Quality Design and Control
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Lecture - 50
Design for Reliability-II (Contd.)

So, this during this session; I will be taking up some more numerical problems on quality and reliability.

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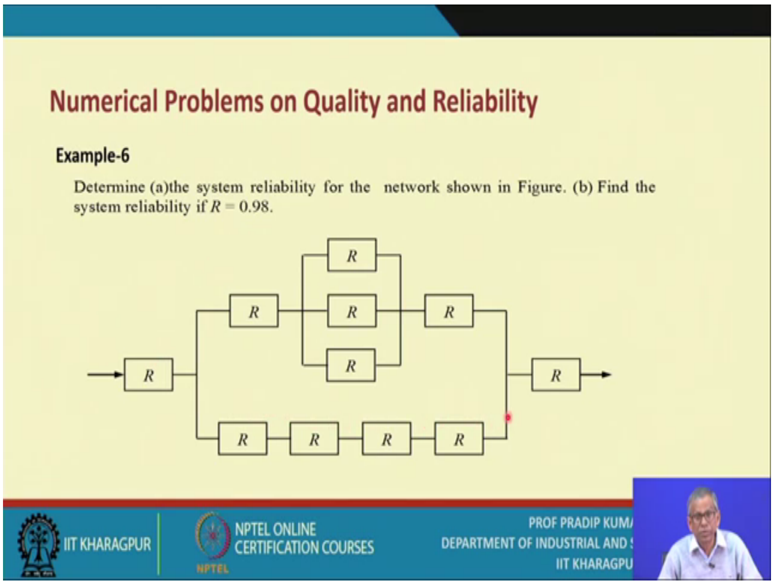

Just remember one particular aspect that is the kinds of problems we are dealing with these are typical related to quality and reliability; obviously, we have covered a large number of topics till date. And given a particular problem you must understand that which aspects of quality or reliability or quality and reliability this problem refers to.

And also, while you solve a particular numerical problems; so, you follow a systematic approach and sometimes you know just referring to one particular numerical problems may not be enough in understanding the concepts. So, it is supplemented with many case studies; so, during the assigning assignments of your. So, while will provide the assignments to you.

Now, sometimes in the sort cases also we may include and obviously, this understanding of these numerical problems we will help you in addressing those case studies ok. Now let us talk about the next examples on next numerical problem like here what you find there is a system structure given right; so these are the this is the system structure you have one parallel configuration now this parallel configuration is linked with the two other component this is in series.

And similarly all this four components there also in series and this is this is one subsystem, this is one subsystems and these two subsystems are in parallel. And then this parallel subsystems is linked with one particular component over here and another component over here in series. So, so, is a typical example of a network indicating a combination of series and parallel structure?

So, determine the systems reliability for the network shown in figure find the systems reliability if R equals to 0.98; that means, what we have we have ensured that all the individual components they are having the same reliability is it ok. And you know this components may be different; obviously, it will be different and in any system, but what how do you ensure that whatever may be the design of a particular component make sure that the reliability is very high and they are almost same for the reliability value is same for all the components so that is a very you know the challenging assignment for any designer.

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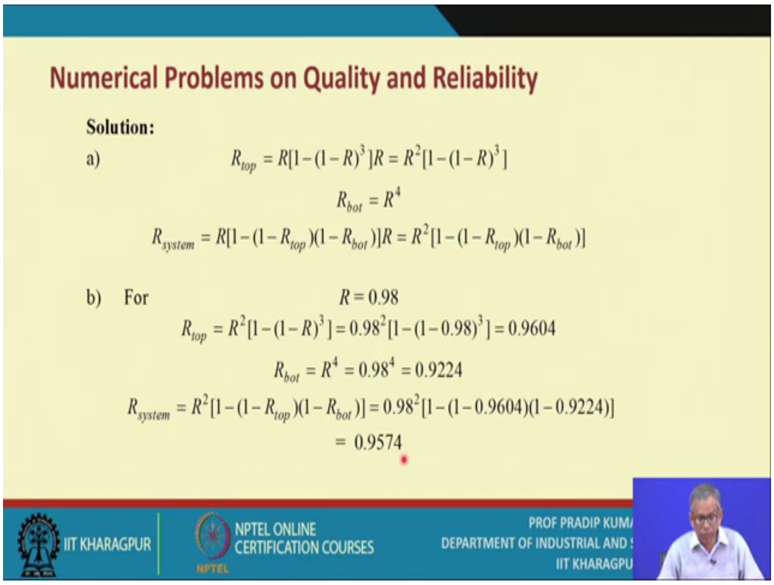

