MINERAL ECONOMICS AND BUSINESS

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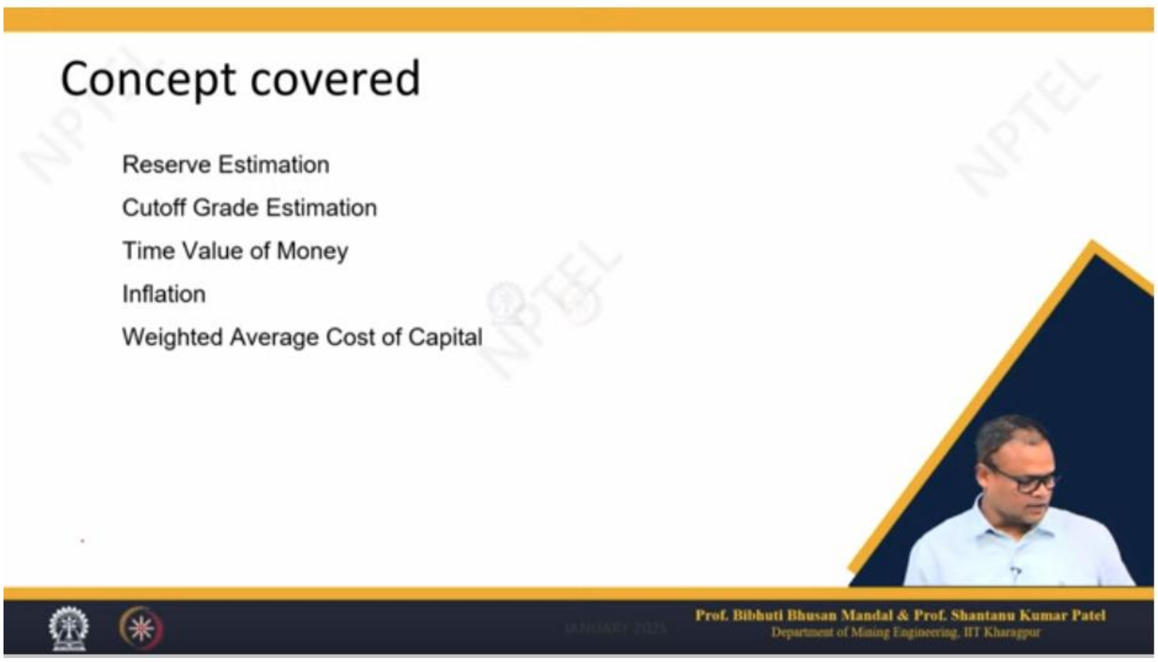
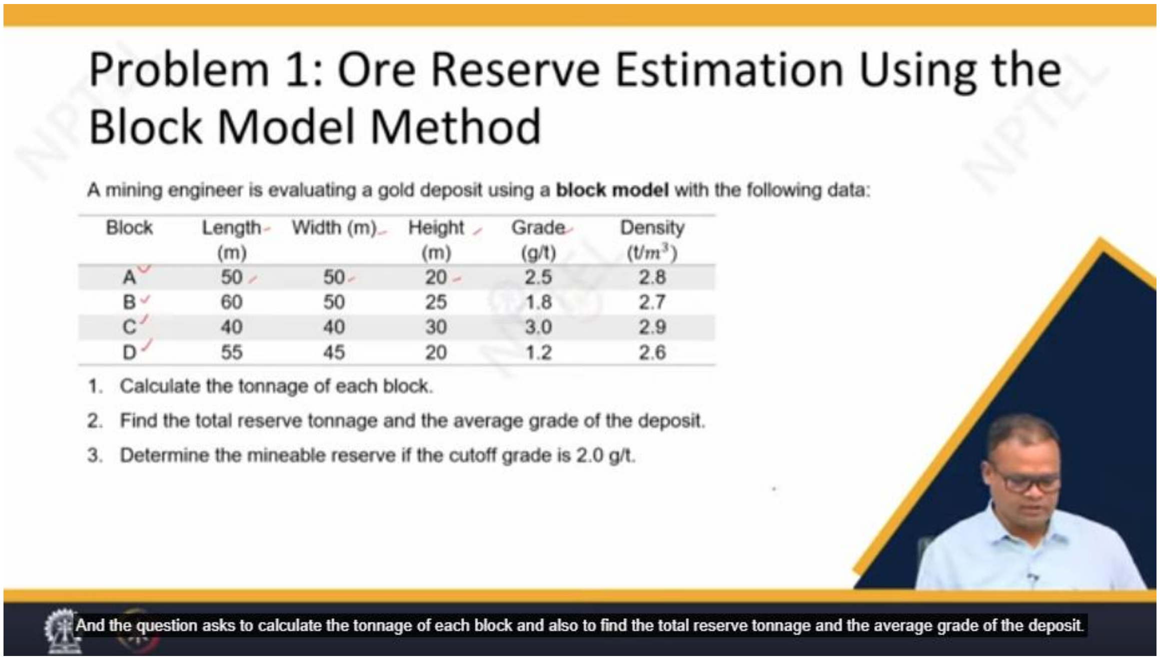
Lecture 56: Problem-Solving

