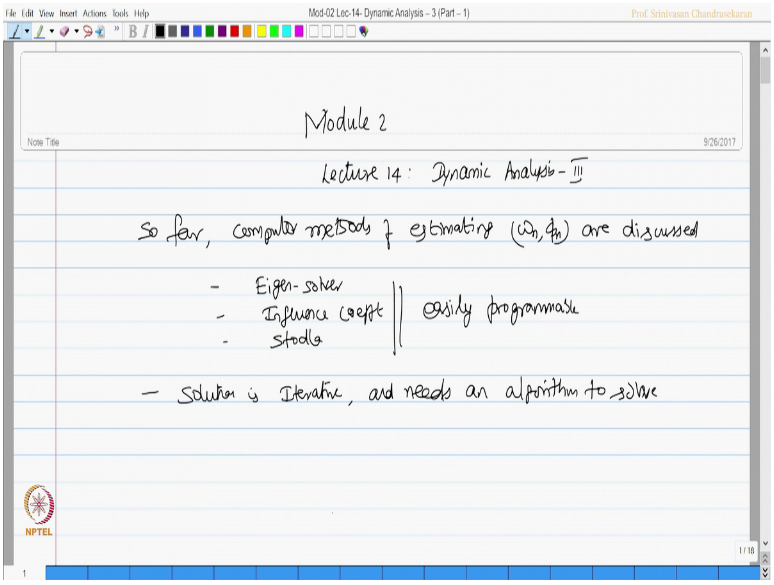
Computer Methods of Analysis of Offshore Structures
Prof. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Module - 02
Lecture - 14
Dynamic Analysis - 3 (Part – 1)

So, friends let us continue the discussion on the 14th lecture in module 2.

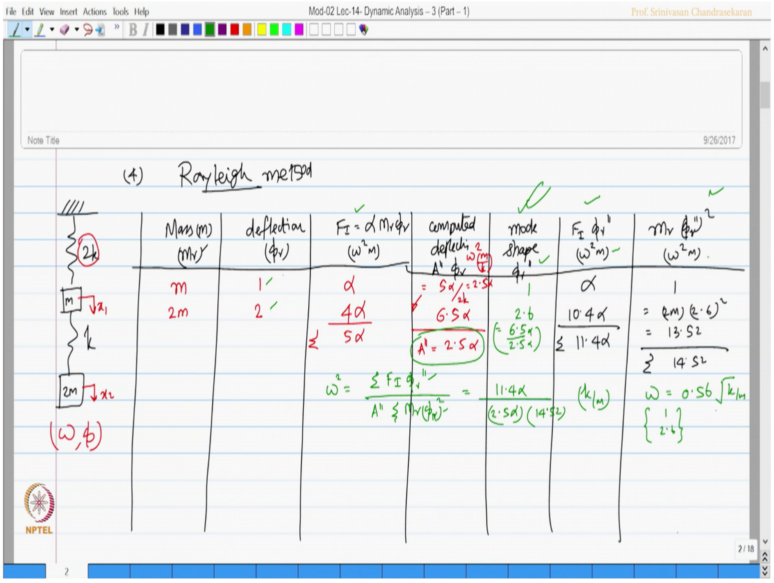
(Refer Slide Time: 00:35)



We are discussing computer methods of estimating natural frequency and mode shapes. So far in computer methods of estimating natural frequency and mode shapes are discussed we have discussed Classical Eigen solver method, we have discussed Influence coefficient method, we have discussed Stodola's method, all are easily programmable. The solution is iterative and needs an algorithm to solve.

Let us now discuss one more method which is the 4th method which is given by Rayleigh which is again a numerical method which is easily programmable.

(Refer Slide Time: 02:01)



Let us take an example, demonstrate this method let us take a problem which I am drawing here, it is a this is 2k, this is k, this is m and this is 2m and the degrees of freedom are this is x 1 this is x 2, we want to find omega and phi for this system.

So, let us take Rayleigh method it is again a tabular form numerical in method, let us say mass deflection which I call as phi r which I call as mr, inertia force which is alpha mr phi r where units of omega square m are kept outside. Then we say computed deflection which is A double prime of phi r then we say mode shape which is phi r double prime then we say F I of phi r double prime then we also find mr phi r double prime square.

Let us try to make a table enter these values. Let us say I want enter mass m and 2 m these are the mass values. I assumed the deflection with no zero crossing as 1 and 2 arbitrarily I assumed this value, I take the deflections as the spring values which is mr phi r which is alpha omega square m is constant. Here mr phi r which becomes 4 alpha omega square and mr taken as constant.