So, how do you get the solutions; that means, R top; that means, you look at the there is a two structures you have the top one you have the bottom one is it ok. So, this is the reliability of the systems in the top that is R into this one; that means 1 upon 1 minus R to the power 3; that means, the 3 components are in parallel. So, you have the parallel systems reliability and it is linked with two other components in series; the first one then you have the middle one that is parallel systems and that is the third one.

So, this is the middle ones reliability, this is the first ones reliability, this is the third one reliability and they are in series. So, that is why it is like this one and what about the bottom one? Bottom one means there are four components there in series that is why it is R to the power 4 and what is the systems you will have this one and this and this is the outer one the systems there is a component R 1 and this one this is the middle one is it ok.

So, ultimately you have this expression the simplified expressions you have the reliability for the top portion or the top systems this is the reliability for the bottom systems. So, ultimately when you assume that R the value of R or the value of reliability is same for all the components and this value is assumed to be 0.98 considered to very high then you have you can compute the reliability for the top systems and reliability for the bottom systems; so, it is 0.9604 and this is 9224.

Obviously what could be the possible reasons that the bottom system has got you know lesser reliability why? Because it is you can explain like always you know if the system is in series.

So, series configuration the systems reliability is expected to be lower and then the overall systems reliability you have this expressions over here. So, you just you know you take the value of R s 0.98 and you compute this one this is this is known, this is also known and ultimately overall systems reliability is found as 0.9574 ok.

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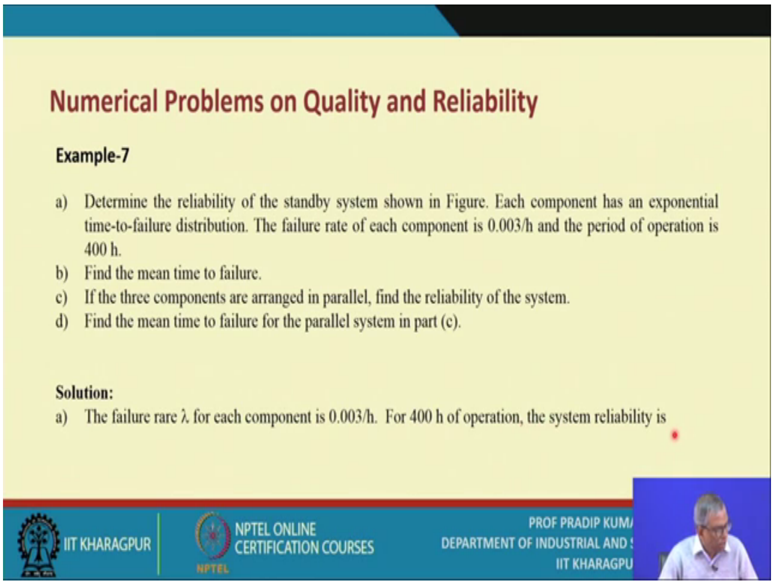

Now, let us talk about the next example; determine the reliability of the standby system shown in figure is it ok? Now the standby systems we have already explained and if you recollect we say that there are several ways you can improve the reliability of a system.

So, one approach or one way to improve the reliability of the system is is creating a system with standby that inside the main system fails; obviously, you know the standby system will start working automatically. So, that is the basic the logic that is the basic rule.

So, the reliability of the standby system you have to determine each component has an exponential time to failure distribution; that means, we are saying that this components are not in you know the burn in phase, but they are in useful life phase refer to you know the life cycle curve.

The failure rate of each component is 0.003 per hour and the period of operation is 400 hours; that means, you need to check that whether the system will run four 400 hours or not is it and when it runs, whether you are getting the intended function or the operation from the systems or not; so, that is your main concern.