Hello everyone, and welcome again to this course on Mineral Economics and Business. So, this is our lecture number 56, where we are going to, you know, solve some problems

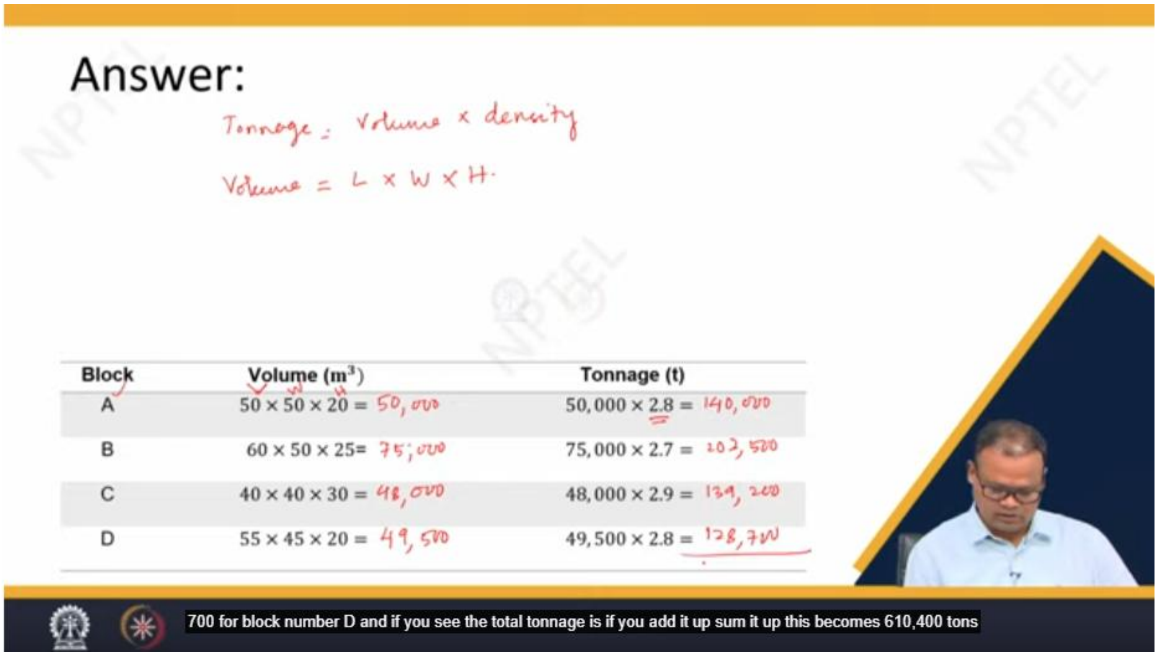
Lecture 56 : Problems Solving



related to the concepts that we have learned till now. So, the concepts are reserve estimation, cut-off grade estimation, time value of money, inflation, and weighted average cost of capital.

