Dynamics of Ocean Structures
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Lecture – 22
Modal Response Analysis for MDOF

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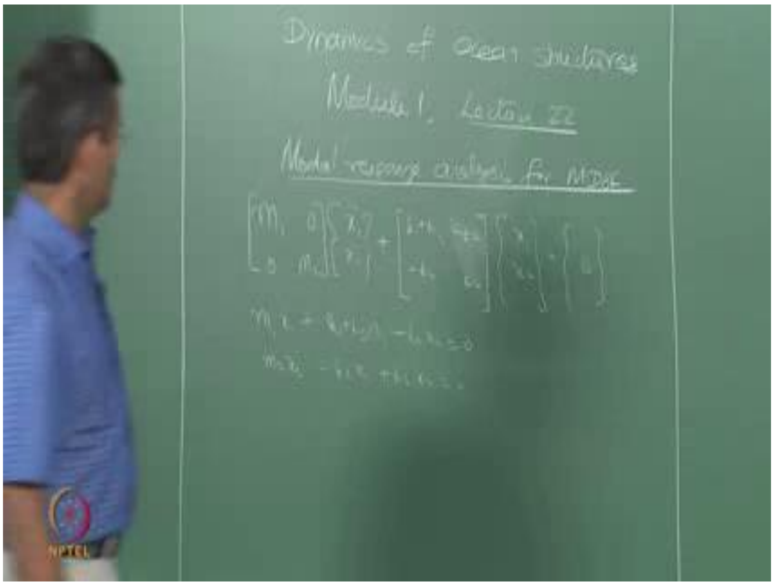

Let us start the modal response analysis in this class which is 22nd lecture and module 1. In the previous lectures we discussed about the numerical methods used for finding out Eigen values and Eigen vectors which are nothing but the frequencies and mode shapes. We have also seen that how they can be easily obtained using numerical methods and they are comparable by all the 4 methods, by which we have demonstrated with a couple of examples. So, we have also understood that 2 important essential characteristics of dynamic system, which is the frequency in mode shape. Frequency is important because you will you have to design the system, where you can keep away the band of frequency of the excitation force, from that of the natural frequency of the system. So, the system does not resonate. Mode shapes are important, because one would like to know what is the modal contribution in the overall response to the analysis.

So, we will try to discuss how the modal response can be made simple, if you have a normalized mode shapes. Instead of having a generalized mode shape, I want to normalize them respect to mass or stiffness, but let us quickly see what is the advantage. So, essentially what we do is, if you have got a normalized mode shape, we will convert the coupled equation of motion, to decoupled single digit equation of motion systems. So, if you have got n degrees of freedom you have got n equations of motion. You will see here I can simply write in the equation like this.

Let say m1 0. M1 0, 0 m2, of x1 double dot, x2 double dot, plus let us take only the system without damping. Let say k1, minus k2 minus k2 and k2 of x1 x2 is said to let us say 0, on f of t. We expand this equation of motion you will see that,, m1 x1 double dot, plus k1 plus k2, of x1 minus k2, of x2 will become 0. Similar the second equation will also have let us say m2 x2 double dot, minus k2 of x1, plus k2 of x2 is 0. So, if you have got n number of equations like this, you have got x1, x2 xn you will see that these equations are coupled.

On the other hand, the first equations have values, of response on x1 and x2 both. Similarly second equation will have x1 and x2, third will have x2 and x 3 and. So, forth you will not be able to decouple them. So, if you want to really find out the x of t, or x vector, of this whole system you have got to handle mass and stiffness matrix as a whole. You cannot decouple them, but if the mode shapes are normalized, you will see that the equation of motion will be decoupled automatically. So, the solution becomes very easy.

So, we will take up an example, and see I deliberately find omega and phi, which are non normalized. I will normalize in respect to mass matrix get a normalized vector. Then I will transform the coordinates of the entire equation, of motion from x vector to y vector, and I will solve in y, because y will become single degree freedom system equations. Then I get back to x. So, this is what we will demonstrate today. Show them with an example. I will take a 2 degree of reference with an example, because 3 degree you will be taking more time. We will take up about 2 degree freedom system, but the demonstration can be applied to n number of degrees of freedom of any order.

So, the advantage is, when you have got the mode shapes, which are orthogonal. Which are normalized with the mass matrix, it claims certain advantages. So, we will read them first, in the next lecture we will talk about the dampening estimates in different mode shapes, like damping and Rayleigh damping, then we will move on to modal truncation errors. I mean if you want to truncate the higher modes, what could be the error in the overall response. We will talk about that later, which is very important in seismic analysis and inertia force dominated systems, like offshore structures.

So, we will take an example now, and see what happens, if I have a mode shape which is normalized. And how the coupled equation of motion, we will get decoupled by transformation of coordinates from x to a y system. Let see how it is done. So, we will take this example for a demonstration.

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Let say my mass matrix is like this. Let say the stiffness matrix is like this and you do not have a damping matrix. I want to estimate omega and phi. Now one can ask me a question sir what happens to my f of t. Please understand omega and phi are essential characteristics of a given system, they will be and they must be, and they should be present in a system, even if the system is not excited.

So, it is a characteristic, which is natural property of the system. So, omega and phi estimates, does not should not vary and depend, on f of t at all. So, it is a free wave vibration characteristic essentially, it should not depend on the forcing function at all. So, f of t does not bother here at all in my equation and of course, I do not want to include damping here. Because we will talk about damping estimates slightly later, in the successive lecture, now, we all know that there is a 4, 5, methods. We know how to estimate omega and phi. Let us take up the conventional Eigen solver system, and try to demonstrate just to find out omega and phi 1, and phi 2, for this problem.

