Computer Methods of Analysis of Offshore Structures
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Module - 03
Lecture – 02
Random Process - 2

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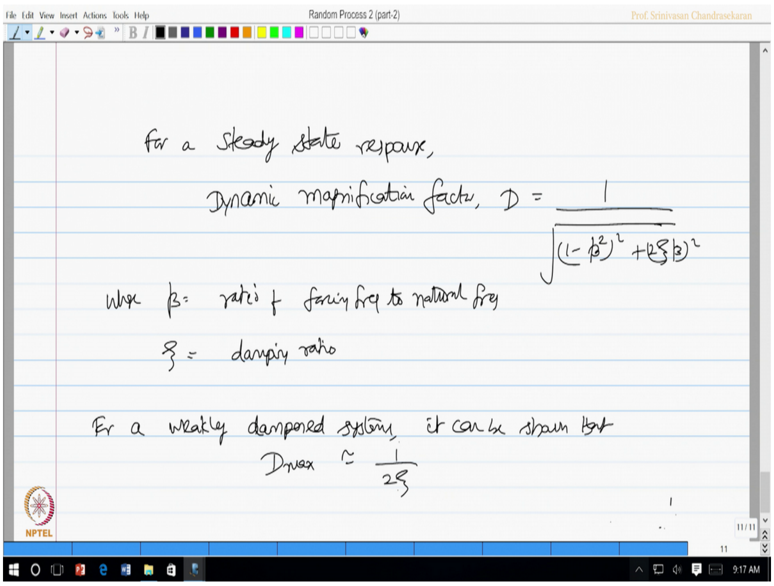

For a steady state response, we know the dynamic magnification factor which we called as D is given by this expression 1 by root of 1 minus beta square; square plus 2 zeta beta the whole square where beta is the ratio of forcing frequency to the natural frequency of the system and zeta is the damping ratio. So, standard expression in structural dynamics.

So, let us say for a weakly dampened systems, it can be easily shown that the maximum value of the dynamic amplification factor will be bounded by 1 2 zeta for the benefit of the listeners if you really wanted to look at more details on structural dynamics.

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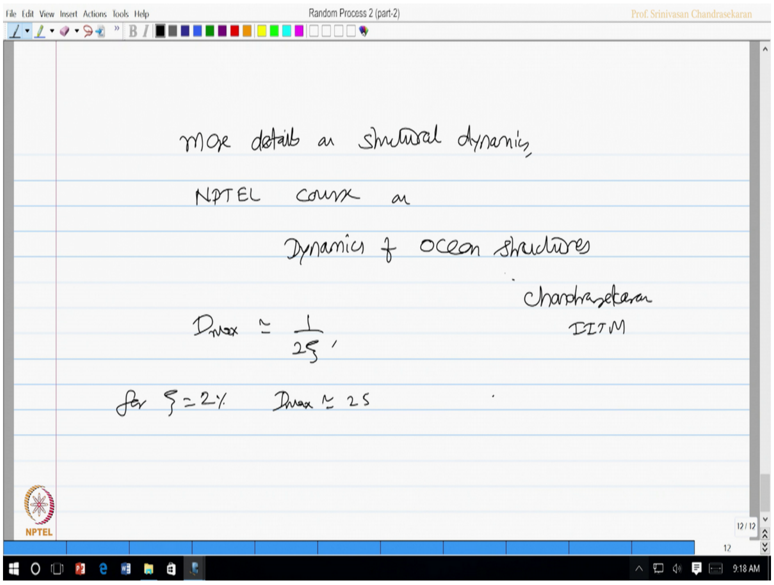

I shall refer you to an NPTEL course on dynamics of ocean structures through IITM Madras portal; please look at this course in detail, if you really wanted to know more about the derivations what we did in the last slide.

Having understood that we know that the maximum amplification factor will be governed by one way to zeta so, for zeta about 2 percent which is a very common case D max is approximately about 25; what does it mean?

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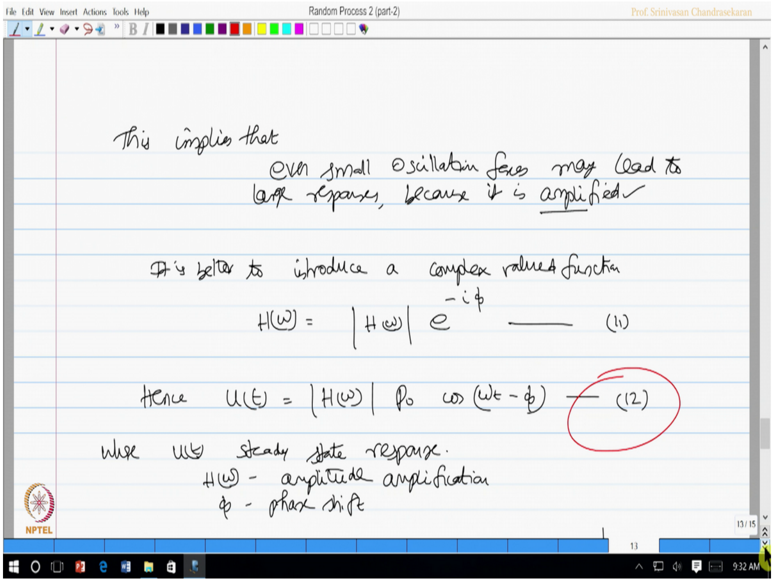

