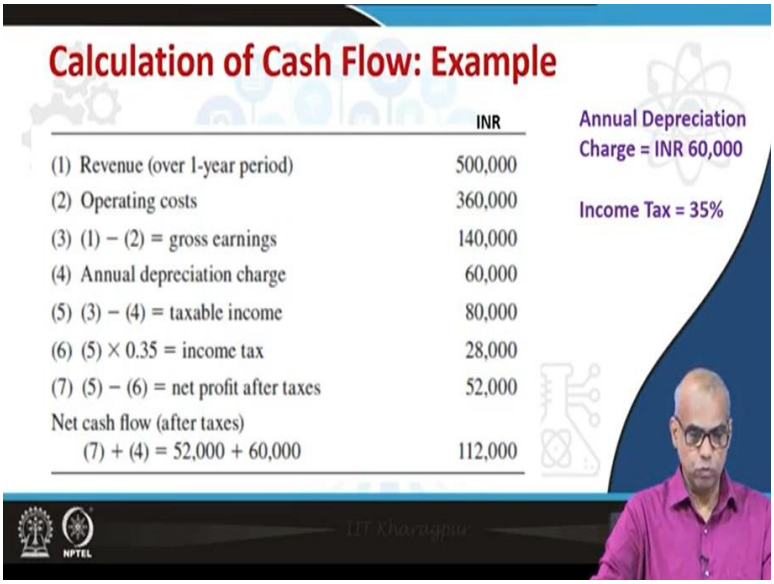

So this is a small example which shows the calculation of cash flow. All the figure represents the time period for 1 year. So revenue over 1 year period is rupees 5,00,000, Operating cost is 3,60,000 rupees, so what is the gross earning gross earning is revenue from sales minus operating cost so difference between these two which is 1,40,000. Now let us consider the annual depreciation charge is fixed at 60,000 rupees. So the annual depreciation is 60,000.

So what is the taxable income? Taxable income is you have to subtract the depreciation from the gross earning. So you subtract 60,000 rupees from 1,40,000 and you get 80,000. So, this is the taxable income. Let us consider income tax is 35%. So the amount of income tax that the company will pay is 35% of 80,000 rupees which is 28,000 rupees. So, what is the net profit after income tax?

Net profit income tax is taxable income minus income tax. So 80,000 rupees minus 28,000 rupees is 52,000 rupees. So 52,000 rupees is net profit after tax and what will be the net cash flow? Net cash flow will be the net profit after tax + the depreciation. We have learnt that the depreciation goes to the corporate residue. So 52,000 + 60,000 which is 1,12,000.

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Now we will talk about profitability standards. Now when you measure profitability I have to evaluate the profitability against some known standards. So I have to fix certain standards. So what are my standards for profitability? Profit is the goal of any investment. Any anticipated profit from an investment must be judged related to some profitability standard. A profitability standard is a quantitative measure of profit with respect to the investment required to generate that profit.

The profit must be judged relative to the investment, what you see in the table is two investment options A and B. The required capital investment for option A is 1,00,000 rupees and that B is 10,00,000 rupees. The profit per year for option A is 10,000 rupees and profit per year for option B is 30,000 rupees. While profit for option B in absolute terms is higher it is 30,000 rupees, but what about return on investment?

Note that we are getting 10,000 rupees per year on an investment of 1,00,000 rupees for option A which gives me a return on investment as 10% while a profit of 30,000 rupees per year on an investment of 10 lakh rupees for option B gives only 3% return on investment. So the profit must be just relative to the investment. For any investment to be profitable, the investor whether it is corporate sector or whether it is individual we expect to receive more money than the amount of capital invested.

A fair rate of return or return on investment must be realizable. Otherwise there will not be any motivation for investment. Whenever we invest we expect that we must get more than the amount we invest. So fair rate of return or return on investment must be achieved.

