Computer Methods of Analysis of Offshore Structures
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Module – 01
Lecture – 24
Analysis of Space Frame Example – 1 (Part – 1)

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Friends, welcome to the 24th lecture on module 1. We will take up couple of examples of 3 dimensional analysis and try to understand them using simple transformation in step by step procedure. Let us rewind back slightly and understand what we did in the last couple of lectures in 3 dimensional analysis.

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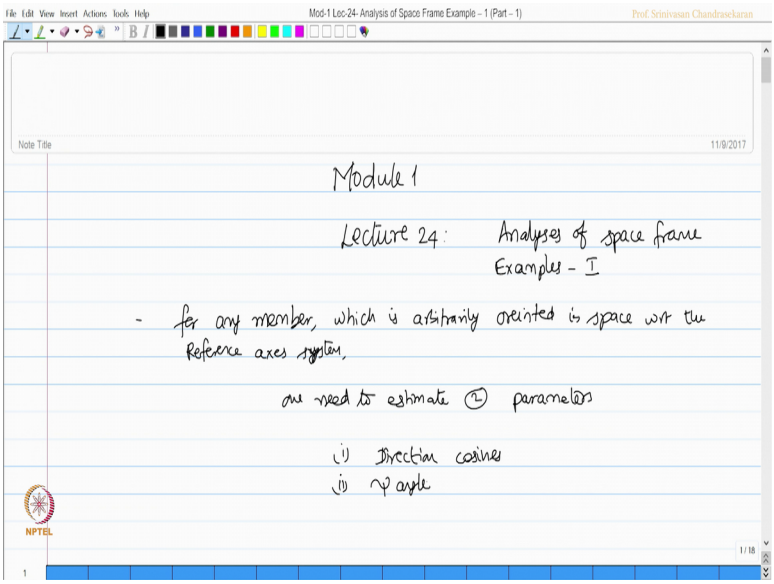

We said that for any member which is arbitrarily oriented in space with respect to the reference axes system, one need to estimate 2 parameters namely the direction cosines and the psi angle.

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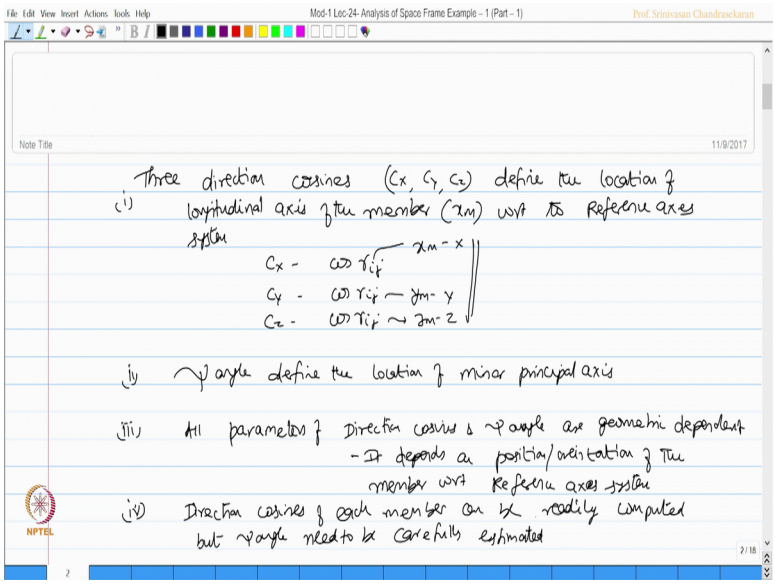

3 direction cosines namely C x, C y, C z; actually defined the location of longitudinal axes of the member that is x m axes with reference to the reference axes system. Please understand C x deals with cos gamma i j C y deals also with cos gamma i j C z deals with cos gamma i j whereas, in this case, I will be related to x m and x. In this case, y m

and y, in this case z m and z respectively in addition the psi angle defines the location of minor principle axes.

We should also agree that all parameters of direction cosines and psi angle are geometric dependent that is it actually depends on position or orientation of the member with reference to the reference axes system. Further to make a very interesting statement direction cosines of each member can be readily computed, but psi angle need to be carefully estimated one can do 2 types of transformation.