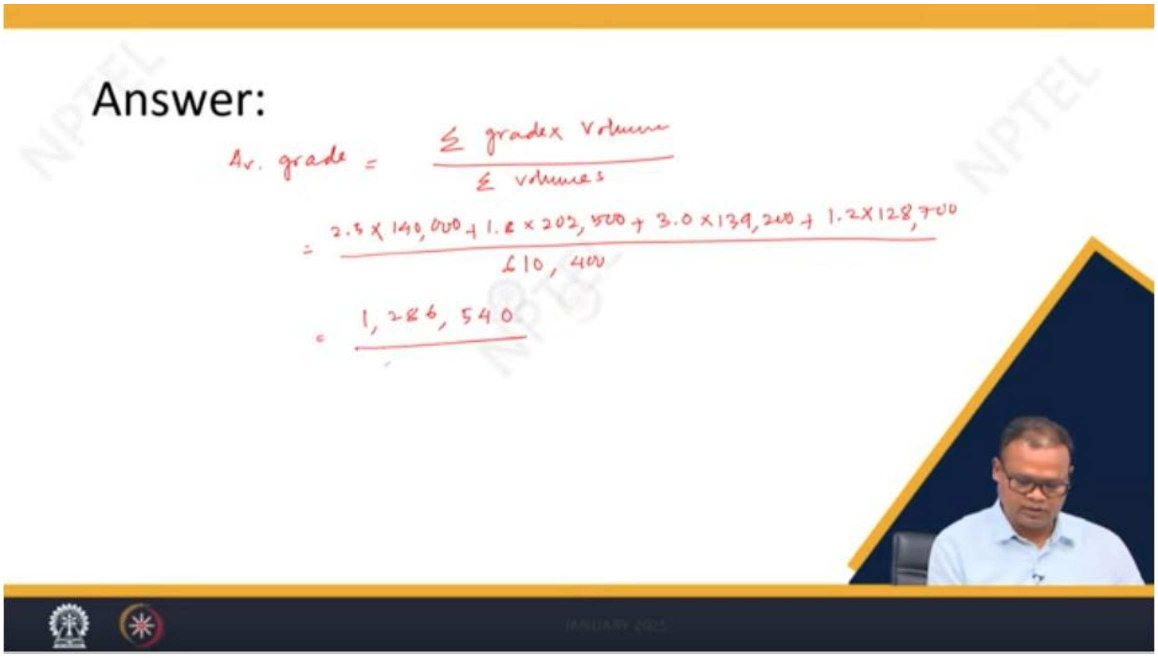


In the first, you know, example that we have here is related to over reservoir estimation using the block model method. So, here, a mining engineer is evaluating a gold deposit using a block model with the following data. So, what we have in this table here is we have 4 blocks: A, B, C, and D, and here the length, width, and the height of each block is given. For example, in the first case, the length is 50 meters, the width is 50 meters, and the height is 20 meters. The corresponding grade for that block is given, which is in grams per ton, is 2.5 for block A. The average density of that block is 2.8. Similarly, it is given for B, C, and D. Ah. And the question asks to calculate the tonnage of each block and also to find the total reserve tonnage and the average grade of the deposit. And the third part of this problem says, in order to mine the mineable reserve, if the cut-off grade is 2.0.



So, for this, the equation for the tonnage is volume into density, and this volume is length into width into height. So, if we see the 4 blocks, you know, the first block has a length of 50, a width of 50, and a height of 20. So, if you multiply this, it becomes meter cube here and now the corresponding tonnage is if you multiply with the density. So, this 2.8 is the density here. So, this becomes your 140,000 tons. Similarly, for this the block B it is 75,000 meter cube. and block C it is 48000 meter cube if you multiply the height width and length.

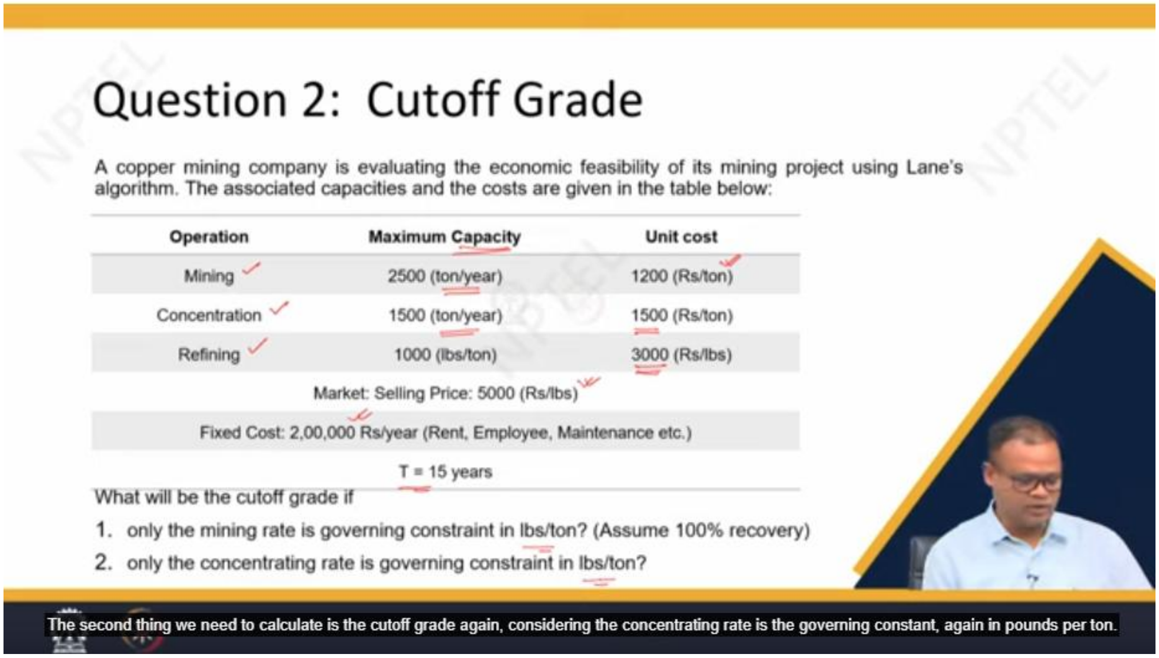
So, in the for block D it is 49500 meter cube. the corresponding the tonnage are 2 0 2 500 for block B it is 139 200 for block C and it is 128 700 for block number D and if you see the total tonnage is if you add it up sum it up this becomes 610,400 tons.



