Kinematics of Mechanisms and Machines
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Lecture – 27
Velocity Analysis Examples

In this lecture, I am going to look at some examples related to Velocity Analysis.

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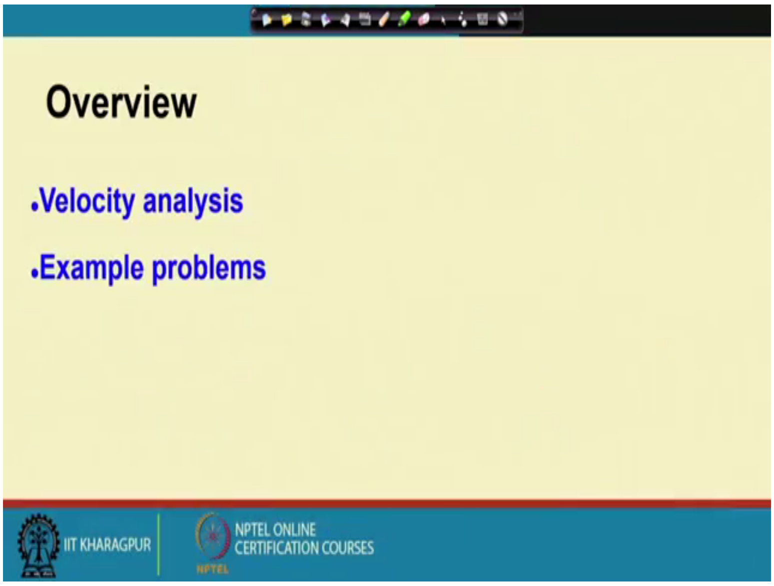

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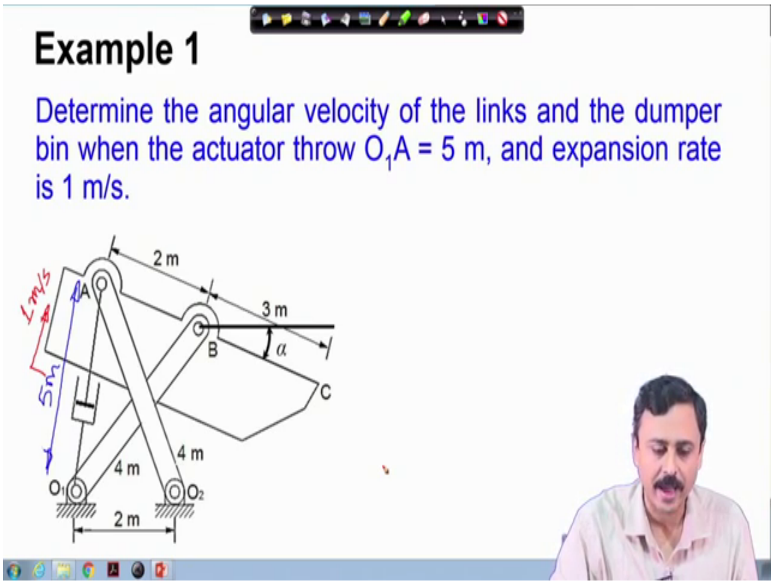

The first example is of the bin which we have lived before, we have discussed the displacement analysis of this bin. Here we have to determine the angular velocity of the links and the dumper bin when the actuator through O 1 A, this is O 1 A; this is given as 5 meter and expansion rate is 1 meter per second. So, this actuator is expanding at 1 meter per second. So, throw is 5 meter and it is expanding at 1 meter per second you have to find out the angular velocity of the links and the dumper bin.

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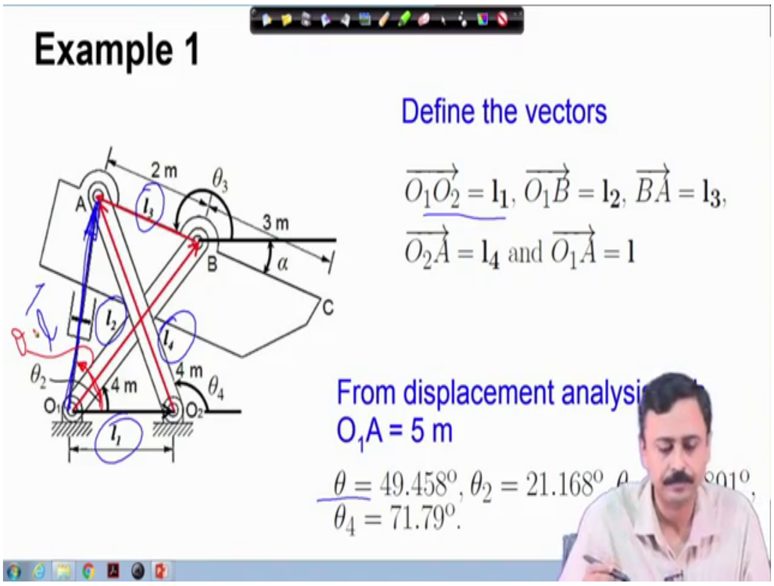