Find the mean time to failure ok. So, you have to apply a formula and then you have to compute this value if the 3 components are arranged in parallel find the reliability of the systems is it ok. And the last one is find the mean time to failure for the parallel systems in part. See now here one point I like to highlight like say most of the time we are computing the value of say the mean time to failure is it the system wise component wise, we are calculating this one.

The another the term you have used that is the MTBF; that means, mean time to mean time between failure and you know there is a there is difference between. So, the mean time to failure and mean time between failure; now supposing you are asked to compute the value of mean time between failure. Now what are the additional data you must call for so, that the MTBF you can calculate is it ok?

So, I think my question is clear; that means, you need to collect data some additional data. So, that you are in a position to calculate the mean time between failure and then uh if you find that there is a significant difference between these two; that means, between MTTF and MTBF what does it mean? That means, related to you know the systems operations or related to the condition or related to the state of the system is it ok.

So, you know why there is a difference between mean time to failure and mean time to mean time to failure and mean time between failures is it ok. So, obviously, there could be you know several examples on this. Now, let us talk about these examples. So, the failure rate lambda for each component is this 0.003 hours for 400 hours of operation the system reliability is this one.

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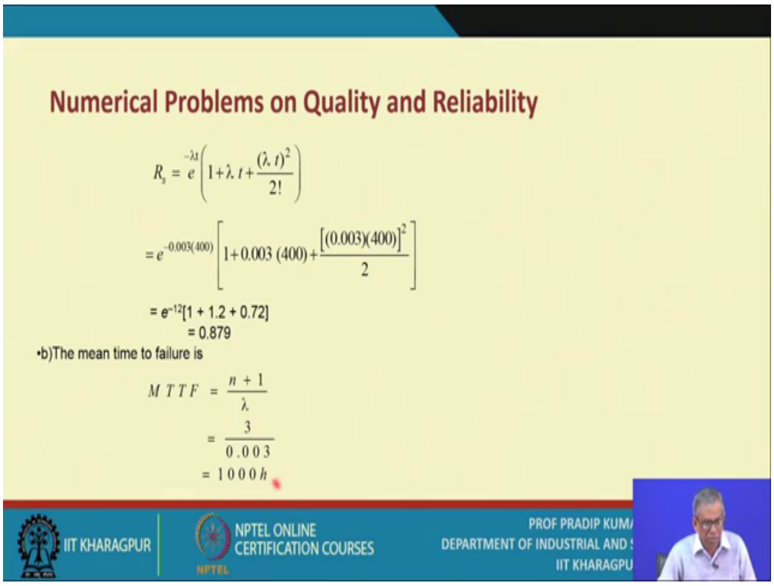

That means, R S is e to the power minus lambda t into this is it we have already computed; that means what we have assumed? How do you get this expression? That means, we are assuming that if the time to failure is exponential with the corresponding parameter value that is lambda; that means, you know the number of failures number of failures will be Poisson distributed with the corresponding parameter value lambda t; that means, number of failures within a period within a time period of t is it t may be 1 hour, t maybe 300 hours whatever the number of failures. So, will be you can prove it that it is Poisson distributed with the parameter lambda into t.

So, that is why it is e to the power minus lambda t into 1 plus lambda t plus lambda t square divided by factorial 2. You just referred to our original expression for you know the systems with standby components. So, there is a general expression; that means, if you have a basic component with n number of say the standby components. And how these to the standby systems is working; that means, at any point in time make sure that at least one component must run and so, that the system runs; that means, system design is such that it depends on ultimately the operation of one component among n plus 1 components is it ok?

So, this extra you know the components you have added that is n number of components in order to improve the reliability; when you try it reflects the level of redundancy in the system. So, now, we have all this data lambda value is known t is given as 400 hours. So, ultimately you get a value of 0.879.