Now, if you want to calculate the average grade here, the average grade equation is average grade is summation of grade into volume of each block. So, you sum it up divide by sum of the volumes.

So, and this becomes you know if you add it up the first one is 2.5 into the volume is plus 1.8 into 200 to 500 plus this is 3.0 is the grade for the block C into your 139 200 plus 1.2 into 128 700 divided by total volume that we have been calculating which is 610 and 400 here. So, if you calculate this you know this becomes 1, 2, 8, 6, 5, 4, 0 divided So, this is 2.11 gram per ton.

So, the last part of this problem is to get the maneuver reserve. So, for that, with a cutoff grade of 2 grams per ton. The cutoff grade is equal to 2 grams per ton. So, in this case, blocks A and C have a cutoff rate which is above 2.0 grams per ton. So, the mineable reserve for this case is equal to 140 thousand for block A plus 139,200 for block B. So, this becomes 279,200.



Now, moving to our next problem, which is about the cutoff grade calculation, and the question says the copper mining company is evaluating the economic feasibility of its mining project using the Lenz algorithm that we have studied before. The associated capacities and costs are given in the table below. So, as we know, we have basically three capacities and costs involved: first is the mining cost, second is the concentration cost, and third is the refining cost. So, we have the maximum capacity of mining per year, which is in tons per year. Similarly, for concentration, we have 1500 tons here, and for refining, it is, let us say, 1000 lb per ton.

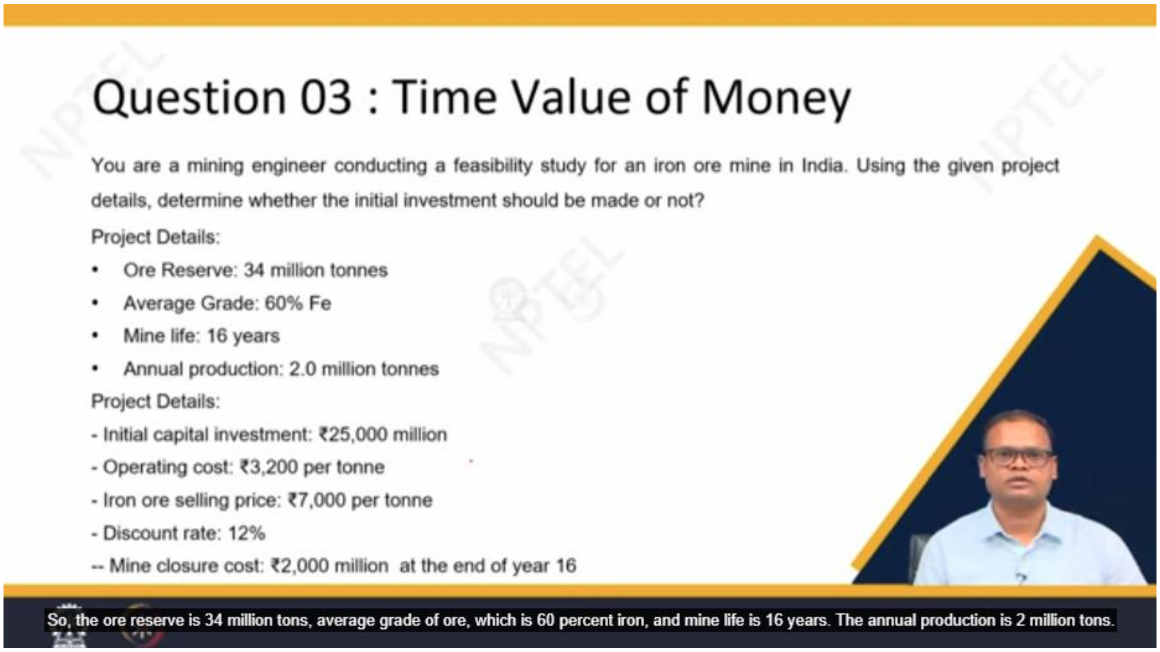
So, to do 1 ton of mining, we need 1200 rupees. To concentrate 1 ton of the ore, we need 1500. Similarly, to produce 1 lb of the final product, we need 3000 rupees here. So, you know the selling price of this final product is 5000 rupees per pound, and the fixed cost is given as 2 into 10 to the power 5 per year, which includes your rent, employees, and maintenance etcetera, and the life of this mine is 15 years. So, what it asks here is, you know, what will be the cutoff grade if the mining rate is the governing constant, and we have to calculate it in lb per ton, assuming 100 percent recovery here. The second thing we need to calculate is the cutoff grade again, considering the concentrating rate is the governing constant, again in pounds per ton.

