Computer Methods of Analysis of Offshore Structures
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Module – 02
Lecture – 12
Dynamic Analysis – 1 (Part – 1)

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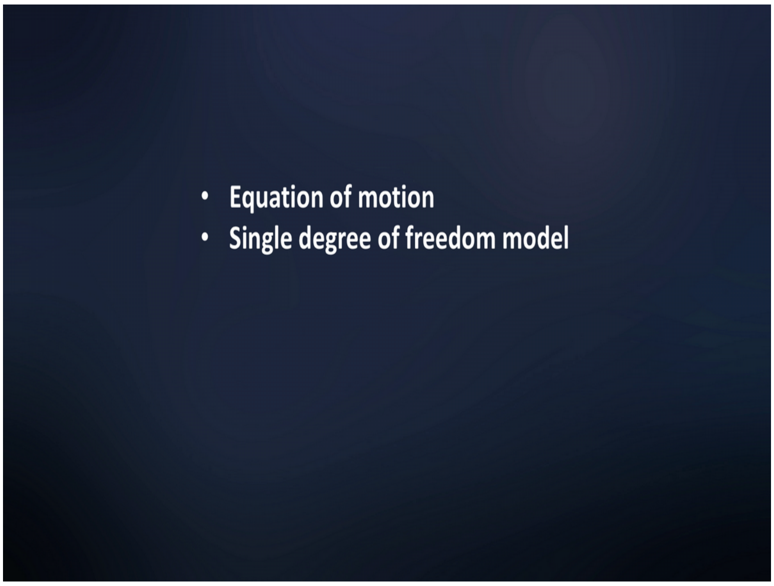

So, friends let us continue with the lectures on module 2. This lecture which is lecture 12 will start introducing computer methods in dynamic analysis.

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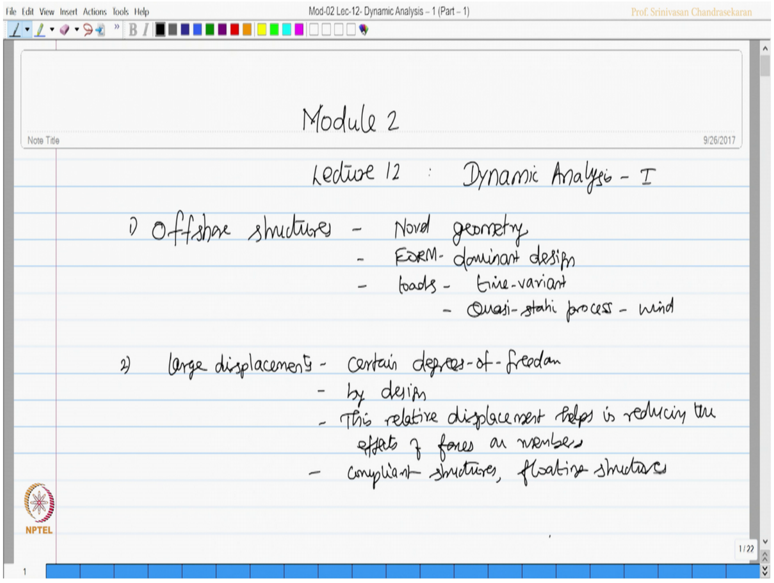

Now, we know that offshore structures have a novel geometry they are form dominant design and the loads which are encountering offshore structures are time variant. However, some of the loads even though they are time variant they can equally considered as a static or quasi static analysis for example, wind.

Secondly, offshore structures also undergo large displacements in certain degrees of freedom. This is actually by design because this relative displacement helps in reducing the effects of forces on members, classical example compliant structures, floating structures.

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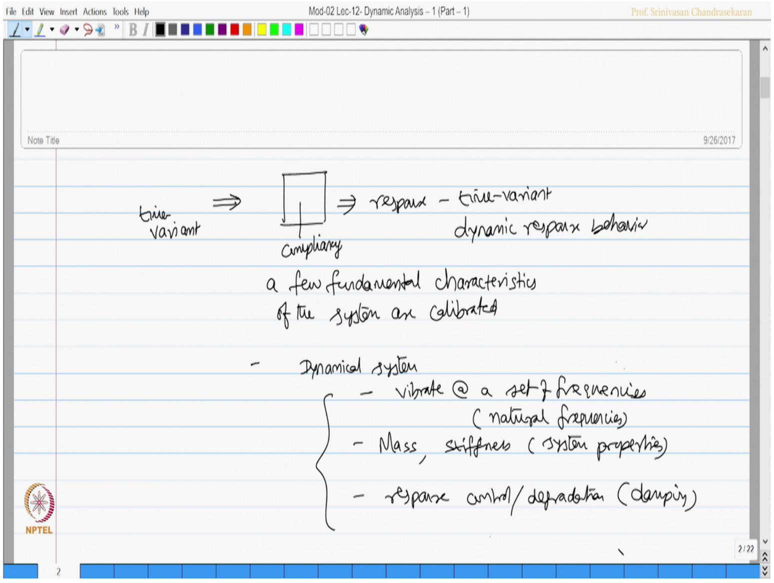