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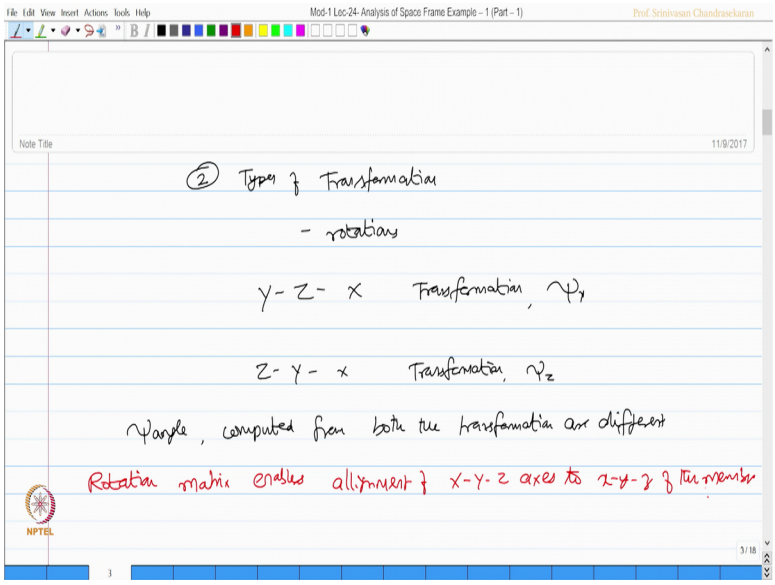

In fact, to be very specific, we should say types of rotation 1 is y-z-x transformation which will give you ultimately psi y.

Another is z-y-x transformation which will give you psi z please understand the computation of angle psi computed from both the transformations are different so; obviously, the rotation process enables aligning or alignment of x-y-z axes to x-y-z axes of the member that is what we are trying to do.

Let us take an example and try to understand how to compute this psi angle.

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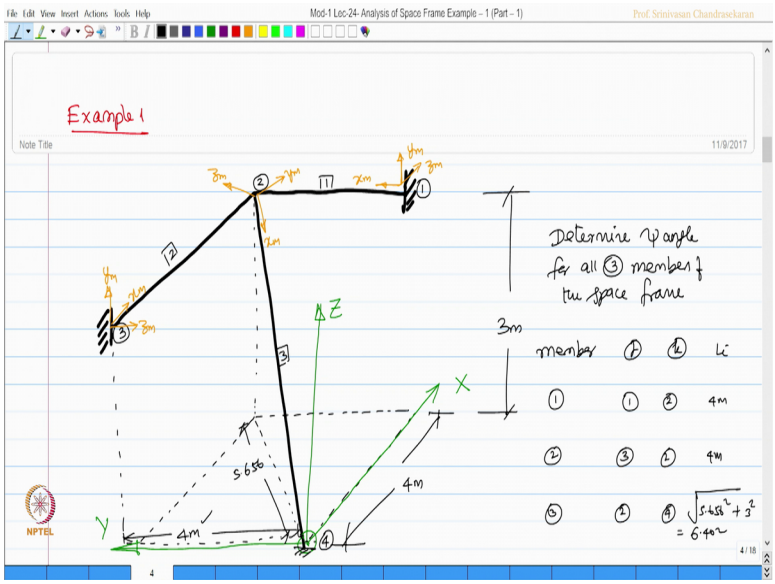

So, we do one example as shown in the figure now. So, let us try to; so, let us mark the global axes like this; this is my x axes, this is going to be my y axes and this is going to be my z axes and this becomes my origin for the reference axes system and I have 3 members the third member actually is connecting this point to this point.

So, now there are 3 members fixed at both the ends here we are able to visualize it in a 3 dimensional space. Let us now mark the dimensions; let us say this dimension is 4 meters, this dimension is also 4 meters and the height is 3 meters. Let us name the member, this member is member 1, this member is member 2, this inclined member is member 3, let us name the joints, let us say this is joint 1, joint 2 and joint 3 and this is just restraint and this point.

Let say 4; now the question asked is determine the psi angle for all the 3 members of the space frame shown in the figure; let us talk about member 1.