This means that even small oscillation forces may lead to large responses because it is amplified. So, even for small oscillation forces, it may lead to larger responses because there is an amplification happening in such situation it is always better to introduce a complex function or a complex valued function which can account for the phase lag. So, that function typically looks like H omega is mod value of H omega e minus i phi, I call this equation as 11.

Hence the response function what you are interested in will be given by the transfer function multiplied by P 0 cos omega t minus phi where u of t is the steady state response and H omega gives the amplitude amplification where as phi gives you the phase shift having said this.

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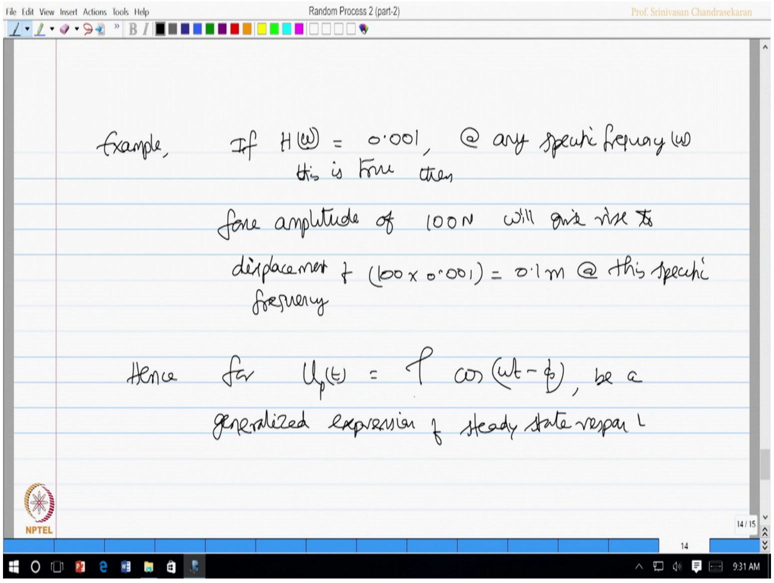

Let us quickly see for example, if H omega for a given linear system is 0.001 at any specific frequency omega, this is true because you know H omega is a function of omega. So, for any specific frequency, let us say 2 omega 0.001, then your force amplitude of let us say 100 Newton will give raise to displacement of hundred into 0.001 which will be point one meters at this specific frequency.

So, the transfer function is very useful to connect the response and the load given to an system at a specific frequency hence for the particular integral u P of t which is rho cos omega t minus phi be a generalized expression of steady state response.

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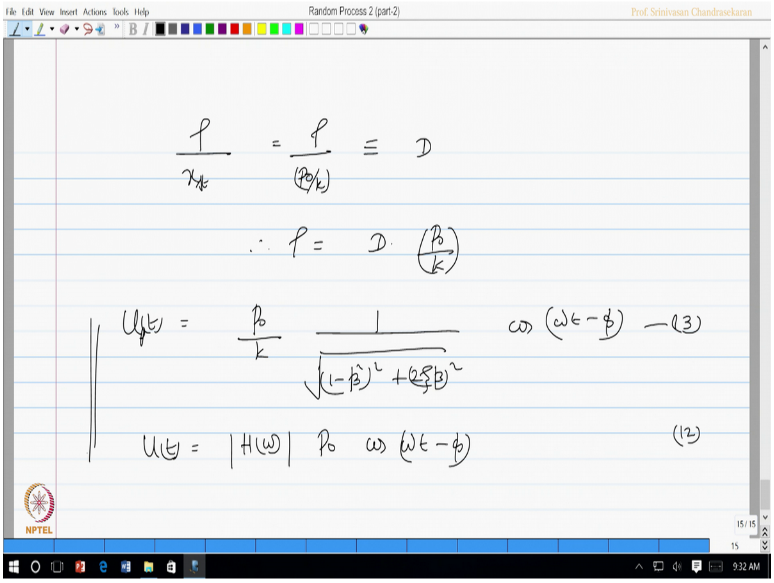

The rho by x static can be simply said as rho by P 0 by k which is the D value therefore, rho can be simply said as D of P 0 by k. So, now, u P of t is actually P 0 by k 1 by root of one minus beta square square plus 2 zeta beta square of cos omega t minus phi, I call this equation number 13. Let us rewrite equation number 12 which we already had here equation number 12 which we already had here let us compare equation 12 is ut is H omega P 0 cos omega t minus phi.