Having said this since the input loading is time variant and the structure has got compliancy the output which is also the response, so the response is expected to be time variant. One is interested to know what is a response of the system what we call the dynamic response behavior. The dynamic response behavior of a system is known only when a few fundamental characteristics of the system are calibrated. To be very precise we are talking about fundamental characteristics determination of a dynamic system, the moment I said dynamic system you can also encounter few words along with this, they will vibrate at a set of frequencies, these are called natural frequencies.

The system will have a classical mass and stiffness which are system properties. The system will also undergo response control or degradation which is associated with the damping. Now the dynamic systems have certain characteristics which need to be identified and estimated and then they should be represented in a mathematical format to receive the input load, so that the dynamic response behavior of the program can be estimated.

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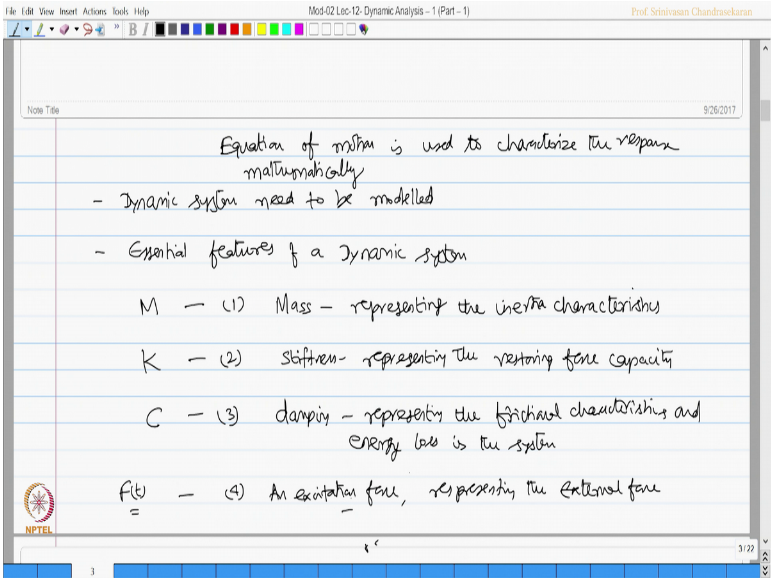

As we all agree and we know your prerequisite generally equation of motion is used to characterize the response mathematically, to do so the dynamic system needs to be modeled. So, then the question comes what are essential features of a dynamic system mass which represents the inertia characteristics of the system, second stiffness which represents the restoring force capacity of the system. Thirdly the damping element which represents the frictional characteristics and energy loss in the system and fourth and the last is an excitation force representing the external force acting on a system.

So, this is represented by M, this is represented by K, this is represented by capital C, this is represented by F of t. F of t because we already said and we saw in last lectures that the excitation force which represents external force or environmental loads acting on offshore structures are time variant. Now the question comes does mass K and C depend on time they will answer this slightly later, but I would urge you to look at standard references to learn more on dynamic analysis.

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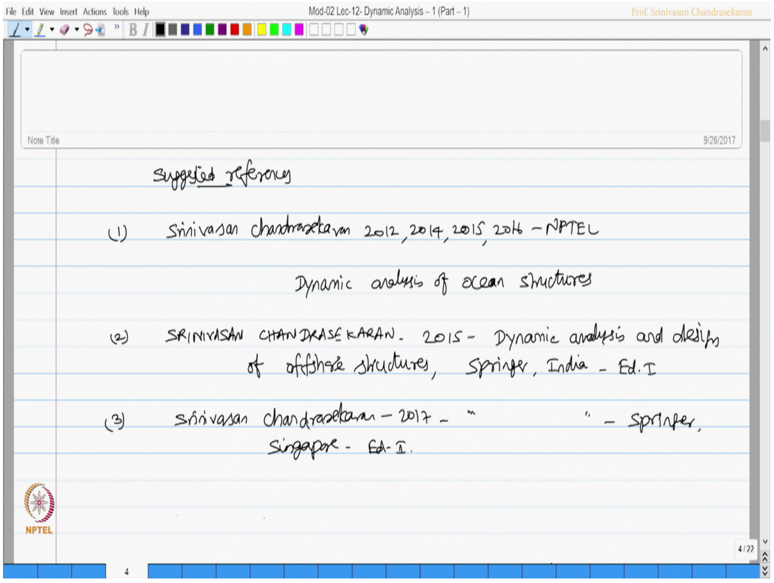

So, these are some suggested references which will give you some additional reading - one my own course offered in 2012, 14, 15 and 16 at NPTEL titled Dynamic Analysis of Ocean Structures. So, kindly go through the video lectures NPTEL which are free downloadable and go through the tutorials for more learning.