So, we know to find the natural frequency omega i. I must say determinant of k minus omega square m, and set it to 0. That is a standard Eigen solver solution. So, the determinant of 2 k, minus omega square, m minus k minus k2 k, minus omega square m should be set to 0. When we expand this, 2 k minus omega square, m the whole square minus k square, it should be set to 0. So, 4 k square, minus omega 4 m, square minus 4 k omega square, m minus k square is set to 0. Omega 4 m square minus 4 k omega square m, plus 3 k square set to 0. Let omega square be x. So, I get m square, x square, minus 4 k m of x, plus 3 k square 0 which is a quadratic in x. So, I can solve x1, x2, which are the roots of this quadratic it can be.

So, this will be 4 k m, plus or minus 16 minus, 12 has 4 root, k m by 2 m square. This gives me x1, as and x2, as that is omega square and omega 2 squares, as the lowest one is considered to be omega 1, because we have to very few omega 1, from the mode shape or let us try to correct it down we know that. So, 4 minus 2 is two, 2 k m by 2 m square. So, I get k by m.

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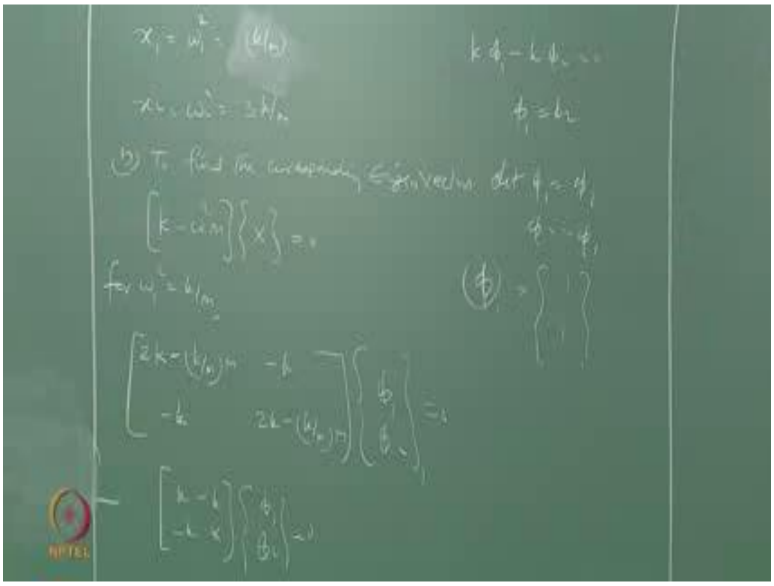

Similarly, 6 k m by 2 m square, 3 k by m it would be omega 1 square as k by m, and this is 3 k by m.

I want to find the corresponding vector, which is the Eigen vector of this. So, thus I can surface to find the corresponding Eigen vectors. So, the rule is simple k minus omega square m, x set to 0. A x is alpha x set to 0. So, for omega 1 square k by m, let us say k, that is this value, these are all individual matrices as remember. It is not a single value of k and single value of m. So, we are talking about multi degree different system equations. So, 2 k minus omega square i, must substitute k by m here. So, k by m of m minus k, minus k again 2 k, minus k by m of, let us say phi 1 and phi 2, is set to 0, there is a first mode shape. So, this amount to 2 k, minus k is k, minus k minus k, k of phi 1 phi 2 set to 0.

So, this shows that to expand this, k of phi 1 minus k of phi 2 is set to 0. It says phi 1 is phi two. So, there are 2 unknowns there are 2 equations, but still we cannot because both the equations will give you the same meaning. So, let phi 1 be phi 1, and phi 2 will also be equal to phi 1. So, the mode shape of one that is the first mode shape will be equal to 1 and 1. So, since the first mode shape is positive, I can say this is the fundamental frequency of the given system because there is no 0 crossing.

So, similarly substitute omega 2 square as 3 k by m.

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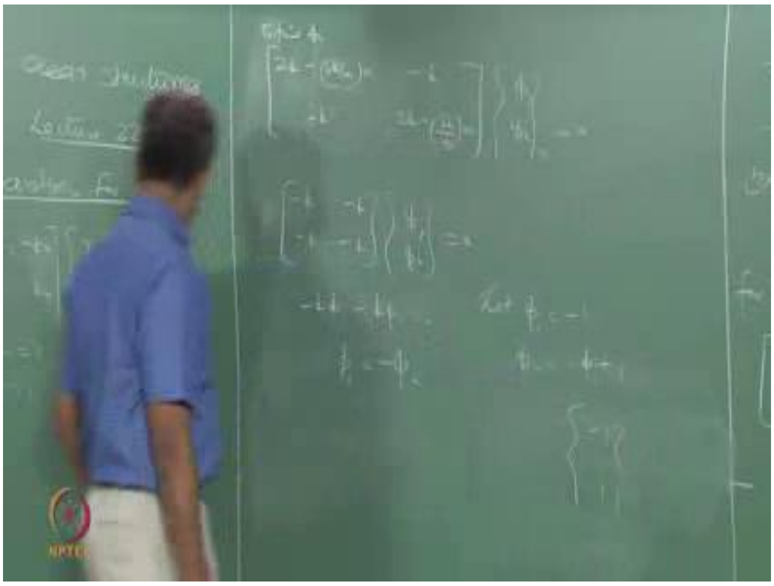

So, to find phi 2, 2 k minus 3 k by m of m, minus k minus k 2 k minus 3 k, by m of m a matrix multiplied by a vector of phi 1 phi two, but of the second vector set to 0. So, this implies minus k, minus k, minus k, minus k, of phi 1 phi 2 should be set to 0 this implies minus k phi 1 minus k phi 2 is 0 this shows me that phi 1 is minus of phi two. So, let phi 1 be minus 1 and phi 2 will be minus of phi 1 which is plus 1. So, the vector is going to be minus 1 and 1. So, I got 2 vectors now here omega 1.