We have defined these vectors before during displacement analysis, let us just go through them again l 1 is O 1 O 2. So, this is the l 1 vector l 2 vector is O 1 B l 3 vector is B A which is the coupler which is actually the bin O 2 A is l 4 and O 1 A is l O 1 A is this vector.

So, this vector is the vector l; from our previous discussions on displacement analysis for this given actuator throw we had found all these angles a theta, the angle theta is this angle that angle is theta, that was 49.45 degree. And theta 2, theta 3, theta 4 we are all determined, theta 3 is the bin angle, but these were determined from the displacement analysis.

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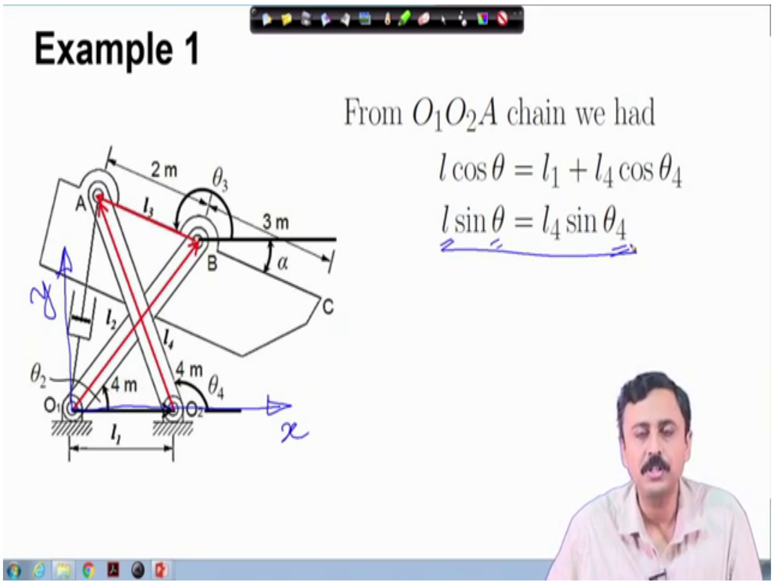

Now, from the chain O 1 O 2 A which is this chain, we can write using the kinematics l cosine theta plus l 1 is equal to l 1 plus l 4 cosine theta 4, we are using the coordinate system x y the same that was used for displacement analysis. Now, if you differentiate this equation with respect to time here you note that l and theta and theta 4 these are functions of time.

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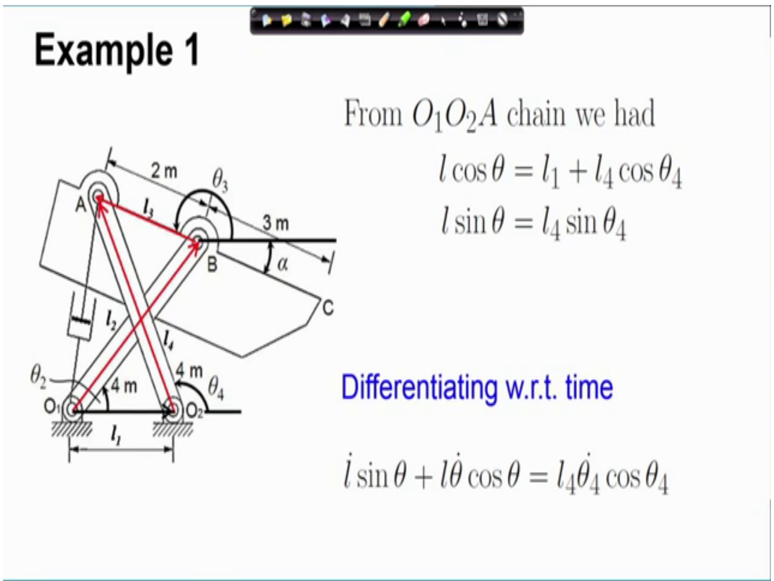

So, if you differentiate this with respect to time you obtain this relation, which relates which involves l dot theta dot and theta 4 dot, of this we only know l dot.

