**Risk and Reliability of Offshore Structures**
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**Module - 01**
**Lecture - 14**
**Exercises – 1**

Friends, let us discuss the module one lectures on Risk and Reliability of Offshore Structures.

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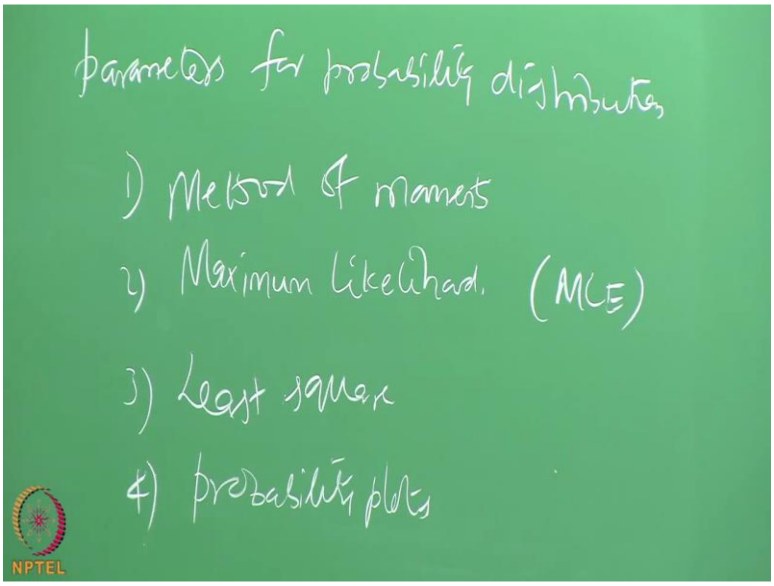


We are talking about lecture and module 1, today will talk about lecture 14 which is going to give you some exercises for understanding the first module. So, this will be the last lecture in the module 1 of the online course on risk and reliability of offshore structures.

Just to go back slightly, we have been discussing about parameters that need to be estimated for probability distribution and there are many methods based on which these parameters can be estimated. We discussed method of movements and maximum likelihood method or MLE like you would estimates in the last lecture. In this lecture will continue with the other two methods, least square approximation and probability plots which is one of the graphical method though estimate the parameter of probability distribution.

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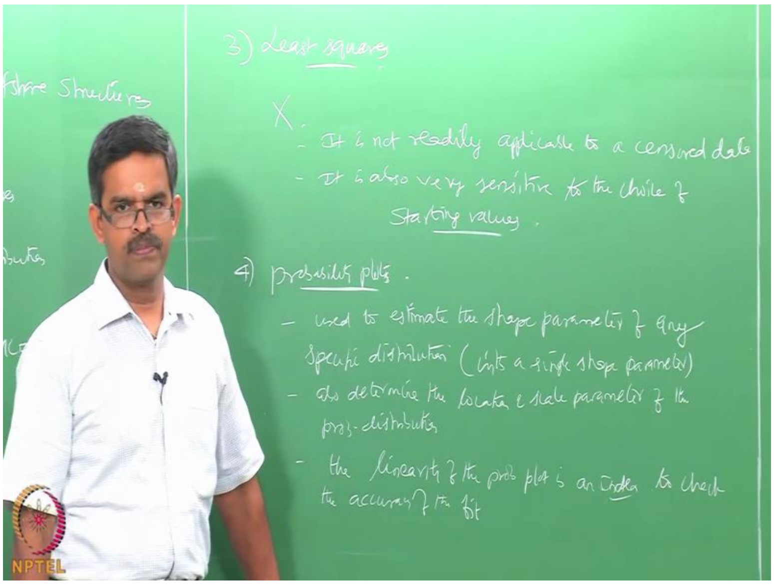


So, let us talk about least squares, non-linear least square method provides an alternative to the maximum likelihood estimates what we saw in the last lecture. Non-linear least square software is available in many statistical software packages which otherwise do not support MLE estimates. So, that is one advantage there many commercial available packages who is support non-linear least square methods which otherwise do not support MLE estimates.

If the softer provides non-linear fitting and hence it has an ability to specified the probability distribution function one is interested in then one can use this directly, and generates least square estimates for that specific distribution assumed by you. This allows the reasonable estimate for distribution even if the software does not provide maximum likelihood estimates. However, there are few demerits by this method. The disadvantage is what this method has is it is not readily applicable for the censor data. Further, it is also very sensitive, very sensitive to the choice of starting values. So for, one has to very careful in using this method for estimating parameters of probability distribution.

Let us talk about graphical method which is called the probability plots. Probability plots can also be used the estimate the shape parameters of any specific distribution this can be used the estimate, the shape parameter of any specific distribution with a single shape parameter. Further after determining the best value of this shape parameter probability plots can be directly used to estimate the location and scale parameter of the probability distribution. So, one can also determine the location and scale parameter of the probability distribution using probability plots.

Main advantage in this method which is so called claimed by the literature is that, the linearity of probability plot is a good measure of adequacy of the distribution fit. So, it gives inherent fitting check also. The linearity of probability plot, once you plot this is an index to check the accuracy of the fit of the assumed distribution correlation coefficient between the points of the probability plot is also a good measure.