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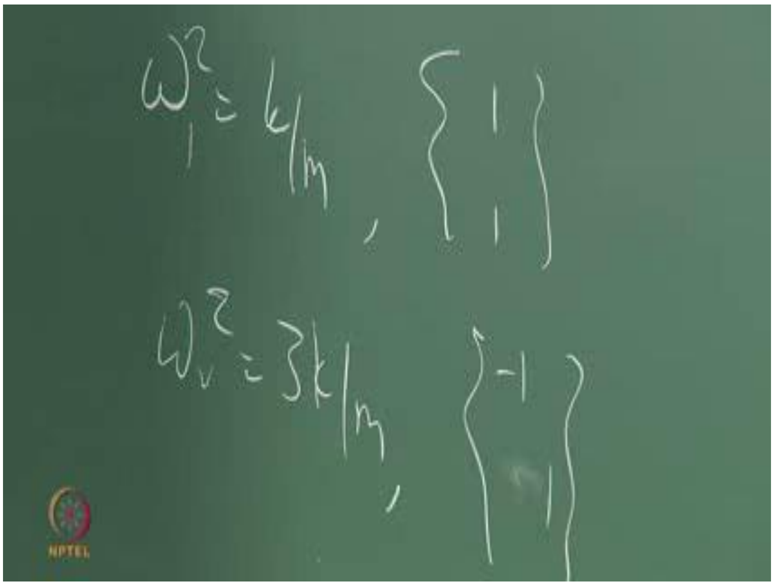

Square is k by m, and the corresponding vector is 1, and 1 omega 2, square is equal to 3, k by m, and the corresponding vector is minus 1, and 1.

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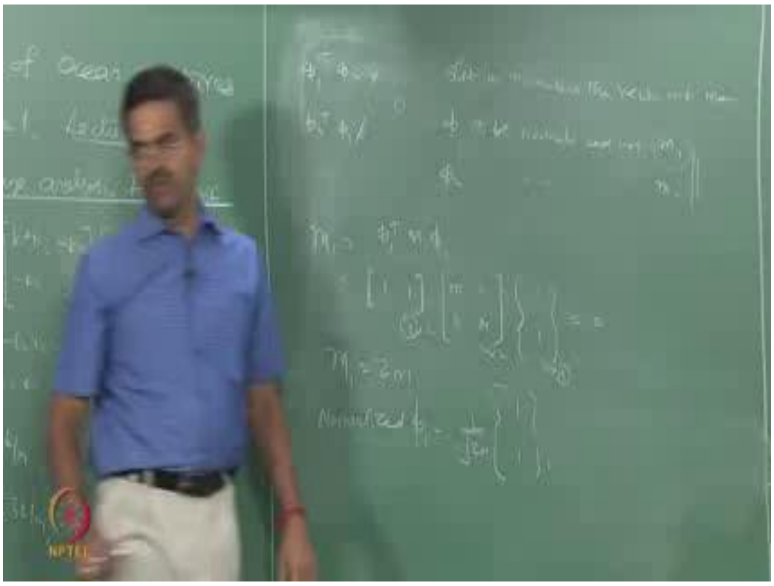

You can always check that phi 1 transfer's phi 2, just check this. Or let say phi 2 transfers phi 1, will not be equal to 0. The cross product should become zero, but they will not. So, they are not normalized. They are not equal to 0.

So, I want to normalize it with effect to mass or stiffness, both let us say, what happens if we do it with mass. So, let me find out. So, let, let us normalize the vector with respect to mass. So, that is phi 1 to be normalized with respect to m1. And phi 2 to be normalized with respect to m2 and so on so forth, because we have got to multiply them with the mass matrix why m1 and m2. The advantage the greatest advantage in the dynamics you please understand the half diagonal terms are actually 0.

If you do this with respect to k, you will see you will get the some other different values. I will show you later. So, it is also advantageous to normalize them, with respect to mass. So, if you look at the evaluation of the dynamics in terms of forming the equation of motion problem itself, the coordinates are chosen the point where the mass is lumped in a given system mass is definitely lumped, and only mode shapes represent the relative pressure of the mass. So, mass becomes very important focus in the whole dynamic evolution itself actually.

So, in a given system if you are able to identify the mass matrix and lump those, in a specific location where you want to measure the displacement. I think thirty percent of your dynamics problem formation is complete, because all the exercises are focusing only towards the inertia forces. I could always normalize this with respect to k also. I will show you if you do that with respect to k you will get back the Eigen values actually. I will show you how it is done therefore, we do not want that we want this. The advantage is half the elements are 0. You get a greater advantage this will decouple the motions. Now the equation of motion will decouple we will see how.

So, let us do that. So, let me find out the value of m1. This m1 is not equal to this value. Please understand the notation may be same m1 is a value with respect to which I am normalizing phi 1. This phi 1 of course, not equal to this phi 1, this is the vector now the full vector which is nothing, but 1 1. The moment I say phi 2 it is minus 1 and 1. I am talking about the full vector. Now these are elements of the vector, though the notation may see be same, but do not get confused. So, I must normalize the first Eigen vector that is what I am saying Eigen vector, with respect to the m1 value, and subsequently with respect to m2 value.