Secondly, there are couple of text books which I want to advocate why I am referring my own books because you will be able to easily follow the style of my explanation. One book is 2015 Dynamic analysis and design of Offshore Structures published by Springer India. The next one could be again in 2017 this is edition one same title this is published by Springer, Singapore and this is edition II. So, this will give you additional reading about dynamic analysis. So, you will be able to appreciate some of the important terminologies and basics of dynamic analysis, but in this course we look into the computer methods of dynamic analysis where we will give you this program the MATLAB coding and solve the problems using computer program having said this.

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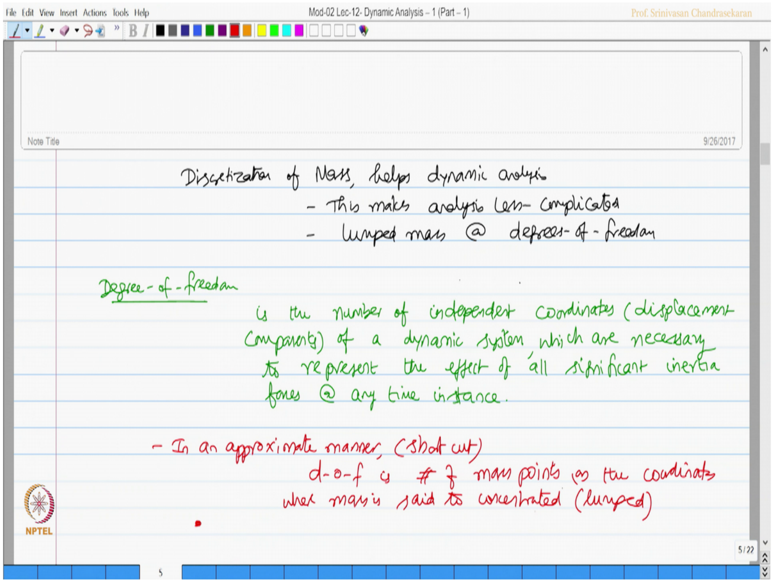

It is very important to know that discretization of mass helps dynamic analysis. In fact, this makes analysis less complicated. The moment I said discretization of mass then I will also add it to that I would like to lump the mass at various degrees of freedom. Now the question comes what is degree of freedom. Degree of freedom friends is the number of independent coordinates or displacement components of a dynamic system which are necessary to represent the effect of all significant inertia forces at any time instance.

In an approximate manner or as a shortcut one can remember that degree of freedom is the number of mass points or the coordinates were masses said to be concentrated or let us say lumped. Please understand it is always not true that you can have one point were masses lumped, but this can have 6 degrees of freedom there can be one degree of freedom the mass can have different components. So, this is only a shortcut to understand a similarity between the lumped mass and degree of freedom. The classical definition actually is the number of independent coordinates which are required in a dynamic system to represent the inertia forces at any instant of time. Since we say inertia force we are linking that to the last mass part that is the reason.

Having said this one of the very common model which is being used for dynamic systems in offshore structures is spring, mass and dashpot model.

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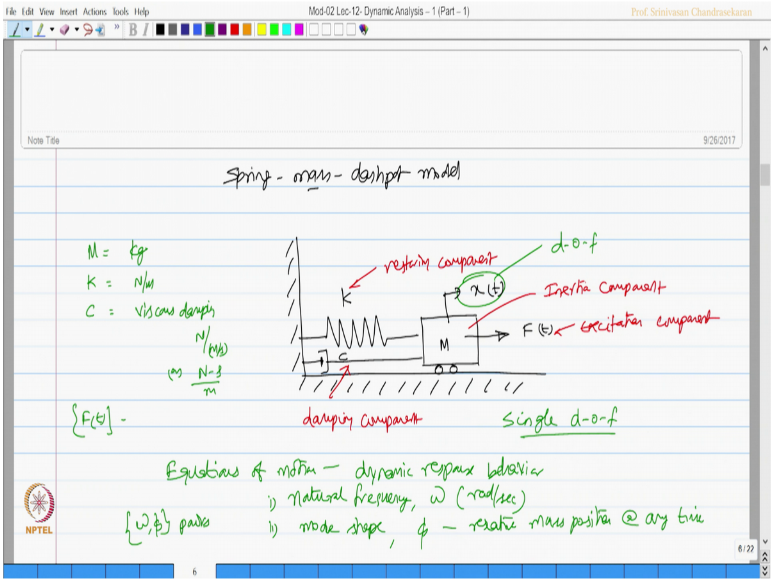