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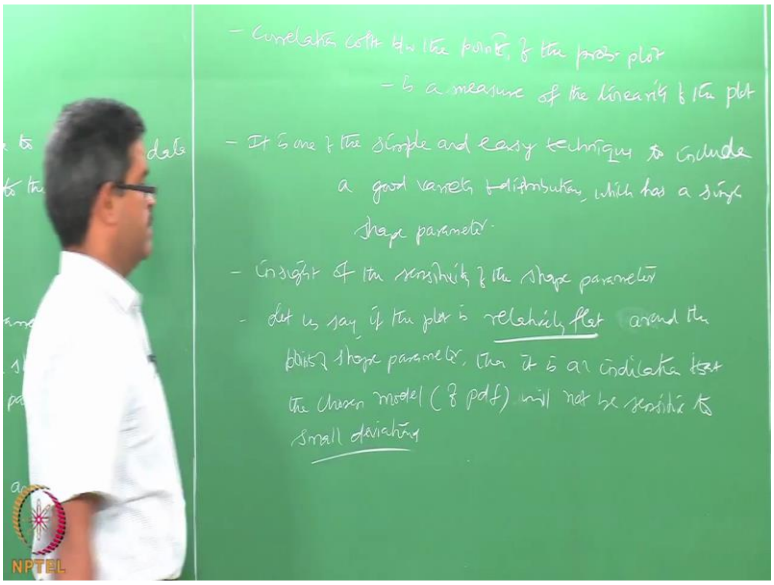


Between the points of the probability plot is also a good measure of the linearity of the probability plot. It is one of the simple and easy techniques to implement of wide variety of distribution with a single shape parameter, to include a good variety of distribution which has a single shape parameter. The basic requirement of this method is to be able to compute the percent point function which is required in the computation.

So, probability plots provide insight of the sensitivity of the shape parameter, they also provide insight of the sensitivity of the shape parameter. If the plot is relatively flat in the neighborhood of the optimal value of shape parameter let us say if the plot is relatively flat around points let us say, around the points of shape parameter then it is the strong indication that fitted model will not be sensitive to small deviation. Then it is an indication that the chosen model of probability distribution this will not be sensitive, will not be sensitive to any small deviations.

So, it also gives you a check based upon the flatness of the probability plot near the vicinity of the points of shape parameter, one can also qualitatively find the insensitivity or sensitivity of the chosen model, for any small deviation in the given data. The maximum correlation value provides a method for comparing the distribution.

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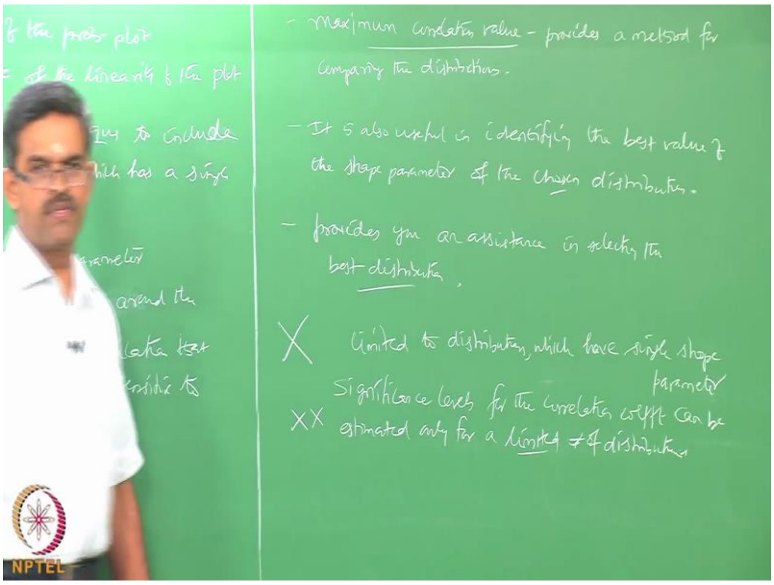


It is also useful in identifying the best value of the shape parameter of the chosen distribution. For example, one could use the probability plots for standard distribution like variable, log normal etcetera comparing the maximum correlation coefficient achieve for each distribution it can help in selecting the best distribution to use. So, this method also provides you a check or provides you assistance in selecting the best distribution that is another advantage of this.

Of course, this method has certain disadvantages though there are many advantages of this method there are few disadvantage as well. This is limited to distribution with a single shape parameter probability plots are widely available in common statistical software for a limited number of distributions, that can be advantage. So, need not have at actually select any specific shape value, you can always use standard softer packages because probability plots being a graphical methods is mostly available in all commercial software which have been use for probability distributions.

Significance levels for correlation coefficient can estimated only for a limited number of distributions. That is very important, though the maximum correlation value can provide a method to compare the distribution and flattening points or flattening part of the curve near the vicinity of the shape parameter will also give an idea about the sensitivity of the data with respect to the chosen distribution. But the significance levels for the correlation coefficient can be estimated only for can be estimated only for a limited number of distributions. This is one of the very serious limitation, one of the very serious limitation, you cannot apply this to all variety of distribution.

First the distribution chosen by you should have a single shape parameter and the significance correlation, coefficient the significance will be also applicable only to limited set of distribution and number of distribution, not to all. If the given maximum correlation value is above a given value let us say the maximum correlation value (Refer Time: 14:45) is above a given value. Then distribution provides an adequate fit for the data with a given confidence level.

So, in this module we have been discussing rules of probability, why probability is very important, how reliability gives you positive asset of failure, what is the difference between or differences reliability analysis and safety analysis, where is question of failure coming into play in the whole discussion, how risk and reliability or connected to each other, how reliability is circumscribed with probability theories, how uncertainties are very important and why uncertainties cannot be completely avoided, what are different set of or varieties of uncertainties in the data which is being used in reliability analysis, how you will handle this uncertainties.