So, for the first case you know we know where the mining is governing constant. So, we know that g m the cutoff grade g m is c divided by s minus r where our c is concentrating cost so which is 1500 rupees per ton our s is the selling price for the final product which is 5000 rupees per pound and r is the refining cost. which is our 3000 rupees per pound so if we calculate you know put the value of c s and r this becomes this is 1500 divided by 5000 minus 3000 which is 0.75 lb per

So, this is the cut off grade ah assuming mining is the governing constraint yeah. So, second part of this problem says you know the concentrating rate is the governing constraint So, in this case, we know that the the equation for this cutoff grade is G c equal to C plus F divided by capital C whole divided by S minus R, where C again is the concentrating cost again is 1500 rupees per ton. F is the fixed cost.

We know that this is 2 into 10 to the power 5 rupees per year. C is the concentration capacity. capacity and we know that this is 1500 ton per year and S is the selling price. is our 5000 rupees per pound and refining cost r equal to refining cost is we know that this is 3000 rupees per pound So, if you put all these values, this equation of G c becomes

1500 plus 2 into 10 to the power of 5 divided by 1500, whole divided by 5000 minus 3000, which is s minus r, and if you see, this value is coming out to be 0.817. So, this ends our, you know, the second problem here



coming to the third problem, you know, like what it says is related to the time value of money, and it says you are a mining engineer conducting a feasibility study of an iron ore mine in India. Using the given project details, determine whether the initial investment should be made or not. So, in here, what is there is, you know, the project details are given. So, the ore reserve is 34 million tons, average grade of ore, which is 60 percent iron, and mine life is 16 years. The annual production is 2 million tons.

And further project details are like initial capital investment is 25,000 million rupees, the operating cost is 3,200 per ton, and the iron ore selling price is 7,000 rupees per ton. The discount rate is 12 percent. And the mine closure cost is 2,000 million at the end of 16 years. So, what it is trying to say is that if you want to draw this cash flow diagram. So, we have some initial investment. So, let us say it is called I, and you know, we have up to the 16th year.

So, year number 1, 2, 3, and all the way up to the 16th. And in here, what we have is we are selling some ore, which is 2 million tons per year, and we get some amount, let us say A1 here. And you know, and there is some operating cost, let's say that is O. So, A1 minus O is the total, you know, the positive cash flow at, you know, year number one. Similarly, we have for year number two, three, and all the way up to the 16th year. So, on top of that, you know, we have a mine closure thing, which is, you know, it says 2,000 million rupees at the end of the 16th year, and we have to calculate what is the entire, you know, NPV for this project. So, in here, you know, first you need to calculate the revenue per year.

So, per year equal to the production per year. into price of the ore per ton so if we just multiply this thing this is you know we are producing 2 million ton into 7000 is the price of the ore so this is becomes 14000 million rupees the operating cost ah operating cost per year equal to you know per ton ah operating cost operating cost per ton into you know operating cost ah you know tons produced is you know we are producing 2 tons and the operating cost is 3200. So, which is 6450