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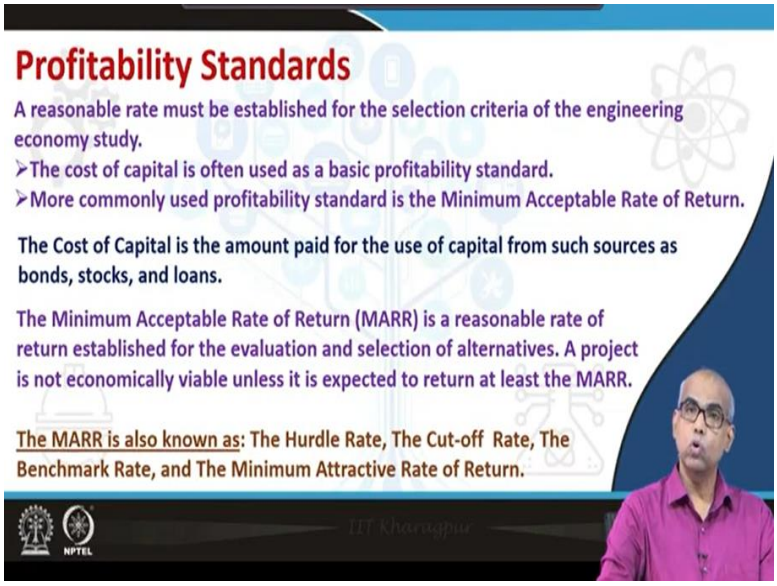

A reasonable rate must be established for the selection criteria of the engineering economic study. So that is profitability standard, so to evaluate profitability standard we must established certain reasonable rate as standards and against which will perform the economic evaluation of a given business proposal. Generally two types of profitability standards can be used more commonly.

The cost of capital is often used as a basic profitability standard. Second which is more common and generally used is the Minimum Acceptable Rate of Return. So two types of profitability standards are cost of capital, second is minimum acceptable rate of return. Minimum acceptable rate of return is more commonly used profitability standard. The cost of capital is the amount paid for the use of capital from such sources as bonds, shares or stocks, loans, etc.

The minimum acceptable rate of return is a reasonable rate of return established for the evaluation and selection of alternative. A project is not economically viable unless it is expected to return, at least the minimum acceptable rate of return. The minimum acceptable return is also

known by the Hurdle Rate, the Cut-off Rate, the Benchmark Rate, and the Minimum Attractive Rate of Return so all these are synonymous.

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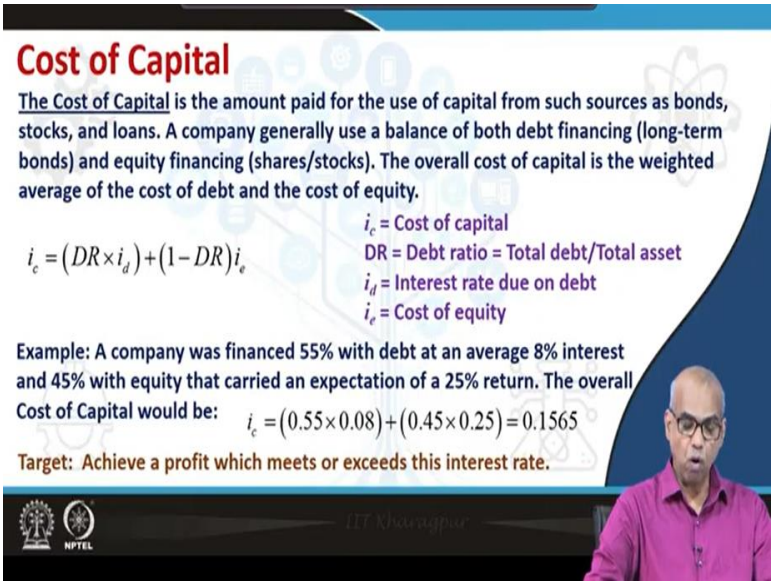

The cost of capital; The cost of capital is the amount paid for the use of capital from such sources as bonds, shares or stocks and loans. So a company raise funds from such sources, they issue bonds, they issue shares and receipt or accumulate money from general public. Company can also take loans from the lenders. Now company generally use a balance of both debt financing and equity financing.