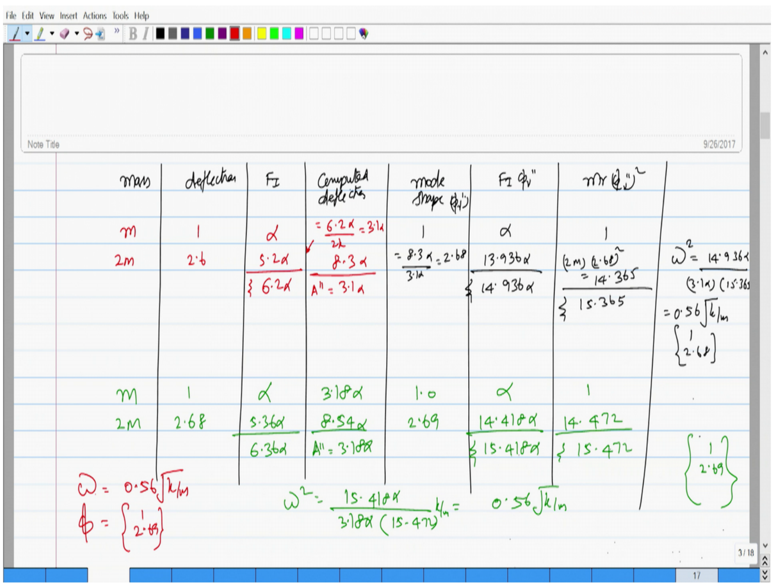
So, I make this sum the sum is phi alpha. I find this value is actually equal to this phi alpha divided by this stiffness which is I write here as 2.5 alpha and I will have a constant omega square m by k 2.5 alpha. By the same logic I can say this will be 4 alpha by k, but the summation will be 2.3 plus 4, 6.5 alpha.

Now, I take a multiplier a double prime as 2.5 alpha therefore, the mode shapes become 1 and 2.6, this 2.6 nothing but 6.5 by 2.5. Once they do this I will then find F I multiplied by phi r which is simply alpha and 4 alpha into 2.6 that gives me 10.4 alpha I sum this up I say 11.4 alpha. Then in the last column I find mr multiplied by phi r square. So, this is going to be simply 1, here also I have omega square m constant and here also I have omega square m constant and this is going to be equal to 2m multiplied by 2.6 square which is 13.52. So, I make the sum this is 14.52 and so on.

Now, I want to find omega. So, I get omega I get omega as sum of F I phi r that is this column divided by a double prime which is this value into sum of mr phi r square that is this column. So, that is going to be equal to 11.4 alpha by 2.5 alpha into 14.52.

So, we substitute the units you will see this value will be in omega square m this value will be omega square m they gets canceled, they will cancel and this will be having a multiplier omega square m by k. So, I get omega square m by k. So, k by m is subset I can say that, this omega square k by m.

(Refer Slide Time: 10:32)



So, if we substitute that and take a root I get omega as 0.56 root k by m and the corresponding vector is 1, 2.6 that is this value. I started with 1 and 2 I got 1 and 2.6 non converging so one more iteration. So, again mass deflection inertia force, computed deflection, mode shape, inertia force multiplied by phi r then mr multiplied by phi r square. Let us borrow those values form a problem this is m and this is 2m and the previous iteration it is 1 and 2.6, I will take that value as 1 and 2.6.

So, this going to be alpha 5.2 alpha I request you to follow the same algorithm what we expressed in the last cycle of iteration, last cycle of iteration the same way you get F r you get F I. Then this is going to be this value divided by. So, let us take the sum is going to be 6.2 alpha. So, this is going to be 6.2 alpha by 2 k. So, that is the stiffness. So, 2 k we just I think I should write 3.1 alpha then you add them up it becomes 8.3 alpha and the sum. So, I take a double prime as 3.1, alpha I get the mode shape as 1 and this going to be equal to 8.3 alpha by 3.1 alpha which is 2.68.

Then this is F I phi into phi r, so phi r is this value this is phi r 2. So, it is going to be alpha this is 13.936 alpha I make the sum which is 14.936 alpha. So, this is mr into phi r square which is going to be 1 and this is going to be 2m multiplied by 2.68 square which is equal to 14.365, I make the sum which is 15.365. So, now, I find omega in the same algorithm I should say phi I, F I phi I double prime divided by a double prime and this which is going to be equal to 14 point omega square, is 14.936 alpha divided by 3.1 alpha and 15.365 which will give me omega as 0.56 root k by m.

And the corresponding vector is 1 2.68. I do the next iteration I take this as m and 2m I take 1 and 2.68, this is alpha this is 5.36 alpha sum becomes 6.36 alpha, so this becomes 3.18 alpha, this is 8.54 alpha and therefore, I take a prime as 3.18 alpha I get more chip as 1 and 2.69 that is my motive 1 and 2.69. Then you work on this value as alpha 14.418 alpha I make the sum which is 15.418 alpha this is 1 and this is 14.472, I make the sum it is 15.472. Eigen omega square as 15.418 alpha by 3.18 alpha multiplied by 15.472 which of k by m which gives me 0.56 root k by m as omega and phi is this value.

So, we will believe that it has converged and the final answer omega is 0.56 root k by m and phi is 1 and 2.69 since there is no zero crossing I can call this omega 1 and phi 1 respectively.