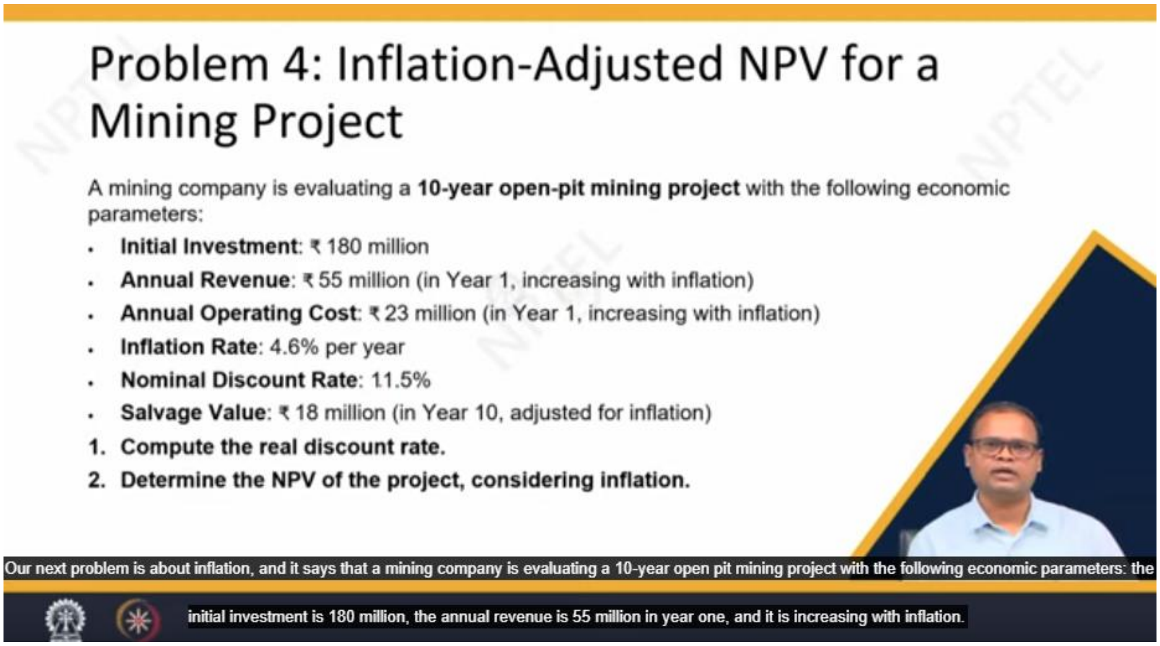
So, and in this case, what we have is, you know, the A, which is the net revenue, net income per year, which is, you know, the revenue minus the operating cost, which is 14,000 minus 6,450. So, this becomes 7600. sorry this is 6400, so 6400, so this becomes 7600 million. So, now we know that you know we have our every year we are going to get some 7600. So, year number 1, 2, 3 and this value of A equal to 7600 in each year this A A A all the way up to 16th year.

So, in this case we know that the present value of all these you know cache inflows is you know you can calculate p equal to a into 1 plus i to the power n minus 1 whole divided by i into you know 1 plus i to the power n. So, here the i is the you know the interest rate and n is the number of years in here it is 16 and a we found out that is 7600. So if you put these values in i equal to our you know we took it like 12% and n equal to 16. So if you put these values it becomes 7600 into 1 plus i is 0.12 whole to the power n is 16 minus 1. divided by 0.12 into 1 plus 0.12 whole to the power 16.

So, this becomes your 53 double 0 2.29 million rupees. So, now if you see, the present value of the mine closure, if you want to calculate, because at the end of the 16th year, we are going to spend 2000 rupees for the mine closure. So, the present value of closure equals 2000 divided by 1 plus i to the power n, which is 16 here. So, if you put these values, 2000 divided by 1 plus 0.12 to the power 16 is 326.2 million.

Again, in rupees. So, the net present value for this project the initial investment is 25,000, and because there is an investment, we have a negative sign here. What we are going to get over the 16 years is 53 double 0 2.29 minus 326.24. So, the first part is our initial investment, and this is after selling the ore and deducting the operating cost.

We are getting 53002.29, and the last part is our mine closure expenditure. So, the present value of all the things. So, this becomes 27676.05 million rupees. So, because this value is positive, the NPV value is positive, we must go for this investment.



Our next problem is about inflation, and it says that a mining company is evaluating a 10-year open pit mining project with the following economic parameters: the initial investment is 180 million, the annual revenue is 55 million in year one, and it is increasing with inflation.

So, what does this mean is the revenue is increasing ah ah based on what is the inflation rate and ah the annual operating cost is 23 million in year 1 and again which is increasing with inflation and the inflation rate is 4.6 percent per year the nominal discount rate is 11.5 percent the salvage value you know at the end of this mine ah is 18 million. ah and it has been adjusted for ah inflation. So, ah we do not have to add inflation component to it and then ah what is the problem ask is to compute the real ah discount rate and ah second thing what it ask is to determine the NPV of the project ah considering the inflation component. So, like to understand this problem, you know, let us draw the cash flow diagram here first. So, in here we have initial investment which is going, you know, negative and it has, you know, the project is for year 1, year 2, all the way up to year 3.