Now, what is the mean time to failure? That is we have already have this expression that is n plus 1 by lambda now how do you get this expression? So, this is another problem I said. So, why do not you know as a learner, as a student you derive these expressions that is MTTF is equals to n plus 1 by lambda; when you deal with systems with standby. And how many standby components you have? n number of standbys. So, you need to derive this expression; so, here n is 2 and. So, n is two that is why this 3 and lambda remain same. So, lambda is 0.003 that is MTTF is simply 1000.

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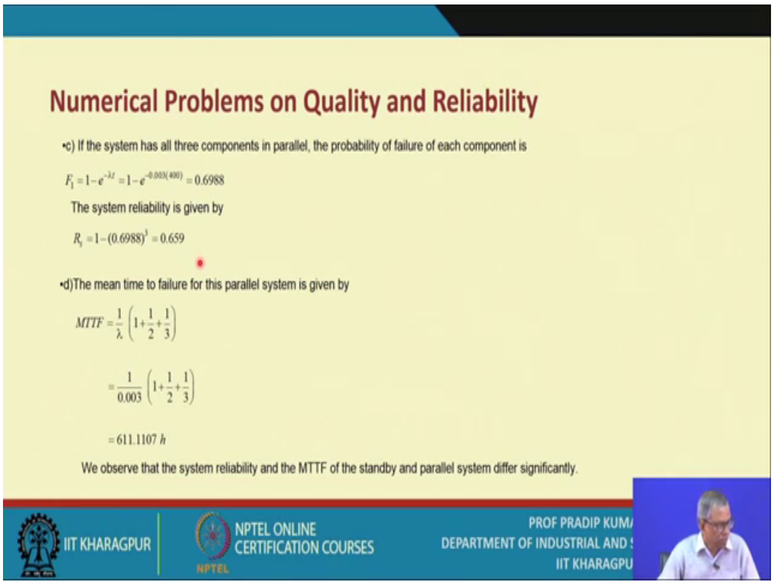

If the system has all 3 components in parallel; that means, many a time you know you are in a fix while you means whether I will opt for a systems with standby or you know or I will say that the system; let the system remain in parallel structure.

So, in most of you know majority of such cases you need to compare the standby systems with the parallel systems. So, if the system has all 3 components in parallel the probability of failure of each component is this is; obviously, that is F for the first the failure probability or the first one that is 1 minus e to the power minus lambda t. So, this expression also we have derived we have refer to this expression. So, this is; that means, lambda is 0.003; 400 hours that is the value of t say you get 0.6988 that is the failure probability. So; obviously, you know if you have 3 components; so 1 minus 0.6988; 3 and what we are assuming that all these 3 components they are they are not only similar they are also identical.

How do you define identical? With respect to their; the time to failure distribution as well as the failure rate is it ok. So, what is the systems reliability? Systems reliability is just 0.659; so, the mean time to you can compare this value with the reliability of the systems with the standby is it ok?

So, the mean time to failure for this parallel system is given by MTTF 1 upon lambda 1 plus 1 upon 2 plus 1 upon 3 and then you get a value of 611.1107 hours. We observe that the system reliability and the MTTF of the standby and differs significantly. Now, MTTF for the standby system it was 1000 hours if you opt for the parallel system, it has come down to 611 hours; so, it ok. So, from this perspective; that means, from the in respect of MTTF; obviously, you know the standby system is better and similarly in respect of the systems reliability the standby system is better.

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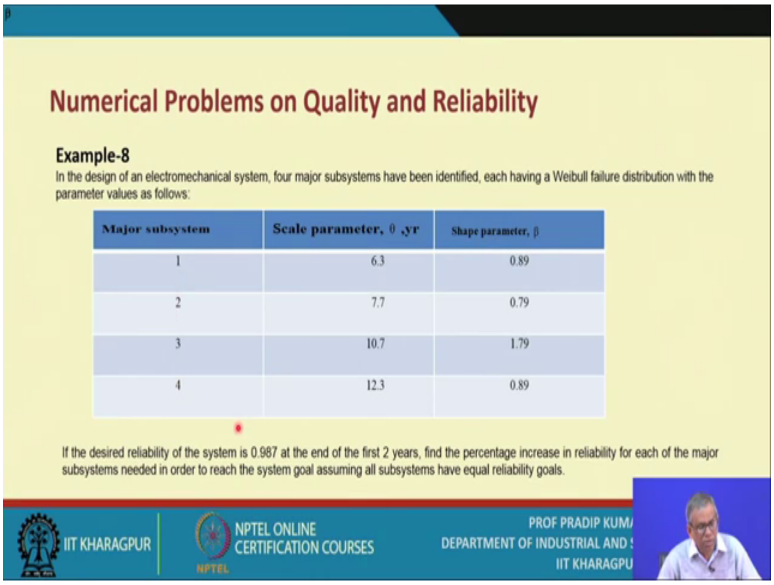