So, what is that m1? So, called let us try to find out that. So, m1 should be equal to phi 1 transpose m phi, because I have to normalize it with respect to mass matrix. So, let us do that. So, phi 1 transpose will be 1 1. The original problem is m and 0, and 0 and m, m, and 0 0 and m. Because this is a example problem which you taken for demonstration m and 0 and m, and then this vector is 1 and 1 set it to 0. So, you can see the compatibility 1 of 2 2, of 2 2, of 1 you will get a unique value which is 1 and 1 only 1, value you will get that value I am addressing as m1. This m1 is not equal to the m1, in the given problem there is a value with respect to which, I will normalize phi 1, why because normal phi 1 is not normalized. Had phi 1 would have been automatically normalized I must get this product as 0 which I am not getting ok.

So, I am normalizing it. One can ask me a question that if I normalize what is the advantage. Please wait I will show you the advantage later. First let us first normalize this. So, can you do this is what is the value of m1. Simple multiplication just finds out what is the value of m1. So, m1 is going to be equal to 2 m. So, therefore, normalized phi 1 should be 1 by root 2 m, of 1 and 1, that is all. Simple and write down the value here. 1 by root 2 m of 1 m, normalized.

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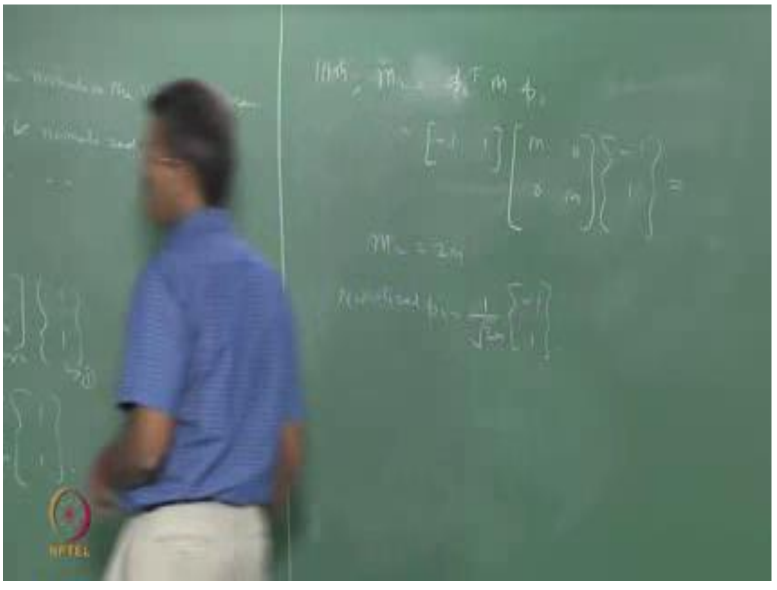

Similarly, can you find m2? I say similarly. M2 should be equal to phi 2 transpose m of phi 2, phi 2 is minus 1 1. M is m 0 0 m. And phi 2 is minus 1 and 1. Should become let say m2, and can you find what is 0. How much 2 m? Can I say normalized phi 2 is 1, by root 2 m of minus 1 and 1. That is the problem. So, we call this value now.

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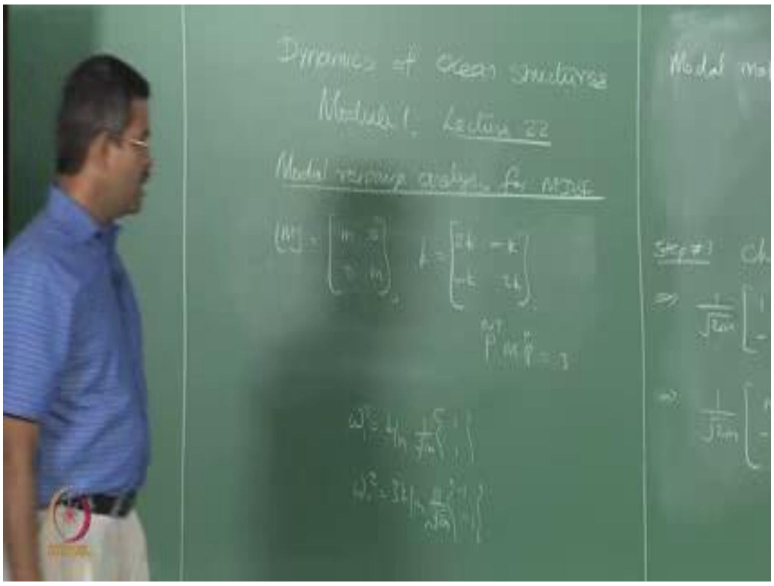

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I will call a new term called modal vector. Which is called as capital phi capital phi is nothing, but 1 by root 2 m of each vector separately. So, I can even call this is a modal matrix instead of vector.

Now, I give a new name to this p tilde matrix. Now let us check. This is step number 3 what we do in step number 1. Step number 1; we do the equation of motion. We found out omega and phi. Step number 2 we found out the normalized vector is of phi 1 and phi 2 with respect to the mass matrix m1 and m2. Step number 3 we want to check p tilde transpose m p tilde, let see what happens to this matrix 1 by 2 2, m of 1, 1, 1, 1, minus 1 1 of m 0 0, m of 1 by root 2 m of 1 1, minus 1. Compatibility it is perfect because 2 by 2 2 by 2, and 2 by 2, you get an answer as a 2 by 2. Let see what is the 2 by 2 you are getting.

So, this will be 1 by root, 2 m of m minus m, m m,1 by root m, of 1 minus, 1, 1, 1, which will give me, 1 by 2 m of, which will become is it, not this is the advantage. You get this is advantage. So, I can blindly say that p tilde m p transpose, will become identity. Let us do this for p tilde, k p, let see what happens.