When you talk about rules of probability we had 10 rules, out of which two rules total probability theorem and base theorem are found to be very useful and very compact which can be directly applied for reliability analysis. So, to understand probability theory we also introduce rules of human thinking what we called plausible, reasoning - and we also said how for a given data the knowledge level of given event or the level of given event or the level of occurrence of specific event the confidence level in the occurrence of an event increases or decreases with a knowledge level added to the event, how the confidence level can be improved based upon the knowledge level added up to the event with some physical examples, we have discussed plausible reasoning theories.

Then we also said how the density function h of x is important to address this uncertainties, what kind of method can be used to really stimulate random variables what are random variables, why are they called random variables, what is the randomness associate with this, why environment loads (Refer Time: 17:09) structures cannot be accurately modeled, what are the difficulties in mathematical numerical modeling and physical modeling of offshore structures subjected to environmental forces, how reliability analysis includes these uncertainties, what are the different class of loads acting on offshore structures, how these uncertainties are addressed in these class of loads using what we called characteristics value.

We also said each one of them is (Refer Time: 17:39) specific kind of events like for example, waves, wind, current, earthquake forces may not have the same period, so we talked about what is called returned period. We understood how to estimate the probability of occurrence of the specific event of maximum is two within the service safe of the structure. Even though we have taken example from the classical designed course using returned periods and the service table structure as 50 and 20 respectively.

We saw in a given illustration example in the last lecture that about 33 percent can be the order of uncertainty therefore, you must model these uncertainties in a proper manner and we also said how to estimate the hypothesis test conducted to achieve the generated random variables to fit in a specific type of distribution. We also said how to estimate the parameter of given distribution by 4 methods; we have compare these methods very quickly may small walk through these methods. Discuss the merits and demerits of these methods and also we said we advocated which methods can be very directly useful in probability estimates or in reliability analysis.

With this background given in this - 14 lectures of this module 1 on the online course title risk and reliability of offshore structure, will talk about few exercise examples now. So, that we (Refer Time: 19:09) of experience of application of these theory is very quickly on problems. Then tutorial laws we posted in the website of this course, you can tried to answer the tutorials, send it back to me for a assessment. Subsequently once the submission date is completed the solution for the tutorial will also be available in the website, it will also be discussed subsequently in the later lectures. Now let us move on to the exercises.

So, I will project exercise problem on the screen. So, if you look at the screen now you have seen the first problem projected on the screen.

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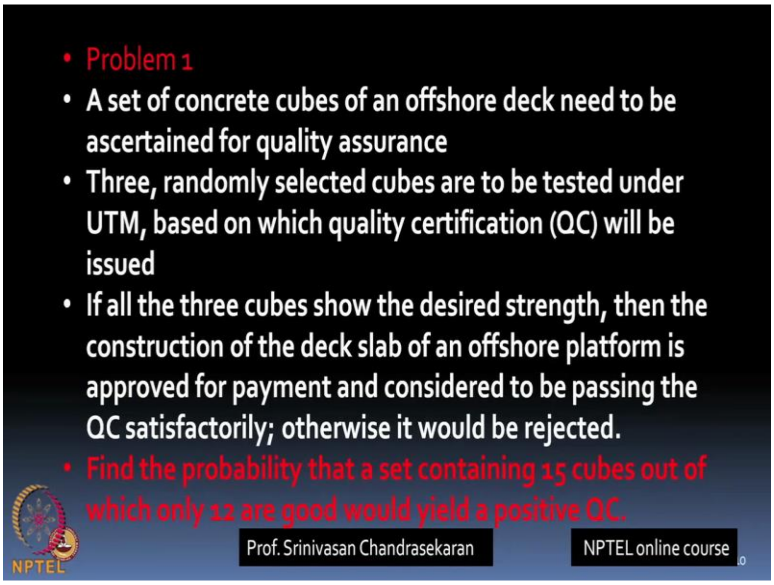


For your understanding, let me read the problem first and tried to understand problem number one which is being solved in this module. A set of concrete cubes of an offshore deck need to be ascertained for quality assurance because you take concrete cubes from the concrete deck being cast for offshore platform. Three, randomly selected cubes are to be tested under UTM which will allow you to get the (Refer Time: 20:17) strength of the cube based on which your quality certification will be provided.

If all the three cubes show the desired strength then the construction of the deck slab of an offshore platform is approved for payment and considered to be passing the quality satisfaction satisfactorily, otherwise it would be rejected. So, that is the seriesness of the of the test results which will be based upon this.

Now, the question comes there are only three samples of the cube being taken though the number may look hypothetical, but for examples say let us consider this - what we have it ask is find the probability that a set contain 15 cubes out of which only 12 are good would be a positive quality certificate for the platform. So, the problem is now available on the screen let us try to answer this problem. So, please look at the black board here we will try to solve this problem very quickly.