Debt financing are long term bonds and equity financing are the resources that comes from share or stocks. So company generally use a balance of both debt financing as well as equity financing. Company generally does not take only debt financing or generally does not consider only equity financing. So a company is generally financed a certain percentage using debt financing and the remaining using equity financing.

The overall cost of capital is the weighted average of the cost of debt and the cost of equity. So that exactly mean is as follows. If DR represents the debt ratio that means the total debt of the company divided by total asset of the company. So debt ratio is total debt of the company divided by total asset of the company. Now if id represents interest rate due to debt and ie

represents cost of equity.

Then the cost of capital will be an weighted average of these two cost interest rate due to debt and the cost of equity. So DR times id+ 1- DR the remaining part times the cost of equity. So this gives the cost of capital. For example say a company was financed 55% with debt at an average 8% interest and 45% with equity that carried an expectation of a 25% return. The overall cost of the capital will be 0.55 into 0.08 + 1 - 0.55, which is 0.45 times 0.25. So, that will be 0.1565 or 15.65%.

So the company must target to achieve a profit, which will meet or preferably exceed the interest rate of 15.65%.

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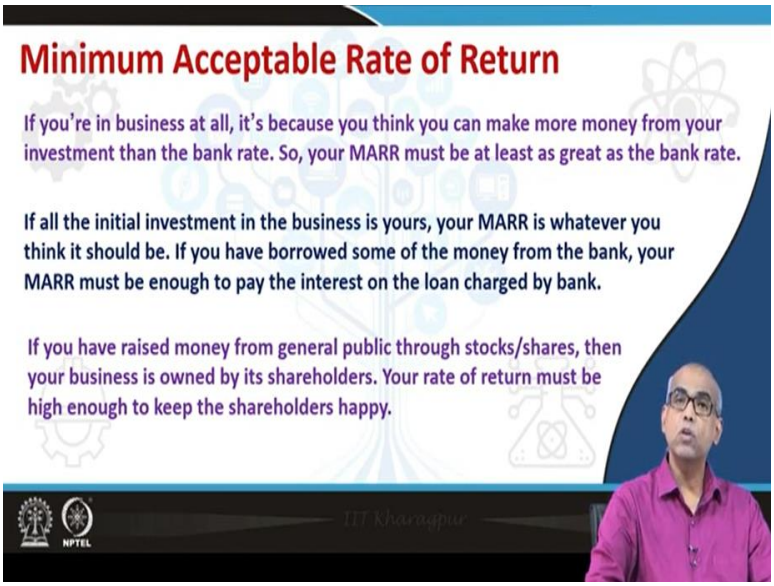

Now, what is minimum acceptable rate of return? If you are in business at all it is because you think you can make more money from investment than the bank rate. So your minimum acceptable rate of return must be at least as great as the bank rate. If all the initial investment in the business is yours, your minimum acceptable rate of return is whatever you think it should be. But if you have borrowed some of the money from the bank your minimum acceptable rate of return must be enough to pay the interest on the loan charged by the bank.

Also, if you have raised money from general public by release of stocks or shares, then your

business is owned partly by its shareholders. So your rate of return must be high enough to keep your shareholders happy.

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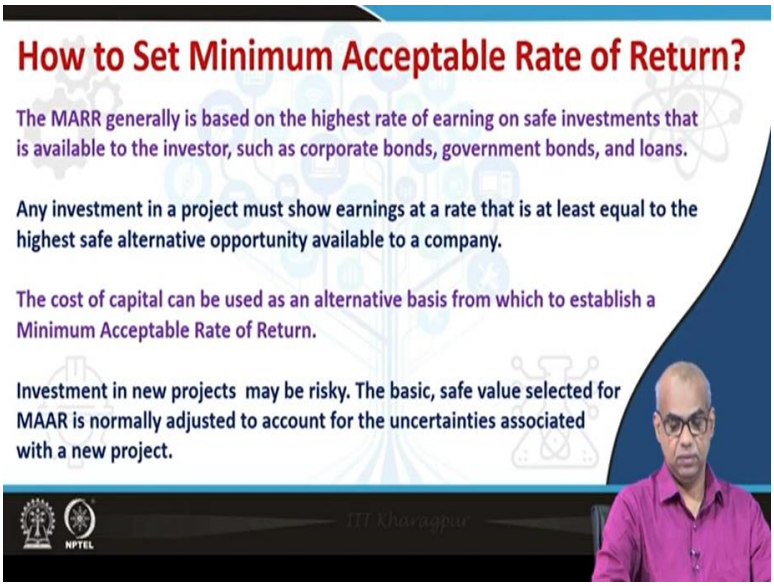