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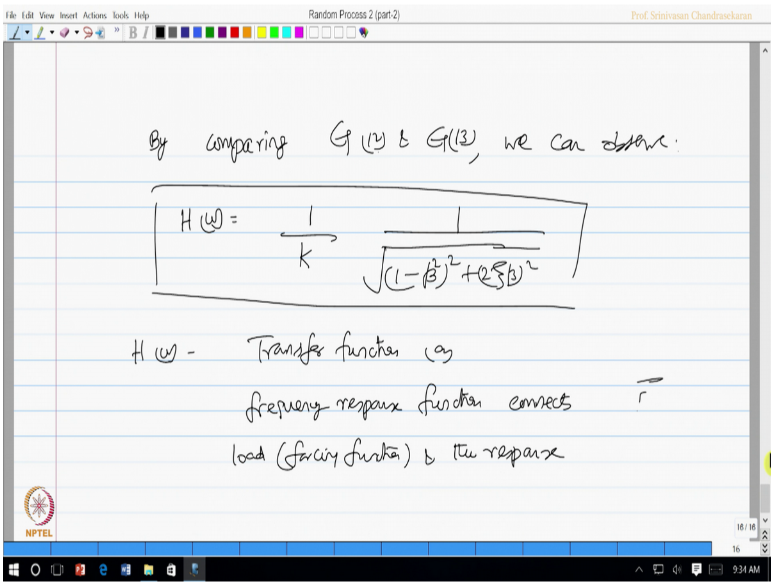

By comparing these 2 equations, we can observe that H omega can be simply 1 by k of root of 1 minus beta square square plus 2 zeta beta square H omega is called the transfer function or also called as frequency response function which connects load or the forcing function and the response. So, that is a very interesting equation which we derived.

Let us further pay attention more to explaining this equation.

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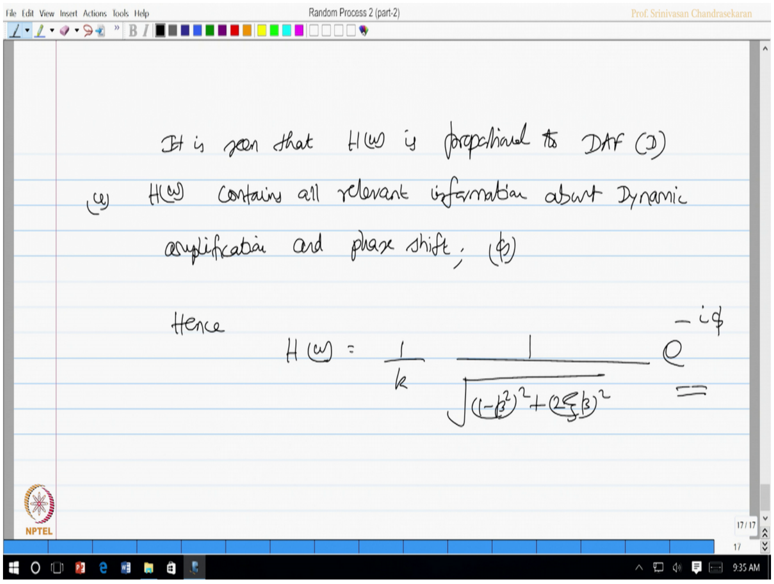

It is seen that H omega is proportional to the dynamic amplification factor t that is H omega contains all relevant information about the dynamic amplification and phase shift phase shift is of course, given by phi hence H omega as we said is 1 by k of root of 1 minus beta square square plus 2 zeta beta square e to the power of minus i phi.

There is a specific reason why we use e power minus i phi in this equation.

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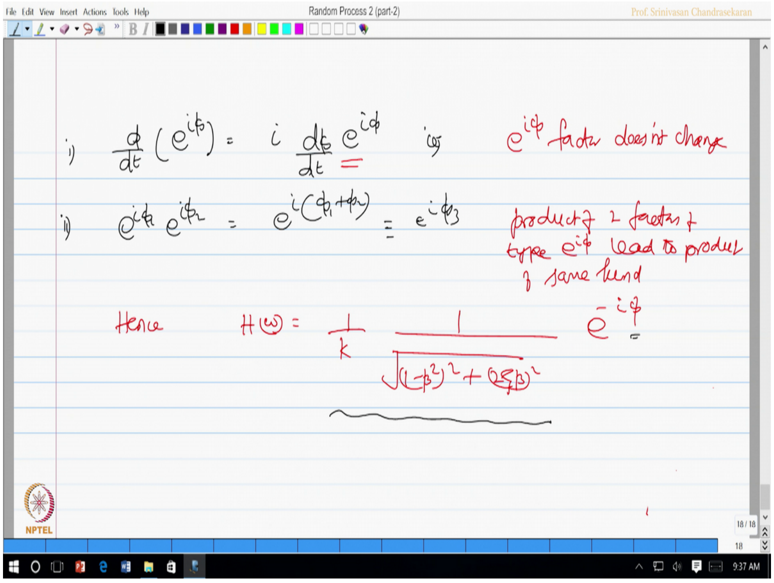