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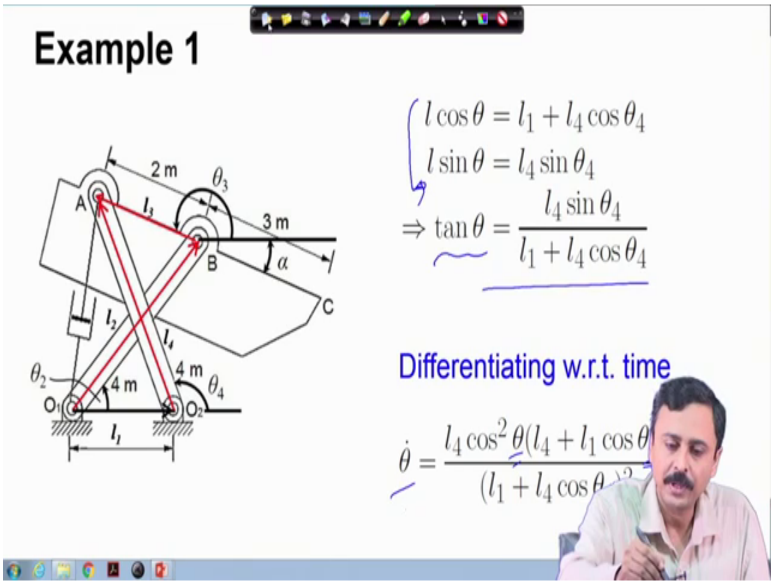

Next, if you look at again these two expressions, these two equations and divide 1 by the other you can find out tangent of the angle theta which turns out to be this ratio. And, if you differentiate this with respect to time you have this expression relating now theta dot and theta 4 dot. In terms of the angles theta and theta 4, since theta, theta 4 are known to us therefore, we can find out we have this relation between theta dot and theta 4 dot.

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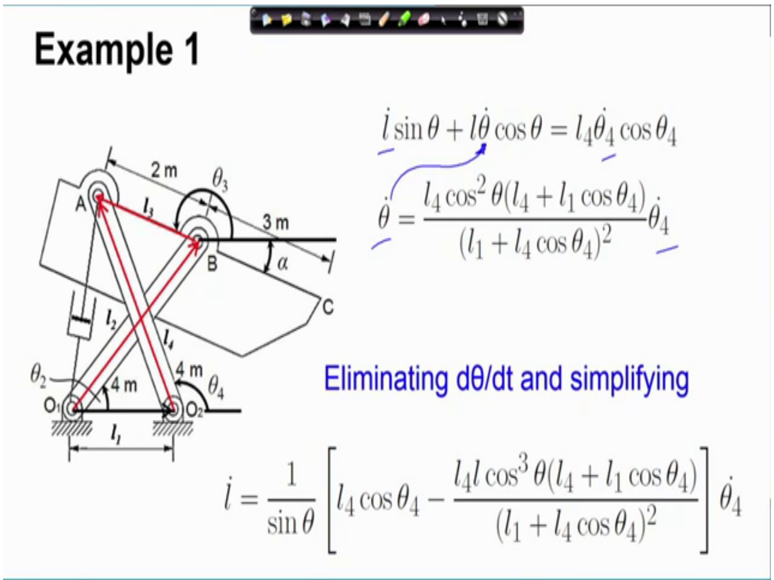

Now, let us look at the previous expression that we had determined. So, these are the two expressions, this involved theta 1 dot theta dot and theta 4 dot and here I have relation between theta dot and theta 4 dot. Therefore, if I eliminate theta dot between the 2 then I have a relation between theta 4 dot and l dot.

So, if you eliminate theta dot and simplify then you have a relation between l dot and theta 4 dot. Out of this l dot is given to us the expansion rate is given to us and from the displacement analysis we already have theta 4 and theta.