How do you set minimum acceptable rate of return? The minimum acceptable rate of return is generally based on the highest rate of earning on safe investment, that is available to the investor. For example corporate bonds, government bonds and loans. So your business plan must return more than such safe investment options available as corporate bonds, government bonds, etc. Any investment in a project must show earnings at a rate that is at least equal to the highest safe alternative opportunity available to a company.

Otherwise why should company go and invest in your business proposal. The cost of capital can be used as an attractive base as an alternative basis from which to establish a minimum acceptable rate of return. Investment in new projects may be risky. The basic safe value selected for minimum acceptable rate of return is normally adjusted to account for the uncertainties associated with new project.

So the basic safe value selected for the minimum acceptable rate of return has to be adjusted to account for the uncertainties that exist in new project.

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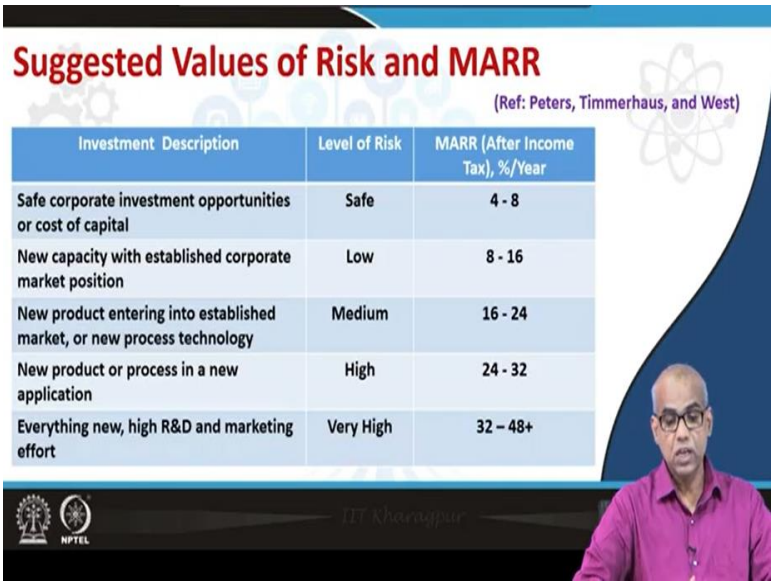

So here a table is presented which shows suggested values of risk and corresponding minimum acceptable rate of return. So the absence of any other guidance this table can be used to understand the level of risk and pick up a minimum acceptable rate of return against which you will perform the economic evaluation of your business proposal. See level of risk is safe for safe corporate investment opportunities, or cost of capital.

Your minimum acceptable return may be in the range of 4 to 8%. When risk is low the minimum acceptable rate of return may be in the range of 8 to 6% per year. For medium risk the minimum acceptable rate of return will be in the range of 16 to 24% per year. For high level of risk the minimum acceptable rate of return may lie between 24 to 32% and when the level of risk is very high the minimum acceptable rate of return has to be set as high as 32 to 48 or plus percent.

And these are the investment descriptions which has corresponding level of risk. So what you notice is that as the risk increases. For example, when you have a proposal where everything is new which costs very high research and development and marketing effort. The level of risk associated with the proposal is very-very high. So definitely your acceptable rate of return has to be very attractive.

That is why the minimum acceptable rate of return increases as the risk increases in your business proposal. So to evaluate economically a project you can pick up or select a minimum

acceptable rate of return and then perform the economic evaluation of the project and that project will be profitable only when it returns at least with the rate which is equal to minimum acceptable rate of return.

So to do that you must know the methods which we will be using to perform economic evaluation. So in the next class we will learn about those methods. With this we stop our discussion on lecture 21 here.