Now, the next example that is example 8 what you know what you assume that if you remember that exponential time to failure distribution is a special case of. So, Weibull time to failure distribution right and when you refer to Weibull distribution in Weibull distribution is having 3 parameters. So, the gamma that is the first parameter this is referred to as the location parameter. So, value of gamma may lie between minus infinity to plus infinity.

And then you have the shape parameter the shape parameters the notation is beta ok. So, it is greater than 0 and; that means,. So, nonnegative at the positive and then alpha is basically the skill parameter. So, when we assume that the distribution is Weibull then when you refer to the reliability modelling and reliability analysis there is a reason that we assume that the value of gamma is made is 0 is assumed to be 0 ; that means, the location parameter does not have any influence on this is it ok.

But you can have you can select the possible values of the other two parameters like say beta and alpha the. In this example what we are referring to? We are referring to the design of an electromechanical systems there are main subsystems surrounding you. So, in the design of an electromechanical system four major subsystems have been identified. So, what are those major subsystems? 1, 2, 3, 4 each having Weibull failure distribution; actually it is Weibull whenever you say failure distribution it means time to failure distribution with the parameter values as follows.

So, what are those parameters values scale parameters theta or alpha whatever it is and the shape parameter beta I have already mentioned is it ok. Now these are the values we have obtained; that means, this is the subsystems now this is 6.3, this is 0.89, this is 7.7, this is 0.79; all are greater than 0. For the third subsystem it is 10.7; it is 1.79 and for the fourth subsystems it is 12.3 and the value of beta is 0.89.

Now, my question is how do you get these values? 6.3 or 0.89. So, just think about it is it means if you are asked to you know get this values. So, which procedure you follow which technique you apply reading my. So, later on we may take of these issues that how do you get these values of say scale parameter and the shape parameters is it ok; so keeping aside for the time being these questions.

Now, let us talk about this problem. So, if the desired reliability of the system is 0.987; consisting of all these four subsystems; at the end of the first two years it is clear. Find the percentage increasing reliability for each of the major subsystems needed in order to reach the system goal assuming all the subsystems of equal reliability goals; is it clear? So, I repeat if the desired reliability of the system is 0.987 question is raised how why do you specify 0.987 what is the basis? Is it ok?

As I have already told you that whenever the we deal with the reliability issues for a particular product many a time we assume that the product is at the prototyping stage is it ok. So, during the prototyping stage you carry out a lot of experimentation so, that ultimately when you analyse the results for different design alternatives and for different structure for different system structure. You say I have got several alternatives and the expected value of reliability for an alternative is this one ok; so, you do experiments

So, supposing during experimentations you find that this is a value 0.987 you have already you know you say that this is an acceptable value 0.987; it could be 0.98 or 0.99 or say point simply 0.97; so, some value you must specify ok. So, that your recommendations are very specific so, that is that is the basic purpose of assuming such a value.

Find the percentage increasing reliability for each of the major subsystems; so, these are the major subsystems.