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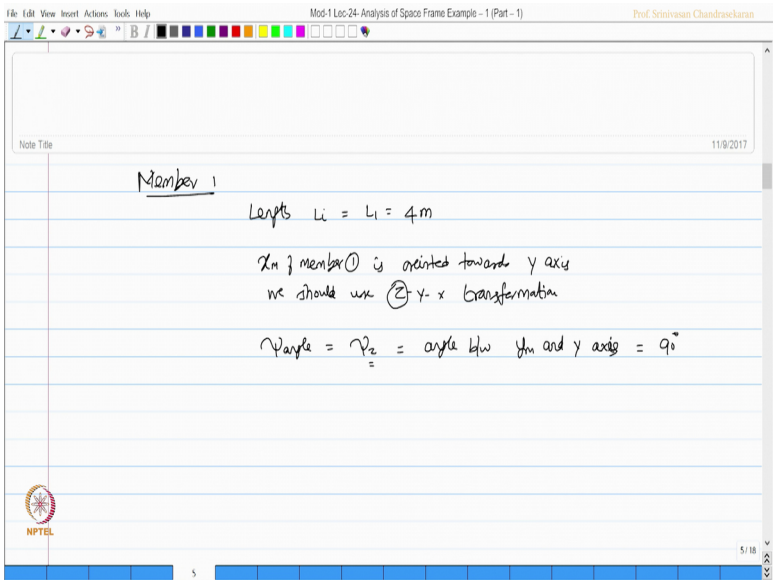

We know the length of the member L 1 is 4 meters length of the member is 4 meters, let us choose the local axes of the member like this. So, this is my x m, y m and z m for in the second member; let us say this is my x m, y m and z m for the third member along the length is x m, y m and z m.

So, let say the member j and k and length of the member; let say the member 1, member 2 and member 3; for the member 1 j end is at 1 and k end is at 2 length of the member is 4 meters, for the member 2, j end is at 3 k end is at 2 length of the member is again 4 sorry; yeah, 4. So, if I calculate this, you know this value is going to be this dimension is going to be 5.656 that is root 2 of 4 meters, but I want to know this length. So, this length of the member will be it originates at 2 j end k end is at 4 where length is going to be square root of 5.655 square plus 3 square which is 6.402 that is the length of the member 3.

So, let us go to member one this is member one whose length is 4 meters. Now x m of member 1 is oriented towards y axes is it not; see here x m is oriented towards y axes. Therefore, we should use z-y-x transformation; now interestingly the psi angle will be psi z, it depends upon what it is the first transformation; we do this is actually the angle between y m and y axes is it not; now you can see here y m and the y axes is 90 degrees.

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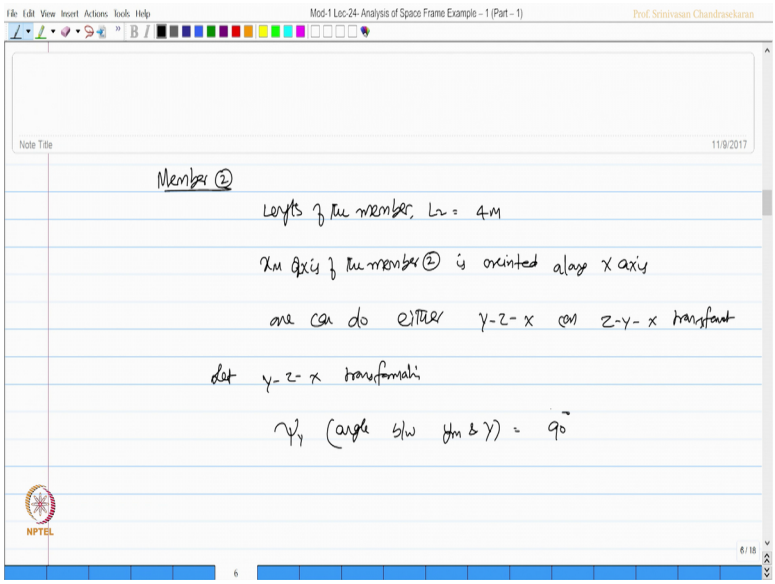

So, now I can say this is 90 degrees. Similarly, let us do this for member 2 length of the member L 2 is again 4 meters. Now you see the longitudinal axes of the member that is x m axes of the member x m axes of the member is oriented along x; is it not is oriented along x axes. So, one can do either y-z-x or z-y-x transformation; let us consider y-z-x transformation. So, I will now compute psi y which will be the angle between y m and y axis let see that y m is vertical y x horizontal. So, the angle is going to be 90 degrees.