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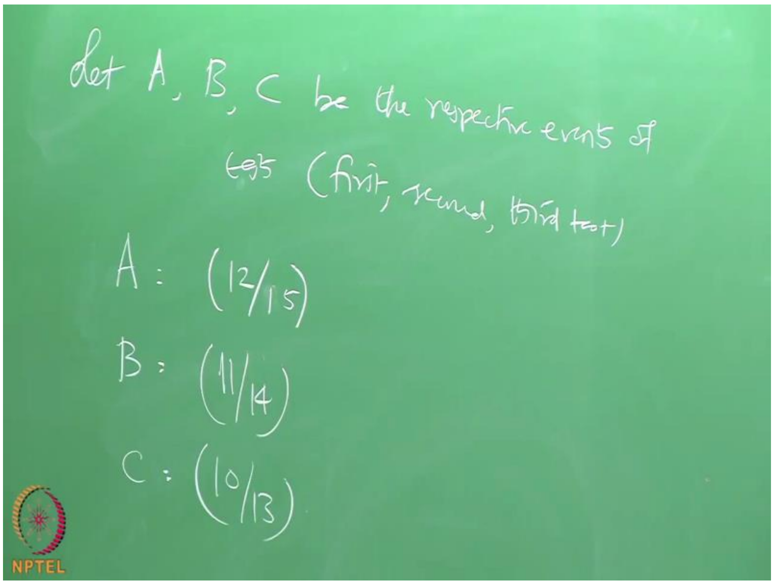


So, let us say solution. Let us say problem one, let A B C be respective events, what are this events of tests let us say first, second and third test you are conducting destructive test essentially UTM is a destructive test. Therefore, let us talk about A. A is the probability of conducting the first test. So, it could be 12 on 25 sorry 12 on 15, because that is the 15 number of cubes have been selected for checking. The cubes wants, they have been taken and destroyed in the UTM they will not be replaced therefore, the probability of the second test is now going to be 11 on 14 because the denominator was of reduced to be one number where cube A or the A cube or the test A makes one cube to break which cannot be replaced. Similarly for C it could be 10 out of 43.

Having said this it is also noted that the quality check will be declared positive only if all the three cube tested would be assist as good. That is what the statement says in the problem therefore, the probability of getting all the cubes good.

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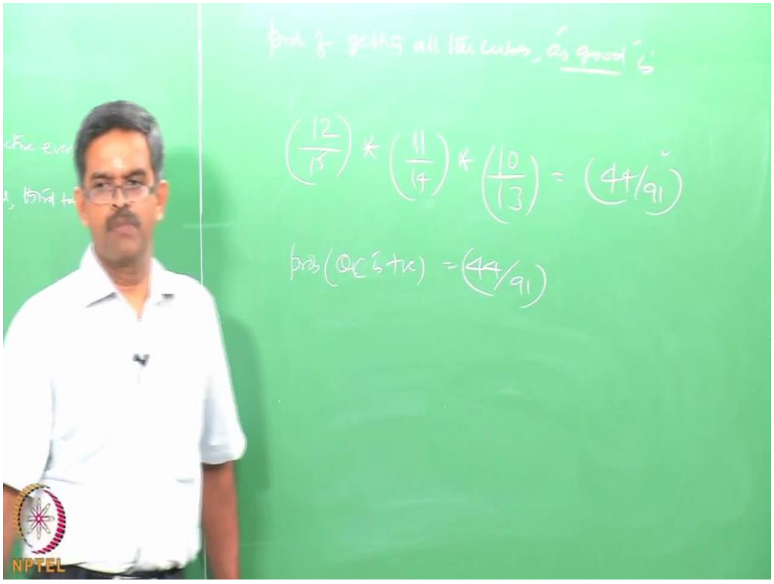

Probability of getting all the cubes as good is given by 12 on 15 multiplied by 11 on 14 multiplied by 10 on 13. So, the probability is going to be 44 by 91 you can check this value in the calculator. Therefore, the probability that the quality check is positive, the probability that quality check is positive is given by 44 on 91, about let us close around 50 percent.

Let us move on to problem number 2, please look at the screen.

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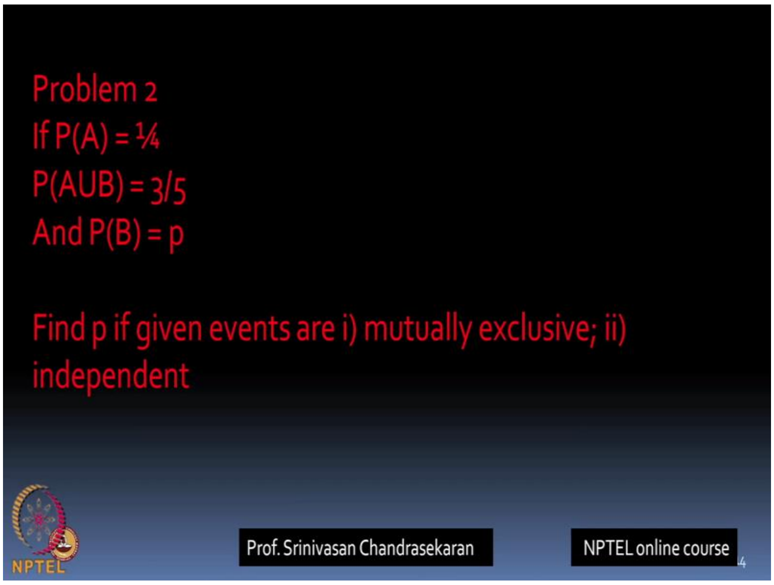


Problem number 2 is now available on a screen. If probability a is 0.25 that is one-fourth and probability of A union B is 3 by 5 and we do not now the probability any event B let it be P. Find P that is the probability of B, if the given events A and B are mutually exclusive and they are independent. Let us answer this problem.