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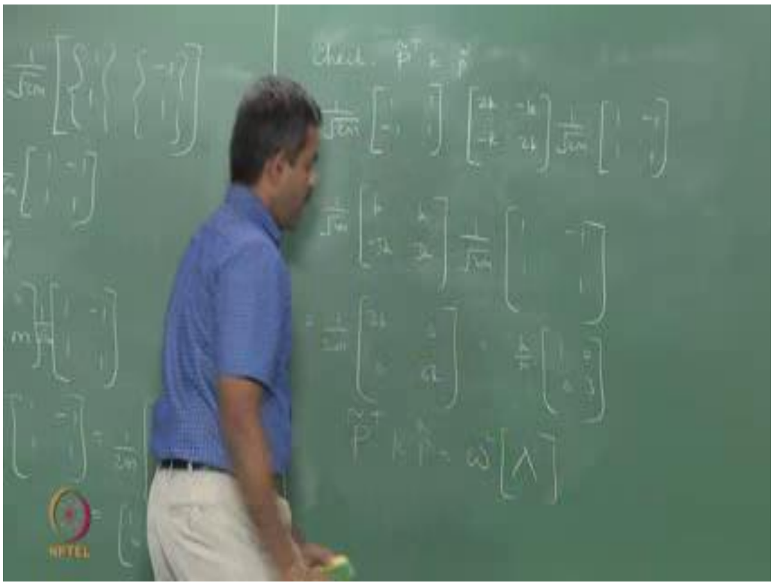

Which implies, very intelligently, we can interpret this slightly in a different way see, what happens, I can say p tilde transpose k, p can be written as omega square m, where this is an Eigen value, because Eigen values for this problems, are k by m, and 3 k by m. So, when you have got a normalized vector, or an a normalized modal matrix which is generalized, or normalized with respect to mass matrix, you have got 2 advantages one the multiplier of this order, will become identity the multiplier of this order, will give you the Eigen values directly.

So, when I encounter such multiplications in my equation, I need not have to do the multiplication any more. I can straight away use these values, and the equation of motion will become thoroughly simplified actually. Now let us apply this concept and try to decouple the equation of motion, by changing the coordinate system from x to that of y. Why we want to decouple because if we change the transformation of coordinates to x to y, you will see originally the equation of motion is coupled on the other hand the term x1 will have reference of x2 and the term x2 will have reference of x1.

Now, I want to have decoupling of these two. So, they will become individual single degree freedom system equations. I already we know how to solve a single degree freedom system, be it in x1 be it in x2, we know how to solve them that is the idea. So, having understood this, part let us rub this, and take this to the step number four.

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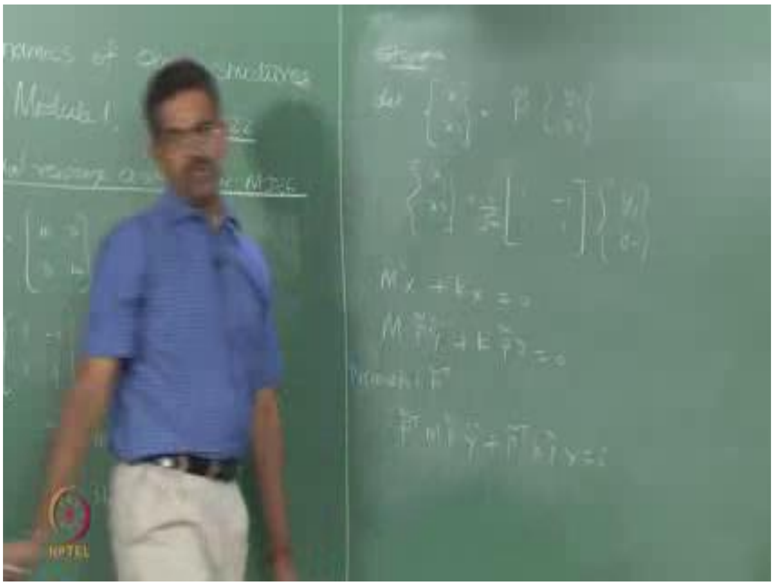

Where we will demonstrate the advantage, of this procedure, for solving the problem ultimately I want to know the x vector, of this equation of motion which is my response vector.

Step number 4, let x vector which is the original vector be expressed as, b tilde of y vector. On the other hand x1, x2, it can be now expressed as 1 by root 2 m, of what is the p tilde vector, is this the p tilde vector, of y1 vector . So, now, m x double dot, plus k x is set to 0. That is the original equation of motion. I relate the equation of motion because, I know x vector is p tilde times of y vector. Therefore, I can say m x double dot vector will be p tilde times, of y double dot vector, plus k of p tilde, of y using the same relationship, as above. I can write this I pre multiply this equation by p tilde transpose see what happens, p tilde transpose m p tilde y2 vector plus p tilde times, force k p tilde of y vector becomes 0. We already know this is the identity, and we already know that is Eigen values. So, let us substitute that here.

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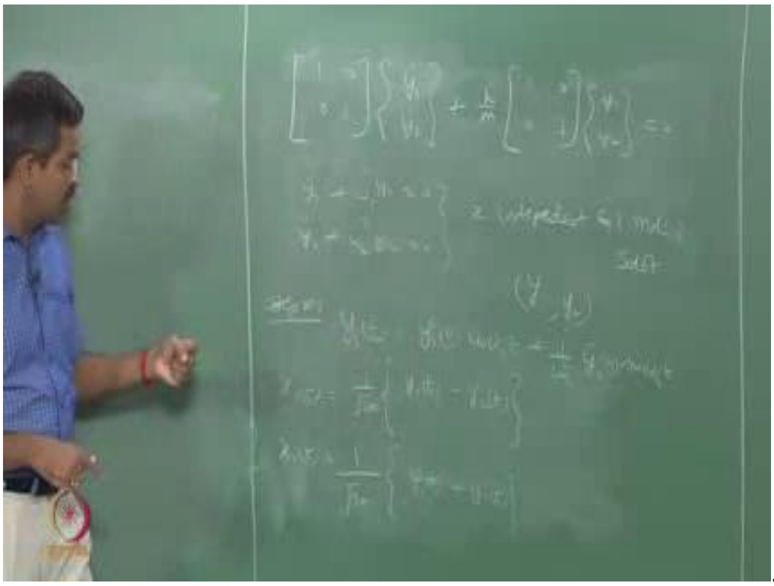