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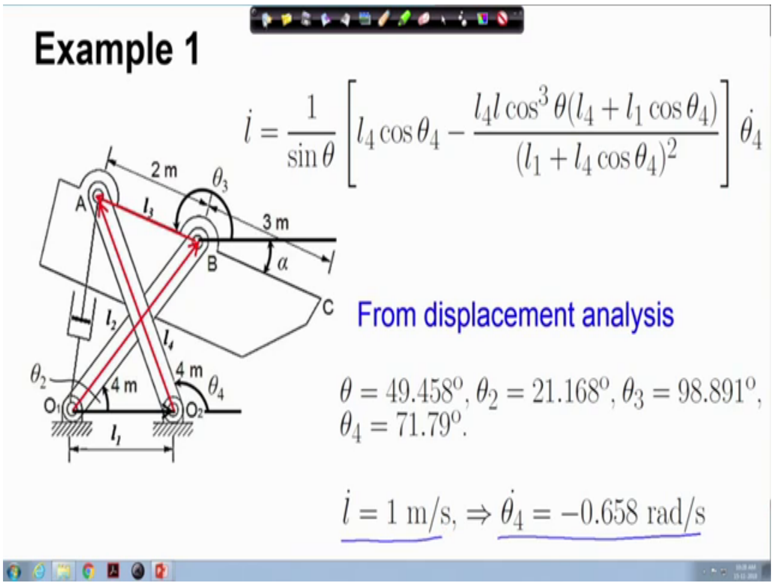

Therefore we can determine theta 4 dot, that turns out to be minus 0.654 radians per second for given expansion rate of the actuator as 1 meter per second. Now, once we have theta 4 dot, now we can use the relation between theta 4 dot and theta 2 dot and find out theta 2 dot.

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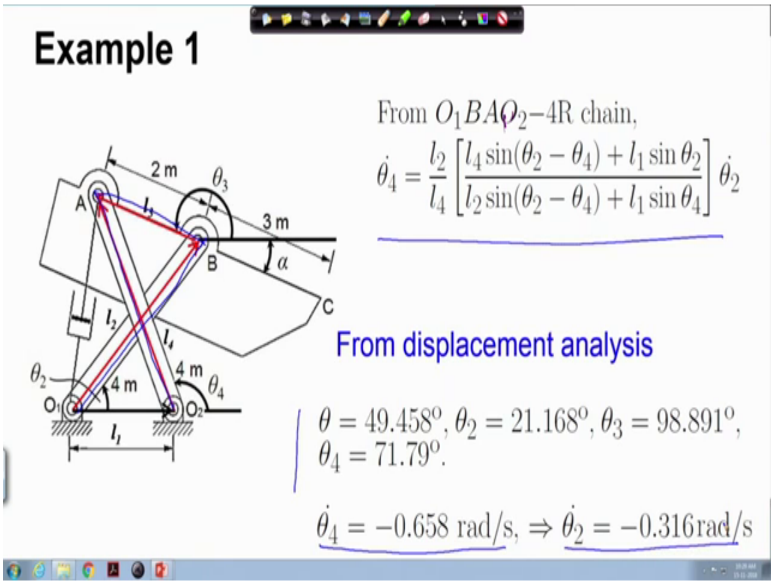

This was our relation which we have found from the analysis of this 4R chain the 4R chain is O 1 B A O 2. This is the 4 bar chain whose analysis we have done previously and we have found this relation between theta 2 dot and theta 4 dot. Now using that, since we know theta 4 dot now we can find out theta 2 dot which has been determined here.

So, from the displacement analysis we know these angles from the previous velocity analysis we know theta 4 dot. So therefore, from the above expression we can now find out theta 2 dot.

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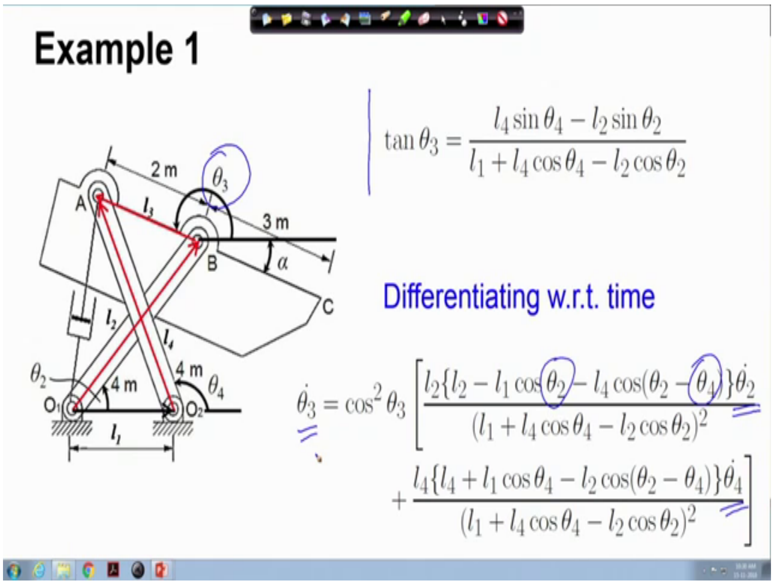

Finally, we need to find out the angular speed of the bin, the rotation of the bin. Now, this expression we had derived during displacement analysis of the 4R chain. So, tangent of this angle theta 3 is given by this ratio which is in terms of theta 2 and theta 4.