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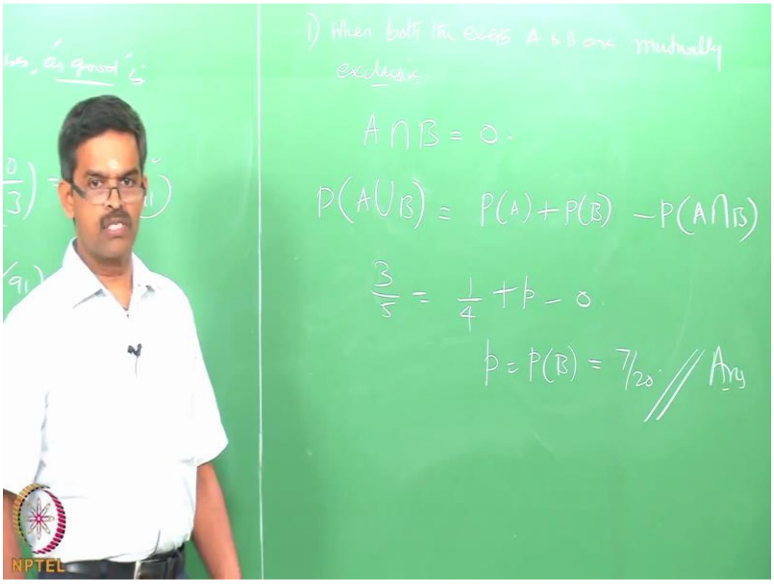

Now, when both the events A and B are mutually exclusive; for that you remain exclusive this condition is true. We also know, is given by let us substitute them back we already know this, this is given in the problem as 3 by 5. We already know this is given as one-fourth and of course, we do not know this this what we want to find and this going to be 0. So, substituting back you will get p which is the probability of B as simply 7 over 20. So, that is the answer if the events are actually exclusive.

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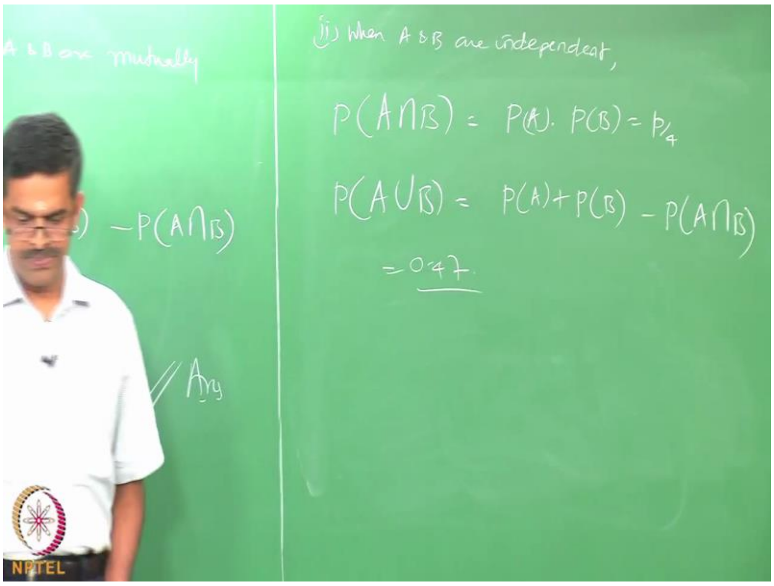


When the events are independent then, A and B are independent then this can be given by just p by 4, substituting back we get this value that is 0.47.

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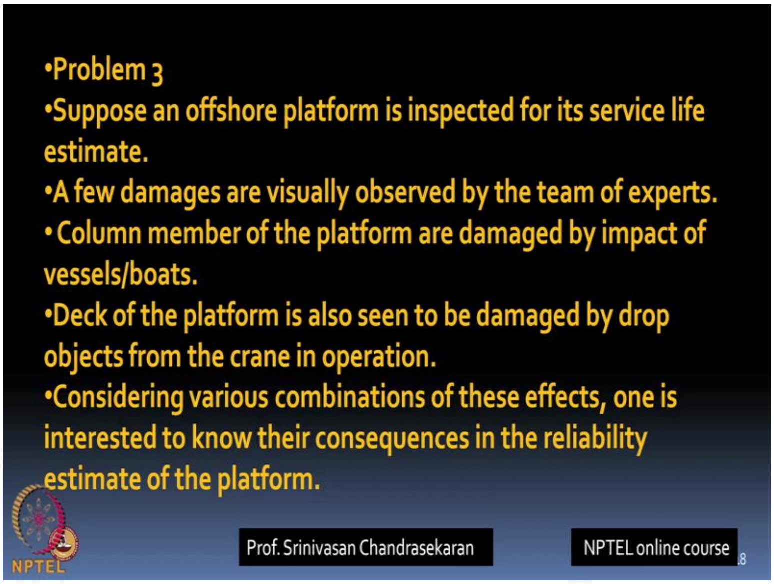


Let us look at the third problem. The third problem is on a screen. Now suppose an offshore platform is inspected for its service life estimates, a few damages are visually observed by the team of experts. Column member of the plat form are damaged by impact of vessels and boats. Deck of the platform is also seen to be damaged by drop objects from the crane when it was in operation. Now considering the various combinations of these effects, one is interested to know their consequences in the reliability analysis or estimate of the platform.