Now, let us read this equation y1, double dot plus, omega square y1, is 0. It is a single degree of freedom system actually. There is no y2 term in this. Similarly y2 double dot plus omega square y2 is 0. We can say for clarity omega 1 square and omega 2 square. Because they are 2 different values, but originally equation of motion had x1, x2, terms in both the equations. Now I do not have y2 term in equation 1, I do not have y1 term in the equation 2, I have decoupled. Them now this is a single degree of freedom system. So, if we have the multi degree freedom system like this, I will have n numbers of single degree freedom system problems. Remember friends this is applicable only when your mass matrix is diagonal, when the mass matrix has got half diagonal term, this is not possible you will not be able to do it, you may wonder I can do it with respect to k, if you do that with respect to k, you get omega's back actually, you will not get identity matrix we have shown that already.

So, the only possibility of getting identity matrix is, if you do it with respect to mass and that mass is diagonal half diagonal terms as 0. Usually it is a practice, but in offshore structures half diagonal terms will not be 0. There are examples, I will show you where they are not 0, in that case equation of motion cannot be decoupled that is called coupled dynamic analysis. So, now, I already know these are these are 2 independent, I can write here 2 independent equations of motion, or a single degree freedom system, in y1, and y2 respectively. So, I can solve them I already know the solution, for single degree freedom system in y1 I write it in general step number five.

we know y I of t is it not general. I may be either the first or 2, that does not matter y I of t single degree undamped system free vibration, y I of 0 cos omega I t plus, 1 by omega i, y dot I of 0, sin omega i, t that is the general solution, but I am not interested in getting a y I of t. In fact, I do not want y1, of t y2; of t I want x1, of t and x2, of t because my equation of motion is in x actually. So, let us apply this equation back again, here if you want to know x1 of t. So, x1 of t it can be 1 by root 2 m, of y1 of t minus, y2 of t. Similarly x2 of t can be 1, by root 2 m of y1, of t plus y2 of t. Now the problem is very simple, if you know y1 of t, and y2 of t.

Now, the problem is complicated. Because y1 of t, and y2 of t, depends on initial conditions on y of 0, y dot of 0. I do not have them with me. I have only x 0 and x dot of 0 with me, the original boundary conditions given in the problem are related to x only. So, I have to convert those original conditions, on the y frame substitute them, here get yi's put them here get xi's.

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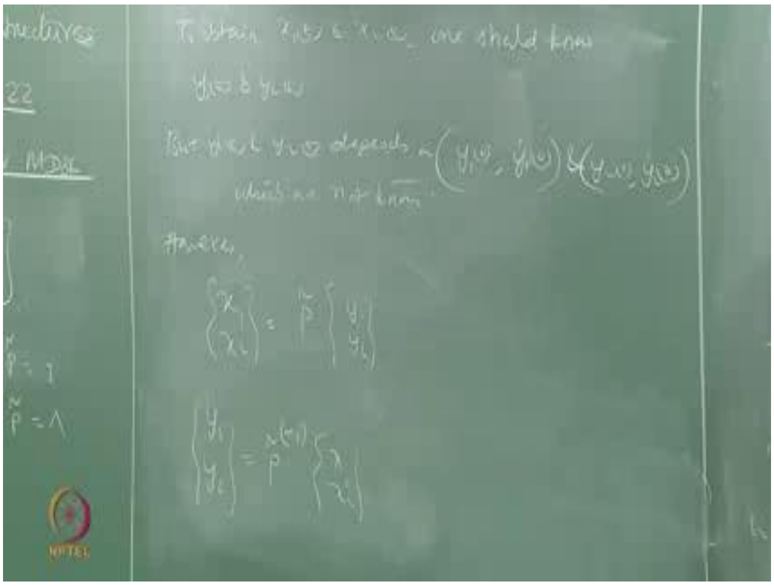

Now to obtain x1 of t and x2 of t, one should know y1, of t and y2, of t, but y1 of t and y2 of t depends on y1, 0 y1, dot 0, and y2 0, y2 dot 0, which are not known, but; however, x1, x2, was equal to p tilde, of y1 y two.

So, now I can say y1 y2, it can be equal to p tilde, inverse of x1 x2.

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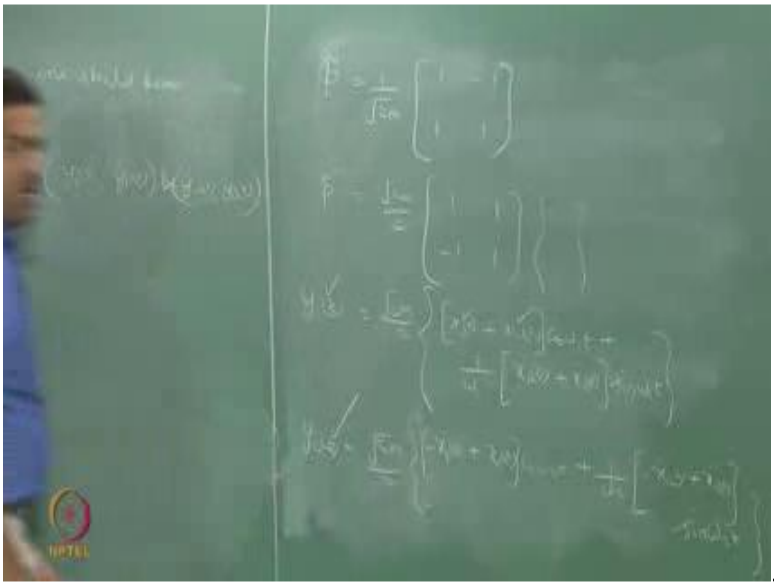
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So, p tilde matrix already, we know let us find p tilde inverse, can you give me this inverse yeah, 1 are you saying row wise is a column wise.