So, d by dt of e power i phi is i d by dt of again e phi that is e power i phi factor does not change that is one important point. Secondly, e i phi 1 e i phi 2 can be e i phi 1 plus 2 which is as same as e i phi 3 that is product of 2 factors of type e i phi lead to product of same kind. So, that is the advantage we have when you use e i phi in this equation. Hence H omega is 1 by k root of one minus beta square square plus 2 zeta beta square of e minus i phi represents the complete information about the dynamic amplification and the phase shift which connects the load and the response of a given system having said this.

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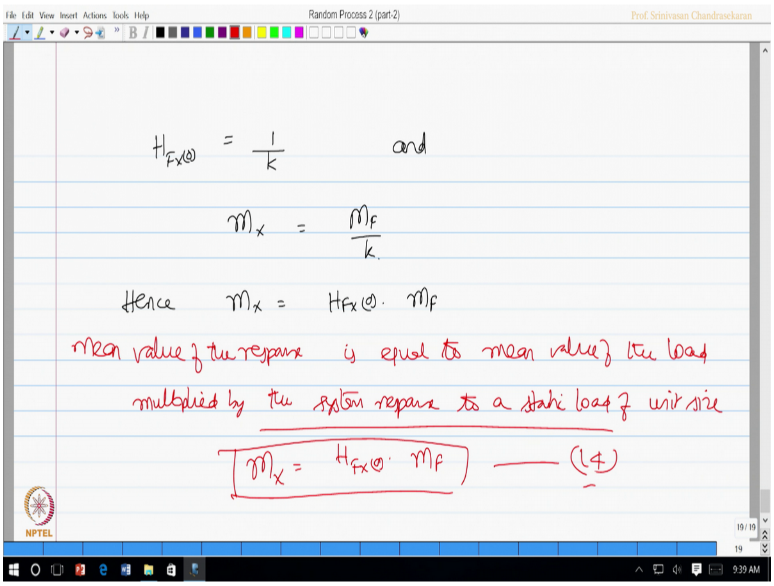

Let us say H Fx 0 is 1 by k and mean x is mf by k hence mx is F x 0 of m F what does it mean is the mean value of the response is equal to mean value of the load multiplied by the system response to a static load of unit size. So, that is a great advantage of interpreting the response and the load function. So, one can now say mx is H Fx 0 of m F equation 14.

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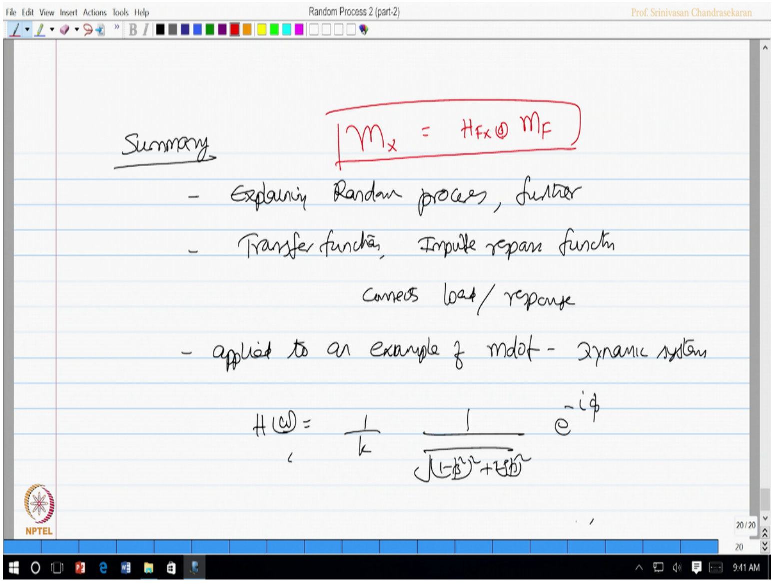

Let us quickly see what summary we learnt in this lecture. We started with explaining the random process further we explained the transfer function or the impulse response function which connects the load and the response.

We also applied this to an example problem of multi degree freedom system in dynamic systems, then we derive the transfer function as simply the proportion of the dynamic amplification factor and we said that the mean value of the response will be given by a simple relation which is expressed here.

So, friends will continue this lecture to take it more advanced in terms of auto covariance of response processes then from that we will try to derive what we generally use as response spectrum in stochastic analysis.

Thank you very much.