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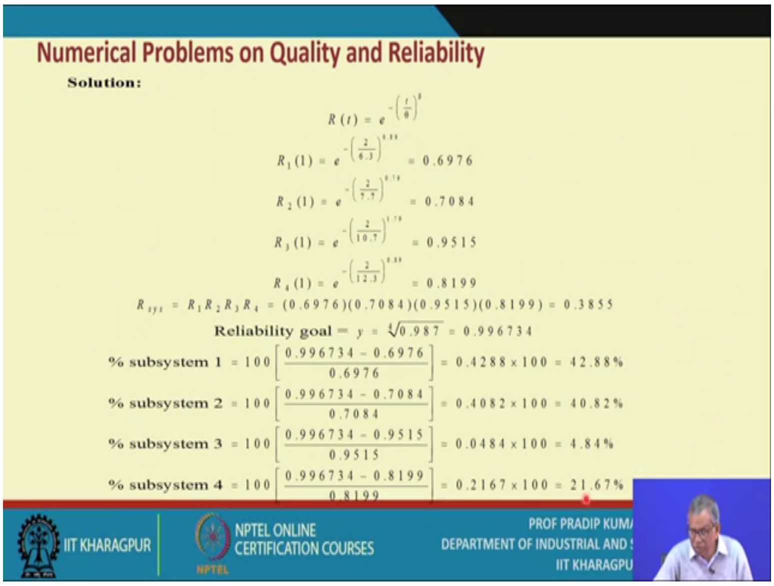

So, how do you proceed? Solution is this is for a given systems e to the power minus t by theta into beta; that means, for a single component assuming that you know the time to failure visible. So, this is basically your expressions for the reliability for the time period t for a component. So, theta is basically the scale parameters and beta is a shape parameters ok.

So, when where we have already refer to the Weibull the density function and the reliability modelling we have done. So, please refer to those expressions; now this is the first subsystems is it ok. So, the first subsystem these two values are given, for the first subsystem the value of theta that is the scale parameter that is 6.3 and beta is 0.89. So, you are applying this formula to get the reliability for say for the first subsystems that is 0.6976.

Similarly, for all other subsystems major subsystems; so, major subsystems to that is the value of theta is 7.7 and 7.9 is the value of beta. So, you get a value of 0.7084 as its reliability; then similarly for the third subsystems the value is 0.9515 when beta value is 1.79 greater than 0 and the theta all alpha is 10.7 the scale parameter.

And similarly you compute the fourth subsystems reliability with the values of beta 0.89 and alpha or theta 12.3 that is 0.8199. Now if the system is in series; so, you just multiply all these values is it is a product term and you get a systems reliability as 0.3858.

So, what is the reliability goal? The reliability goal is you know if you have 0.987 is it in series. So, the individual component reliability should be this one is it clear? Because systems reliability is point you know this must be point reliability goal; that means, the systems reliability is 0.87 that is R to the power 4; is it ok?

So; obviously, you know this will be the expressions for the individual component reliability is it ok; so that the system reliability becomes 0.987; so, this is individual component reliability is as high as 0.996734 ok. So, what is the percentage increase in the subsystems 1? So, simply you calculate; that means, here it is 0.6976 right and what the incremental you require? You must have this value 0.996734. So, what is the percentage increase? That means, the desired value minus the actual value divided by the actual value into 100.

So, percentage increasing the reliability of the first subsystem that is 42.88 and the same way you calculate for the subsystems 2 subsystems 3 and subsystems 4. So, it was 0.7084, now this to be made 0.996734. So, what is the percent increase? Same formula you use that is 40.82 percent increase is required, similarly for subsystems 3 you need to improve 0.48 only just 4.84 percent; that means, sub subsystems 3 is as far as reliability is concerned it is it is a very improved systems and its quality must be very very high is it ok.

So, whenever you say that the reliability is very high immediately you assume that the quality also must be very very high quality of the systems of a quality of the component. So, it is 0.9515 so; obviously, just 4.84 percent increment is required whereas, the fourth subsystems you need an increment of say 21.67 percentage.