Student: Row wise.

One that is all.

Student: 1 by 2.

Now, I can expand this. Y1 of t will be equal, to root 2, m by 2, of x1 0, plus x2 0 of cos omega 1, t plus 1 by omega 1, of minus x1, dot 0 plus x2, dot 0 of sin omega, 1 t. This value we already, know because they are at zeros, initial conditions, they are not the answers x1, of t is the answer, which you want for the original equation of motion, but they are x1 of zeros, and x1 dot of zeros, which are initial conditions in the given problem. We already know them this is also going to be positive only. Because I am going to multiply the row with the column, this is also going to be positive, only both are because they are both are to be corrected with x1, zeros and x1 dot zeros.

Similarly, y2 of t. Root 2 root 2 m by 2 of minus, x1 x2 0 plus x2 0, of cos omega 2 t plus, 1 by omega of 2, of minus x1, dot 0. Plus x2 dot 0 of sin omega 2 t. The moment I know y1 of t, and y2 of t, I can get x1 of t and x2 of t, from this equation. Because p tilde matrix is known to me that is the advantage you have when you have got a modal matrix. So, this column modal matrix p tilde, which is a normalized vector of the corresponding Eigen value pair, which is normalized with respect to the mass matrix, why, because mass matrix has got half diagonal term 0. When you multiply this vector or this matrix, with the mass matrix you will get an advantage, of the identity which is being used in decoupling the equations of motion to solve them, easily as equivalent n number of single degree freedom system models.

So, it is very easy. So, we have never solved any matrix here at all. We simply used only the single degree freedom system knowledge, and found out the solution for a 2 degree freedom system problem, without actually solving any matrix at all. So, this will be easy even if you have got a large size of matrix, because this is repetitive. You see this is repetitive. If you know the initial conditions, this is repetitive you can plot. So, it is very easy to decouple them provided you put 2 conditions 1 the mass matrix becomes half diagonal term 0, and the normalization is done, with respect to the mass matrix and not with respect to k, if you do that you get Eigen values here actually.

So, that is the advantage. So, Eigen values and Eigen vectors both are very important dynamic analysis. When you are not able to normalize them, you call that analysis as coupled dynamic analysis, when you are able to decouple them. You can easily solve the equation of motion like this most of the cases in engineering generally people use this technique, to solve n number of equations of motion to get the solution that is the solved means what you must get the x1, of t values x1, of t values. Let me for complete sake let me write this also. So, I will remove this here. I will write for completion sake let us write this.

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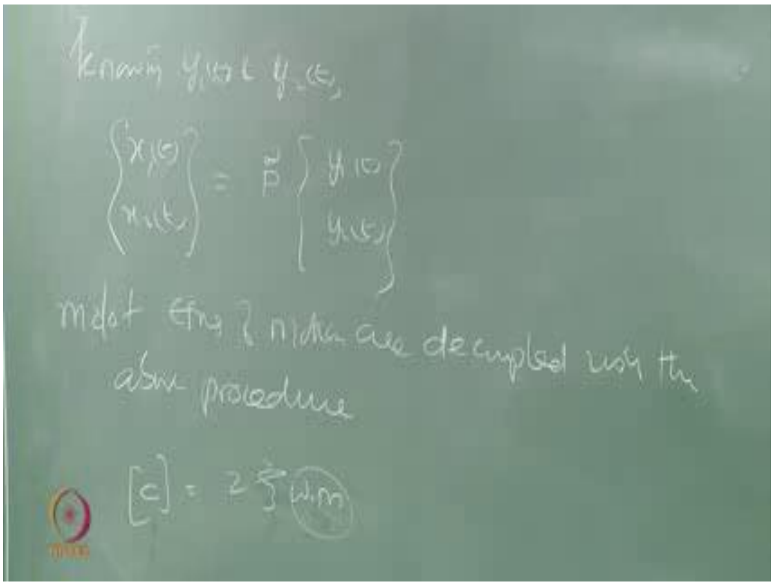

So, knowing y1 of t, and y2 of t x1 of t x2 of t can be simply found out as p tilde of y1 of t and y2 of t, because t tilda is known to me. So, the multi degree freedom system equations of motion are decoupled. Using the above procedure that is all

So, in the next lecture, we will talk about estimating of damping in different modes.

Probably we have found out an equation of c or the estimating of zeta only for a specific single degree freedom system problem. If you have got multi degree then the modal or the damping coefficient in each mode can be evaluated separately that is, important which mode is damped larger and how much. So, we must have estimate of damping in different modes, which we will discuss in the next lecture. So, there are 2 methods available in literature which we will discuss both of them one is Rayleigh's method other is Kahei's damping method. We will discuss both of them, and see what is the advantage what actually is the modal followed in offshore structures, and we all know that damping essentially comes from 2 zeta omega m.