So, in mathematical model which is very popular to do dynamic response analysis of offshore structures, typically this model looks like this say. This is the mass point represented by M, the mass is exerted by a force which is F of t, the mass is lumped at a point therefore, the degree of freedom is x of t, the mass when it moves to the right where the excitation force the mass will exhibit a restoring force represented by K, the response of the mass in terms of time will also decay which exhibits some friction some decay some energy loss which is exhibited or represented by a dashpot indicated by C.

So, friends this is the inertia force inertia component this is the external force or excitation component this is the restoring component and this is my damping component and this indicates the degree of freedom. Since here there is only one degree of freedom this is a classical mathematical model of single degree of freedom. So, look back the definition we said essential features of a dynamic system are mass representing inertia, stiffness representing restoring component, damping representing the frictional characteristics and F of t representing external force. Look back here we have the same components present here. So, this is a typical popular mathematical model which is used to represent identically the behavior of offshore structures excited under time variant loads.

Having said this we would like to know how to write equations of motion to represent or to characterize the dynamic response behavior. So, for single degree it is very easy and simple to estimate the essential features of this model which is the natural frequency represented by omega units are generally radiance per second. By the way unit units of mass will be in kg units of stiffness will be in Newton per meter, units of C we are using the whiskers damping model in offshore structures, so it is Newton per meter per second or Newton second per meter. And F of t of course, we know we have already estimated them in the last few lectures that is one characteristic natural frequency, the second one is the mode shape mode shape has no units it is represented by small phi it is relative mass position at any instant of time when the system undergoes or vibrates at a specific frequency. So, omega and phi are actually pades for every omega there will be every phi that is why there are called eigen values and eigen vectors, eigen is a term related to uniqueness in German language.

So, we will not discuss more in detail about the single degree because single degree freedom system models are relatively simple and they are readymade solution available in the literature you do not need actually a computer program to solve them, let us go for multi degree freedom model systems. So, our job is to mathematically identify a multi degree freedom system model and then solve for omega and phi using computer methods.

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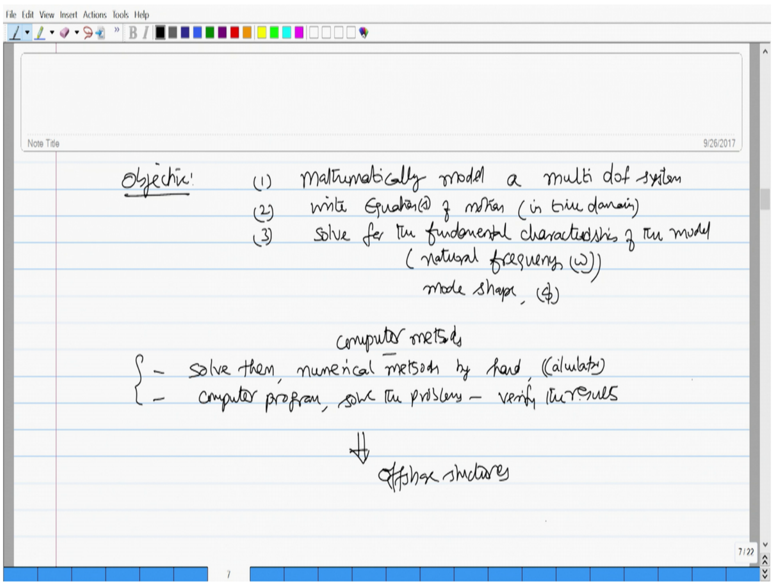

So, what is our objective now? Our objective now is to mathematically model a multi degree freedom system then write equation or rather equations of motion in time domain and try to solve for the fundamental characteristics of the model which are natural frequency omega and mode shape which is phi. So, this we will try to do using computer methods. But I would suggest a small deviation from this objective first we will take a few examples of multi degree freedom model systems solve them using numerical methods by hand that is using calculators.

Then we will also write and explain the computer program solve the same problem using coding and then verify the results that will be better. So, we understand both right. So, once you know this then we will move to application of computer methods of dynamic analysis to offshore structures in reality and explain how they can be solved using different software. So, this objective set in mind.