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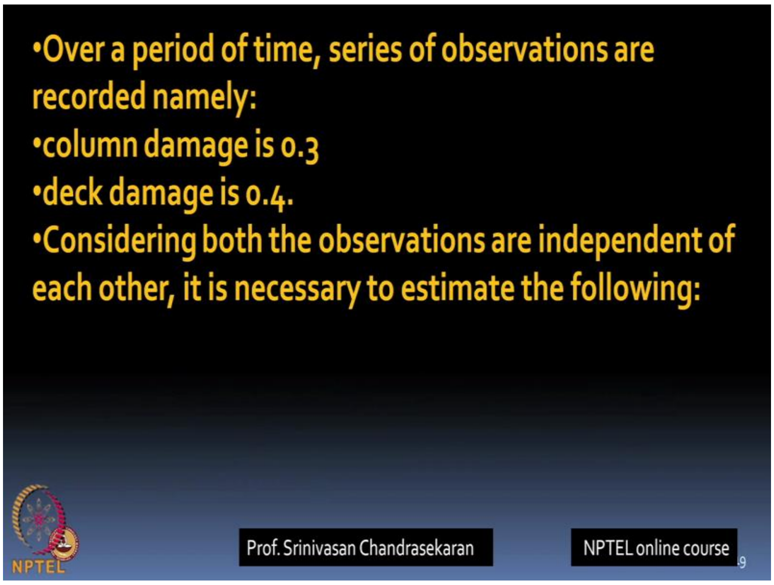


So, over a period of time series of observations are made, let us see the column damage is found to be 0.3, let us write down here.

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Deck damage is found to be 0.4 this is what the (Refer Time: 28:10) inspector and observe. Now considering both the observation independent of each other, it is necessary to estimate the following; you have to find the following. Both of them are independent, what does it mean? Damage of a column does not relate to the damage of the deck and vice versa, what do you want to estimate will be the following. Please look at the screen now, these are the questions which as be answered using this data.

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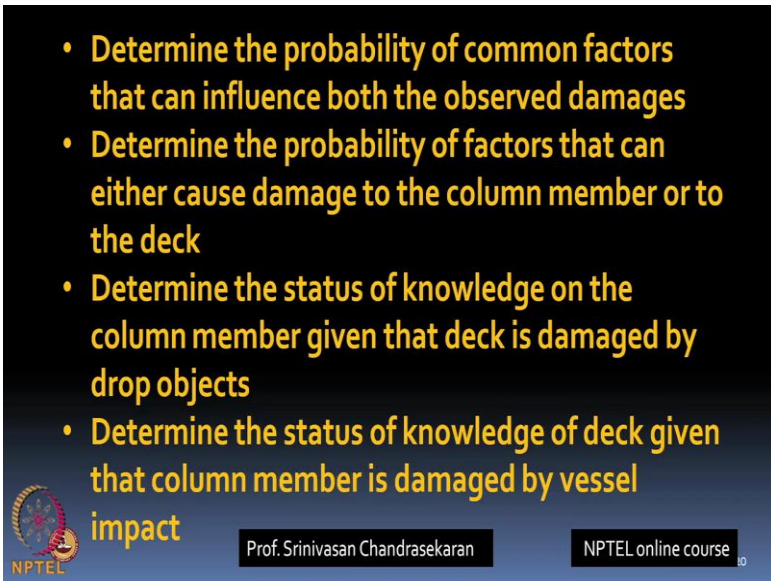


Determine the probability of common factors that can influence both the observed damages that is the first part of the problem. The second part of the problem is - determine the probability of factors that can either cause damage to the column member or to the decks. So talk about either column or deck. Third part of the problem, should answer determine the status of knowledge on the column member given that deck is damaged with the drop objects. Fourth could be determine the status of the knowledge of the deck given that column member is damaged by vessel impact or boat impact. So, there are 1 2 3 4 parts of the question which will answer one by one now. Let us try to answer them here.

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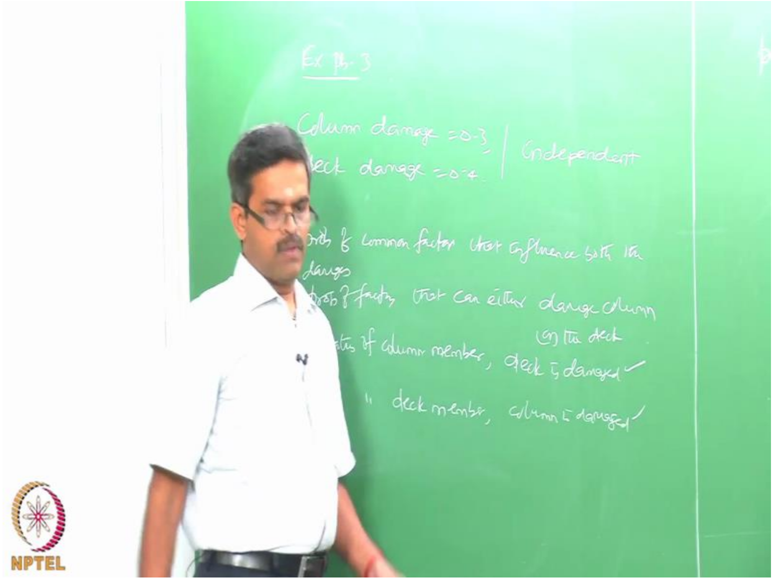


So, the first one what you want to answer is a probability of common factors that influence both the damages. Second part of the problem is - determine the probability of factors that can either damage the column member or the deck. Third could be, determine the knowledge status on the column member given that deck is damaged, so status of column member given that deck is damaged. Fourth could be status of deck member given that column member is damaged. Let us try to answer this.