So, it is actually a dependent variable of k and m. So, the damping should give me a proportion of k, and proportion of m that is the idea, what is the proportion if k is 100 percent or m is 100 percent in what mode, and how much that is the idea, how to catch this idea, is what we will discuss in the next lecture. So, is there any doubt now at this stage? So, we have discussed about 22 lectures, successfully in dynamics first module where we are talking about the fundamental of dynamics, which is applicable to all types of structures not only ocean structures, but application of this ocean structures in terms of design is very important, which I trust upon in my previous lectures, as well as in my textbooks also given.

Relevant examples how to relate this to the design concept in dynamics, of offshore structures, but we will extend the study in detail to arrive m k c, and of course, except t that is a vector, for a given problem whose f of t, is taken from earthquake load wave load current load etcetera, the real life problem. We will take up a t l p a real life offshore structures we will also discuss offshore structures of a new generic form, which we have developed at the IIT Madras patented to IIT Madras we have got excellent structural forms which we patented to IIT Madras, which is got very good representation in the international literature.

So, we will discuss about that experimentally, analytically, numerically, the results which will be very novel idea for research frontier, research domain in terms of dynamics, applied to ocean structures, there we will emphasize on ocean systems more in detail. Once we understand the second module thoroughly. The third module will be for advance dynamics where I talk about stochastic dynamics, which will be completely advanced in terms of dynamic application, in any type of structure especially in offshore structure where fatigue loading becomes very important, in terms of tether pullout stability of structural challenge etcetera. So, that will be very interesting. So, that is the area where we are going to touch in model 3 that is the whole program.

So, friends the examination for the particular course, is now open in NPTEL, you have got to register for the examination, it is not free. For NPTEL it may be the core structure is free under mhrd, but for examination a bare minimum, charges are being levied for conducting the exam all over the country, in fact, all over the world as well. So, the examination registration is already opened. It will close on ninth march. So, we have got about approximately 2200 participants, listening to this course now internationally from about 250 participants are from countries, other than India remaining all are from India. So, you can complete your intelligence, with about 2000 internationals or 2000 students where many of them may be practicing engineering, many of them may be research scholars, with themselves many of them may be faculty.

So, you will really know where do you stand in terms of here, because your certificate will indicate the percentage performance in the course, I had on this is a unique opportunity, you will never get this opportunity back again, you may get a grade in the class of a class of maybe 30, 25. Who all does not know dynamics at all, fine? Getting s grade is not very good index of your intelligence, whereas, getting a grade now in this case in percentile, competing internationally with people who know the dynamic subject is very important, and is very interesting that where do you stand will rate you. So, that is important. So, the registration is now open for the exam. Please register online. Then you will attend the mock examination, and the exam will be conducted in the end of I mean 9th and 16th of may. It is available in the website of NPTEL please see that and most importantly now start referring to textbooks, where you will see the clarity.

What actually people talk about dynamics in terms of application. You will find maybe there are n numbers of textbooks available in the market. I am I am respecting all authors all publishers who have contributed to this domain of research, for the past about 30, 40 years. I will with respect to all the authors and all the publishers and all readers, I want to make this statement opened in the web domain, that clarity in terms of understanding dynamics applied to structures, is very rare, it is very rare. I am handling this subject for the past 23 years, it is very rare. Clarity is missing actually. So, you must be intelligent enough to select a book which you want to follow.

Now, if you open some of the textbooks which are listed in NPTEL, you will find that you will enjoy reading of dynamics, like reading a very casual arts, and science magazine. This is where dynamics is made easy into, lecture media, as done in NPTEL. This is the actually mission of NPTEL. I we want to actually make the subjects which are very difficult, for people to make it as easy as possible. We do not want to take you intrinsic vertical. We want to take you to make first subject friendly, subject easy ready reference is available text is conveyed easily, numerical are solved in your presence with a calculator. You have a confidence yes I can now do dynamics as a friendly subject let it be simple mathematical course.

Once we get that confidence, research of writing equation of motion solving, them for a new structural form, which is an essential part of offshore structural research itself, because we all said offshore structure, is moving towards deeper platforms deeper water desk exploration, the conventional forms will not work. So, you have to go for new structural forms. For all new structural forms there are no readymade solutions available, even from the start stage of design itself, you have got to start from yourself. So, you must know how to derive m, you must know how to derive k, if you have these 2, how to adjust k and m in terms of omega not coming in the bandwidth of omega bar. So, the design and dynamics should be coupled, as a research perspective in the domain of research of offshore structures.

This object of this module will certainly, definitely help you to understand make the subject user friendly first, make it comfortable and convenient even to a under graduate student that is what our aim is. So, try to compete your intelligence level in terms of examination, in this course. Understand where do you stand, why I am giving this preamble because, as we move towards the lecture module in module 2, you will find they are going to be slightly of a higher order of difficulty. Many people amongst you or amongst the viewers may not focus on module 2, as comparable to module 1. When I move to module 3, about 78 percent of them will opt from this subject actually. Only people who have understood module 1, thoroughly will take themselves to be prepared to module 3, otherwise remaining all will flow to module 1.

Interestingly, institutes and departments which teach ocean engineering only, will take you to module 2. All other departments or engineering programs where people do not apply them to ocean structures, will have no specialty in dynamic analysis, because I will show you examples where my k, is un symmetric my m, is half diagonal terms present. This is the very unique problem only in ocean engineering therefore, attend to this course in ocean structures gives you an, actually add an advantage, which will through light on second module.

So, first let I make you to understand this comfortably. Why I am saying this statement because if you are not able to understand the first module thoroughly, if your half way here be sure, that you will revise the complete lectures in module 1, before we attempt to touch module 2. Otherwise you will be very difficult. So, try to rehearsal all the lectures and numerical examples and tutorials given to you, at least follow couple of textbooks, read lot of journal papers, to develop interest in dynamics.

Thank you.