And in here, what we have is, you know, there is, you know, after selling this ore, you know, like we are getting A1 amount of money in the first year, which is given as 55 million for the first year. And the operating cost expenditure we have is 23 million. So, this initial 55 million is increasing and becoming A 2 here. Similarly, this is again the operating cost is increasing and becoming you know A 2 and A 3 and all the way up to A 10. So, in here what is asking is calculate you know what is the NPV of this project considering you know your all these inflation component.

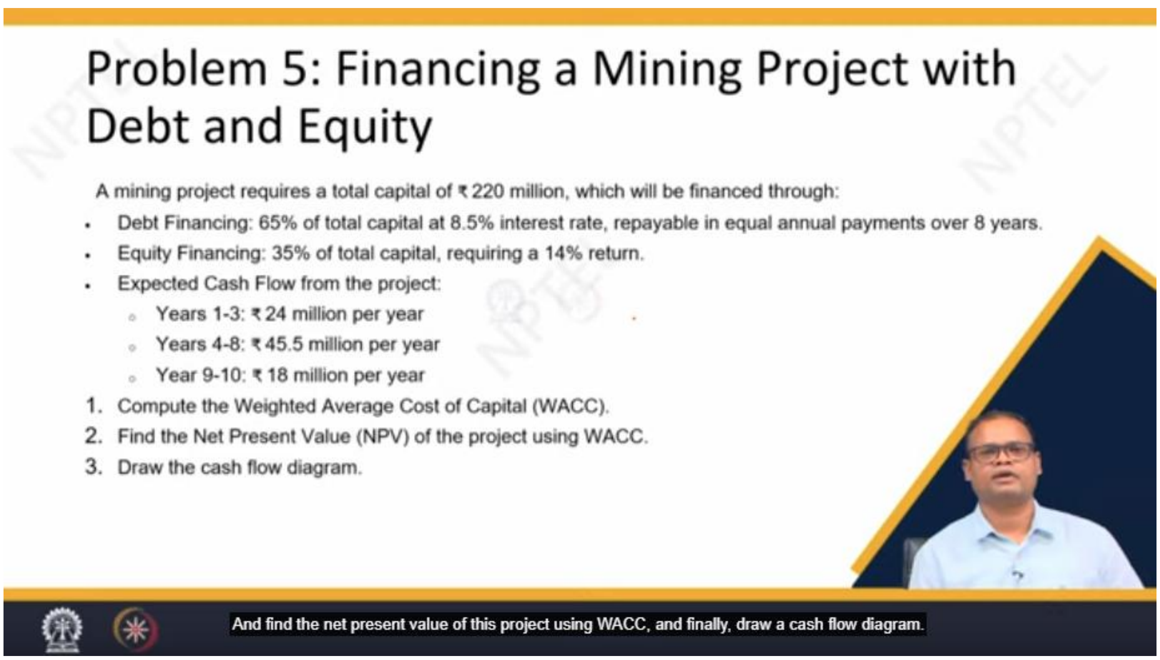
So, first thing what we need to do it here is to calculate the cash flows and in here you know first is the first year revenue we know that is 55 million rupees and the operating cost is 23 million rupees. So, there is an inflation component to this which is 4.6 percent here. So, the revenue will increase to 55 into 1 plus i here and this will further let us say this is x and this third year the revenue will go to x into 1 plus i. So, all the way it will go like that the revenue component. And similarly, the operating cost is also increasing from ah 23 into 1 plus i i actually this is the inflation component which ah we typically write i i. So, and if it is y, so this ah this is becoming y into 1 plus i i in the third year and this is again it is increasing ah ah to fourth year and all the way up to tenth year. So, and in this case the net cash flow is you know if you subtract the 55 million rupees to 23 million rupees this becomes your you know 32 million.

So, similarly, we can calculate what the net cash flow is in each year: first year, second year, third year, all the way up to our tenth year. And if you do that, the table becomes like this: 32 million rupees in the first year, and it is going to 47.97 million rupees at the end of the mine. So, in this case, what we need to do is calculate the present value. We cannot apply the previous formula that we used in our earlier example. We individually have to calculate the present value of all these So, the first present value will be 32 divided by 1 plus i to the power 1, the second one will be 32 divided by 1 plus i squared, and so on not 32, but 33.47, and the last is 47.97. by 1 plus i to the power 10.