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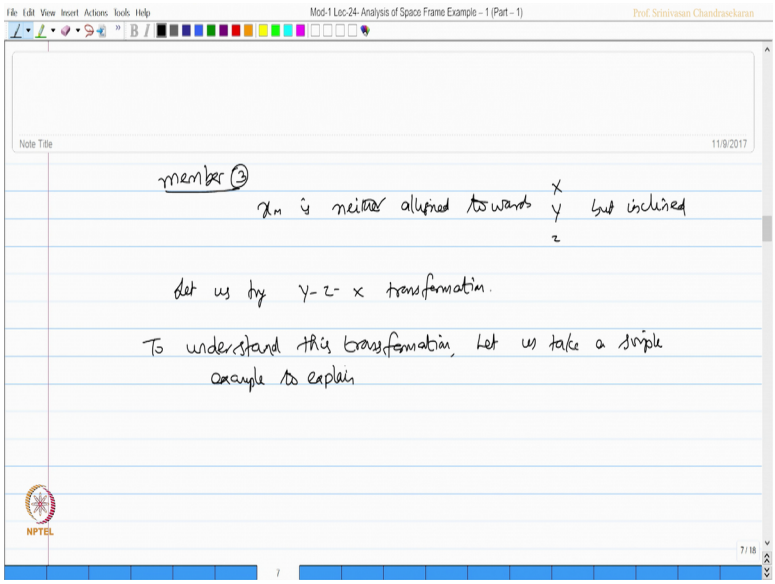

Let us go to member 3; member 3 x m axes is neither aligned towards x, y or z.

But incline is it not; you can see here it is inclined in such situation you can do both the transformation let us try y-z-x transformation that is complicated to understand this; let us do some more explanation to understand this transformation; let us take a simple examples to explain let us do that.

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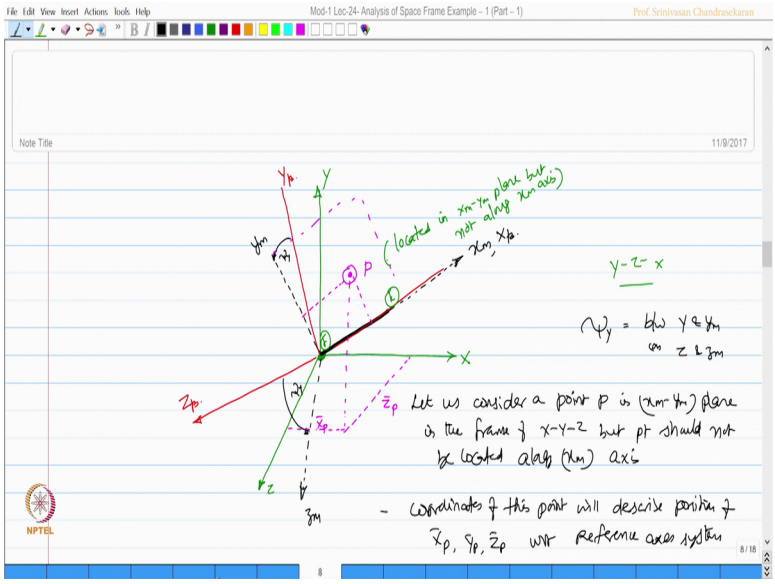

Let say I have a 3 axes system which is x-y-z, I do y-z-x transformation, I want to do y-z-x transformation, I have a vector which is placed arbitrarily and this is my x m axes, it will also be x beta axis.

So, let say this is my y m axes and z m axes; let say this is my x beta which I marking in red color, this is my x beta, this becomes my y beta and this becomes my z beta. So, the psi y angle will be the angle between y and y m or z and z m correct angle between y and y m; this is my psi y or this is my psi y to understand this what we should do. Let us consider a point p in x m, y m plane that is this plane x m y m plane in the frame of x-y-z, but the point should be located or let say the point should not be located along the x m axes select any point let us take this point.

Let us take this point this is my point p it is located in x y m plane, this is the plane you can see here this is the plane, but not along x m line. Now I project this on the x m and y m planes and then projected to z and x plane; obviously, this will be z bar p and this will be x bar p because this is x axes this is y axes this is my jth end of the member and kth end of the member. So, p is the point located in x x m y m plane, but not along x m axes

having said this we need to find out the coordinates of this points coordinates of this point will actually describe position of x p, y p and z p with respect to the reference axes system lets do this.