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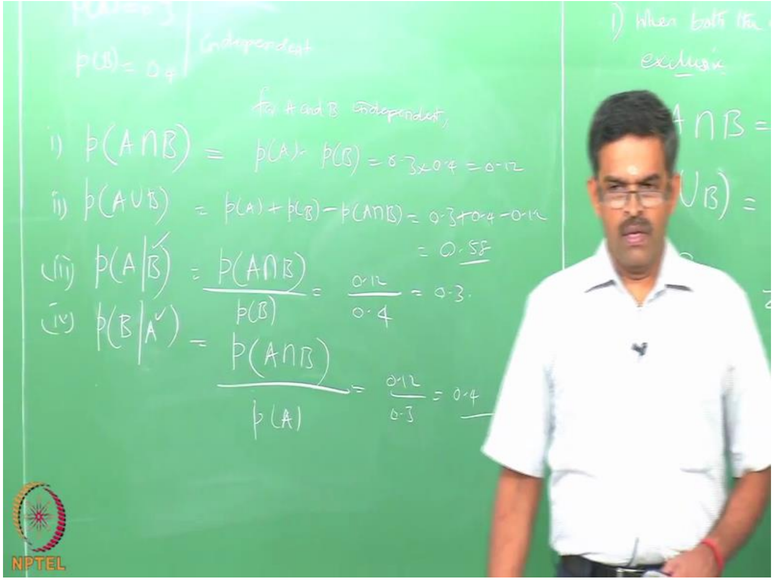


So, we already said both are independent. So, let A is indicated probability of A be 0.3 that is what I have written here which is column member damage. Let p of be the probability of the deck member damage which is 0.4 and both are independent, independent observation. What we need to find out will be common factor. So, I need to find out probability of A and B, I also need to find out the second one the probability of either column damage or deck damage A or B.

Third could be knowledge status of the column member provided deck is damaged. So, knowledge status of the column member provided, deck is damaged. Fourth could be knowledge status of the deck number provided column is damaged. So, if A and B are independent event, for A and B being independent I can say this is straight away given by probability of A, probability of B which can be now simply product of these 12 percent. So, the common factor between the consider damages will be about let say 12 percent.

If we really want to find the damage either column member or the deck number then I should say probability of A plus probability B minus probability of A and B, common factor. So, let us substitute them, 0.3 plus 0.4 minus 0.12 which comes to be 0.58. So, I now want to know the knowledge status on column member provided deck is damage.

So, this can be given by sorry A and B by probability of B, which can be A and B were denote 0.12 by 0.4 which gives me this point.

Similarly this is probability of A and B by probability of A which can be simply 0.12 by 0.3 this is about 40 percent. So, one can simply apply the bias theorem, total probability theorem, rules of probability, what we studied in the previous lecture directly by converting the given analogical problem into mathematical variables and try to list the problem convert the question asked into possible reasoning and probability theory and try to use respective rules and solve them easily with this.

Let us looked at the fourth problem, on a screen now.

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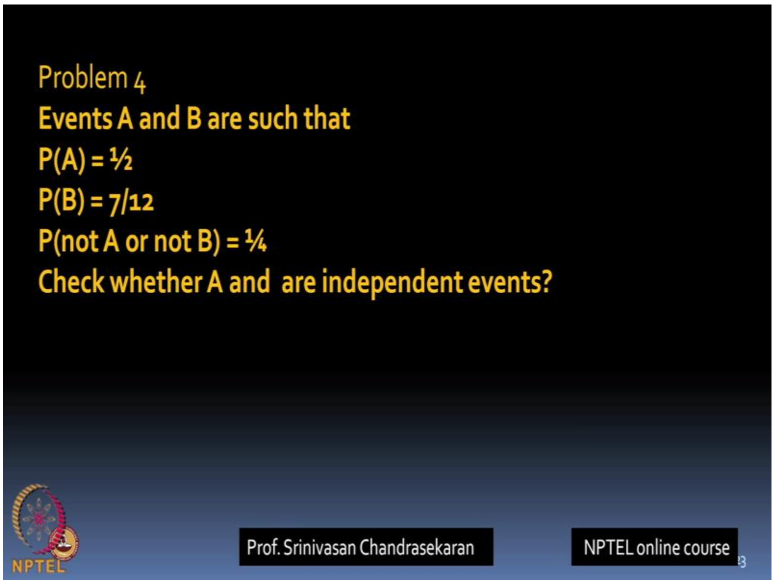


Let us say events A and B are such that probability of A is 50 percent and probability of B is seven by 12. Probability of not A or not B is 1 by 4. Check whether from the data A and B are independent. Let us try to answer this question.

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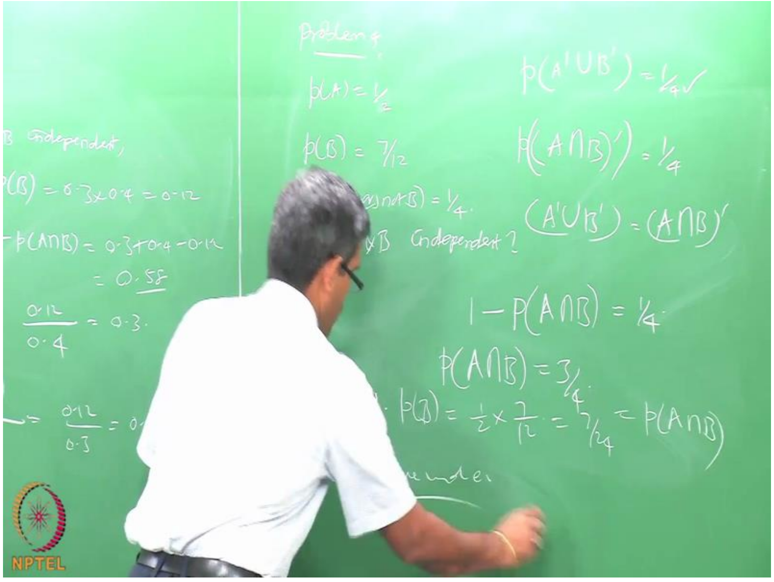