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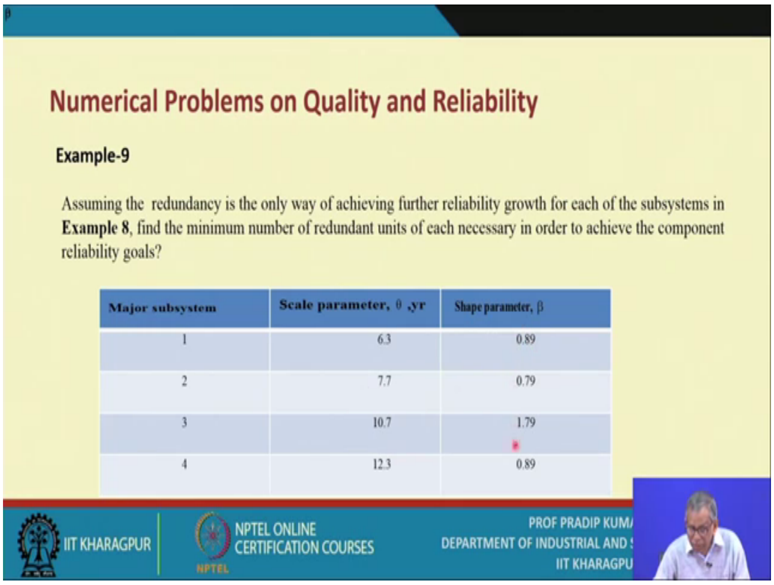

Now, the next examples I will go through quickly; assuming the redundancy is the only way of achieving further reliability growth for each of the subsystems in example 8; that means, you refer to the previous examples; find the minimum number of redundant units of each necessary in order to achieve the component reliability goals; is it ok.

You have set the target right and you know what is the current value of reliability. So, the major subsystems is this again I am I am telling you that what are the you know the scale parameters is a very very important and similarly the same parameters; so, these values remain same.

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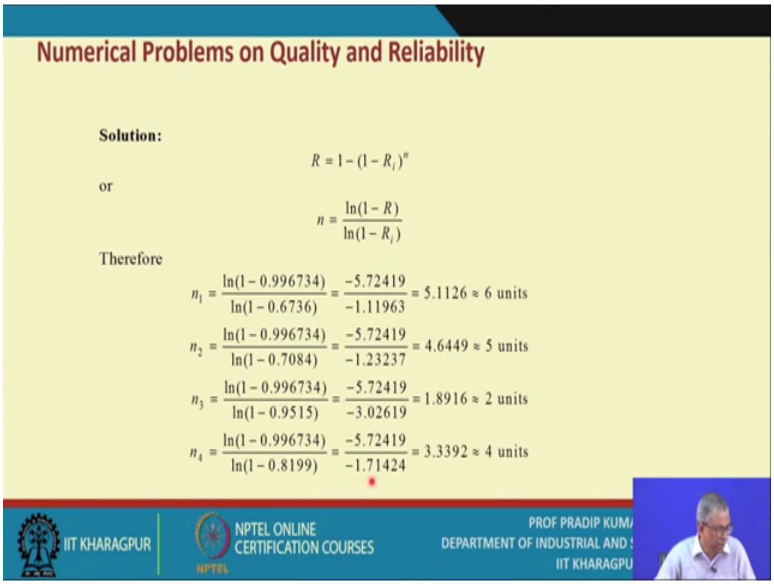

So, what is the solution? Solution is this right; so, this is a parallel systems n components in parallel and so, the value of n will be this one right. So, therefore, n 1 is you calculate n 1; that means, this is your desired value this is the actual value is it you are here you want to reach here ok.

So, what will be the corresponding value of n 1? That means, the six units is actually it is 5.1126. So, the number cannot be you know fraction; so, it is made, so, you run it off; so, it becomes 6. Similarly for the next subsystems; so, this is your desired value is it? And this is your actual value as of now; so, what is the corresponding value of n 2? I have already given the expressions for R; so, your unknown is small n.

So, how many components you require? That means, you require 4.6449 and; that means, it is a 5 units. And similarly for the subsystems 3 you need two more units to be added and in as you know as redundant 1; that means, it is essentially the systems with standby is it the more standbys you add; that means, more the redundancy you add to the system. And this is one way you can improve the reliability of the system and similarly the fourth subsystems, you need to add you need to consider 4 units is it ok.

So, that you can achieve this target value of reliability from the existing 0.8199 is it ok.

So, we have covered a number of we say you know we discussed a number of numerical problems related to quality and reliability. So, I advise that you go through all these problems and the later on you know many such so, the numerical the problems and will be given to you as an assignment.