So, this i is our nominal rate of interest, which is given in the problem. So, if you put all these values, the present value looks like this here, and it is initially 28.7. and going down to 16.15 million rupees for the 10th-year income that we are going to get. So, if you sum it up, the total amount is equal to 218.94 million. So, this is from the net cash flow that is happening in this mine, but we also have a salvage value here.

So, the salvage amount we are going to get exactly at the 10th year because the inflation component is not considered. So, we have to consider the inflation component here, and if you take that, this becomes 18 million multiplied by 1 plus i to the power where i is the inflation rate, and all to the power 10. So, this becomes 28.22 million, and if you calculate the present value of the salvage

Equal to 28.22 divided by 1 plus i to the power n, where n is 10 here. So, 28.22 divided by 1 plus i is 11.5 divided by 100, you can say whole to the power 10, and this becomes 9.5. Million, and this NPV becomes the initial investment, which is 180 million, plus 218.94 million, plus 9.5 million, which is, you know, 48.44. So, if you want to, which is, you know, a positive value. So, again, this is we need to—we must go for this investment. If you want to calculate the, you know, the real rate of return, we can use the, you know, previous formulas that we have learned and calculate the value here.



So, coming to the last problem, which is related to, you know, financing a mining project with debt and equity, which is related to WSCC. Like, here it says a mining project requires a total capital of 220 million. Which will be financed through debt financing, 65 percent at 8.5 interest rate, which is repayable in equal repayments over 8 years. The second thing is the 35 percent from equity financing, requiring a 14 percent return. And the expected cash flows are: 1 to 3 years is 24 million per year, 4 to 8 is 45.5 million per year, 9 to 10 it is 18 million per year. So, what is asked is, you know, compute the WACC, which is the weighted average cost of capital.

And find the net present value of this project using WACC, and finally, draw a cash flow diagram. So, let us start with this cash flow diagram first to understand this problem. So, if you see, you know, the cash flow diagram will look like— We have—we need some 220 million in the beginning, which is our negative, and it will be, you know, from 65 percent debt and 35 percent from equity. So in here, like, you know, the mine is for 10 years.

So year number one, two, three, all the way is, let's say, four, five, six, seven, eight, nine, and 10. And the cash flow is, you know, initially it is 24, all the way up to third year. And it says becoming 45.8%. from year number 4 to year number 8 and at the end it is 18 million for 9th year and 10th year. So, what we are asked to find out is the you know discount rate and what is the NPV.

So, for this ah you know ah let us calculate the debt component. So, the total amount ah that we need is 220. So, it is into 0.65 ah ah like it is 65 percent contribution this is 143 million and equity component is is the total amount 20 into 35 percent of this. So, this is ah becoming 77 million.

So, ah one thing we have to assume here is ah the you know ah the corporate tax. So, that tax is let us say ah 30 percent. So, the WACC is we know that this is d by d plus e into i let us say that into 1 plus t sorry 1 minus t here plus E divided by D plus E and this is I equity let us say.

So, if you put the value, this is 143 divided by 220 plus Id is 0.2. 0.85, which is 8.5 percent, into 1 minus corporate tax is 0.3, ah, plus, ah, 77 divided by 220, ah, into 0.14 is the, ah, the expected return for equity. So, if you calculate this, it becomes which is, you know, 8.77 percent. So, once we calculate, you know, this WACC, we can calculate the present value of all these, you know, cash flows. Like, for the first year, it will be 24. The present value of this will be 24 divided by

1 plus i. So, this i is the previously calculated WACC, which is 8 point So, if you calculate this, this becomes 22.07. The second one will be 24 divided by 1 plus i squared. Similarly, the sixth one, let us say, is 45.5 divided by 1 plus i to the power of 6. You have to calculate all this in between, all the way up to the 10th year. And if you do that, you know, what you will get is the present values here, which change from 22.07 to 7.77 at the 10th year. And, you know, the total value or the present value sum is equal to 215.59 million. So, once you get the present value in the previous slide, the NPV can be calculated as NPV equals the summation of those present values minus debt plus equity. So, which is you

215.59 minus 220, so which is, you know, minus 4.41. So, because the NPV is, ah, coming negative here, ah, we will not go for this investment, and maybe we will change, ah, our debt-to-equity ratio, ah, to a different value. So, that the NPV becomes, ah, positive. So, this ends the, ah, class, ah, today, like the lecture today, which is, ah, lecture number 56.