So, probability of A is 1 by 4 sorry 1 by 2, probability of B is 7 by 12; probability of not A or not B is 1 by 4. I want to check whether A and B are independent, are A B independent. So, we know p of A is 1 by 2, p of B is 7 by 12 A and B are the events. So, we also know probability of A complement B complement that is not A and not B, not A or not B is given as 1 by 4. We also know probability of A B complement, can be written as directly 1 by 4 from this knowledge because A complement B complement can be also said as A and B complement.

Therefore, 1 minus probability of A and B is 1 by 4 which means probability of A and B is given as 3 by 4. But probability of A, probability of B is actually 1 by 2 by 7 by 12 which gives me 7 by 24 is actually not equal to probability of A and B, therefore, A and B are independent events.

Let us do one more problem, look at the screen now problem 5.

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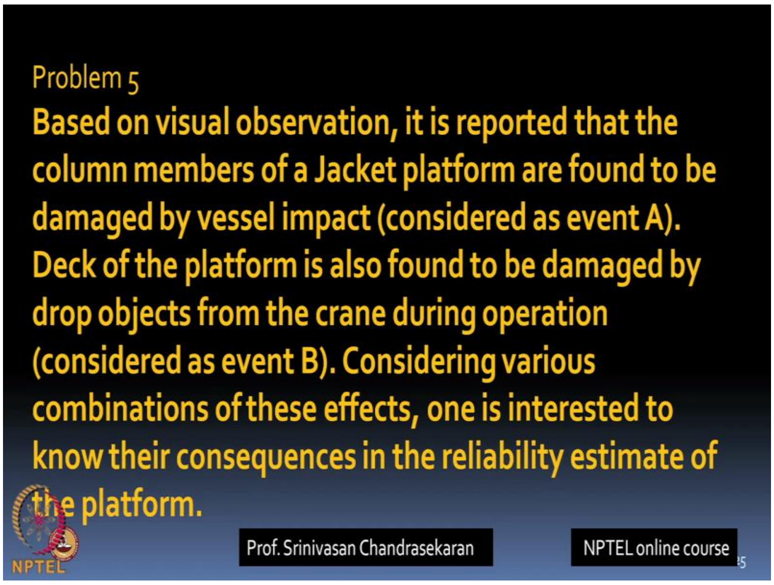


Based on visual observation it is reported that column member of a jacket platform are found to be damaged by vessel impact, we will considered this is event A. Deck of the platform is also found to be damaged by drop objects, we will take this as considered to be event B. Considering various combinations of these effects, one is interested to know their consequences in the reliability estimate of the plat form.

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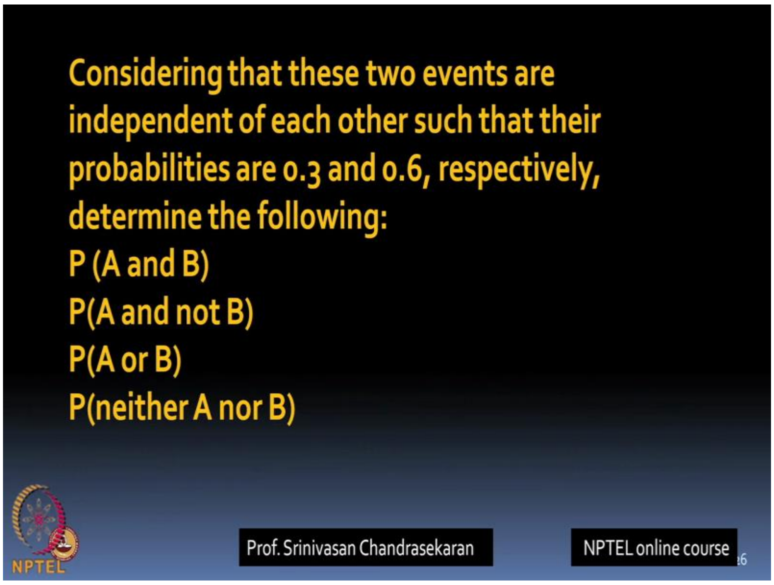

So, the problems in the extension the discussion what we had earlier - considering that these two events are independent of each other such that their probability of 0.3 and 0.6 respectively one is asked to find out probability of A and B, probability of A and not B, probability A or B and probability of neither A nor b.

So, I hope we will be able to do this problem based upon the same rules of probability theory what we discussed. The same application extended of the same discussion from example three is this problem, but I was asked liked in a different manner, we should able interpret the results.

There will be tutorial also based on some theory questions and some more example, numerical example on the first module which will be we available in the website. You try to answer this and reply this back to me as a submission of tutorial and substitute will also be posted back in the websites for further discussions. So, go through the lectures on module 1, summarize them and prepare them well with the additional reading material suggested in the (Refer Time: 39:51) website.

With this we will close the lectures on module 1. We have taken our 14 lecture on module 1. We will move on to the next module where will talk about Reliability Theory basics and Application of theory to offshore structures.

Thank you very much.