If you differentiate this with respect to time you get a complicated expression which is doable, but it is a little lengthy. In that you involve theta 3 dot which we want to find out, theta 2 dot and theta 4 dot and the joint angles theta 2 and theta 4. We have already found out theta 2 dot and theta 4 dot. Therefore, by just substituting these expressions and the joint angles which we already know we find out theta 3 dot.

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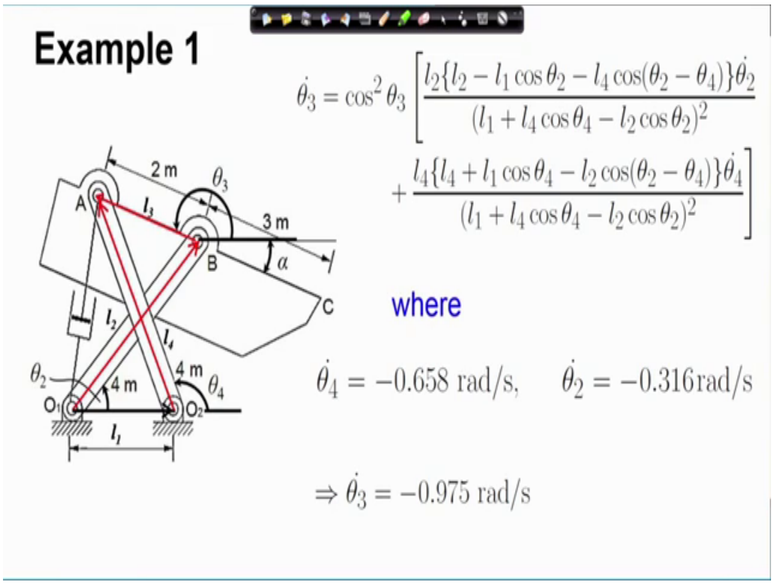

So, that completes this problem in which we had to find out the angular speeds of all the links and including the bin and this theta 3 dot is actually the angular speed of the bin. And negative sign indicates that its decreasing therefore, it is in the clockwise direction the rotation is in the clockwise direction.

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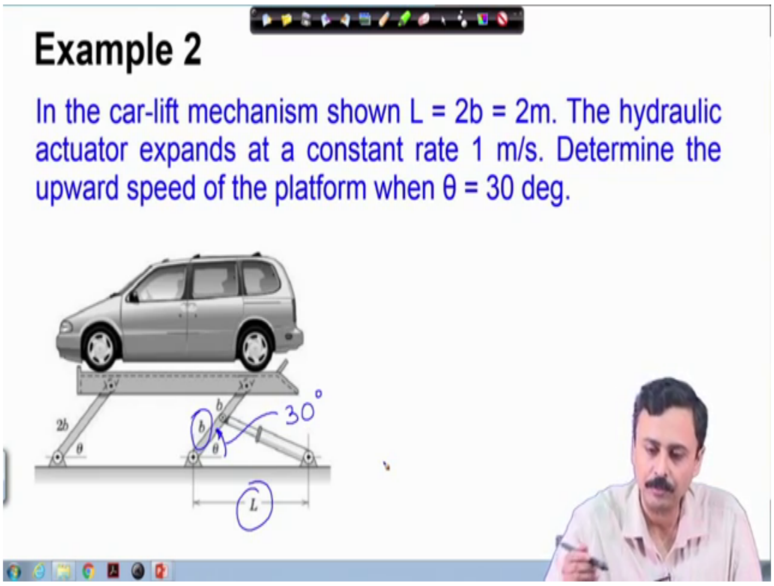

In the next example we are going to look at this car lift mechanism, in this mechanism is given that this length L is equal to 2 times this length b and this length is 2 meter.

So, the problem says the hydraulic actuator expands at a constant rate of 1 meter per second, determine the upward speed of the platform when theta equal to 30 degree, but this is the angle theta which is specified 30 degree. So, at theta equal to 30 degree; what is the upward velocity of the platform?

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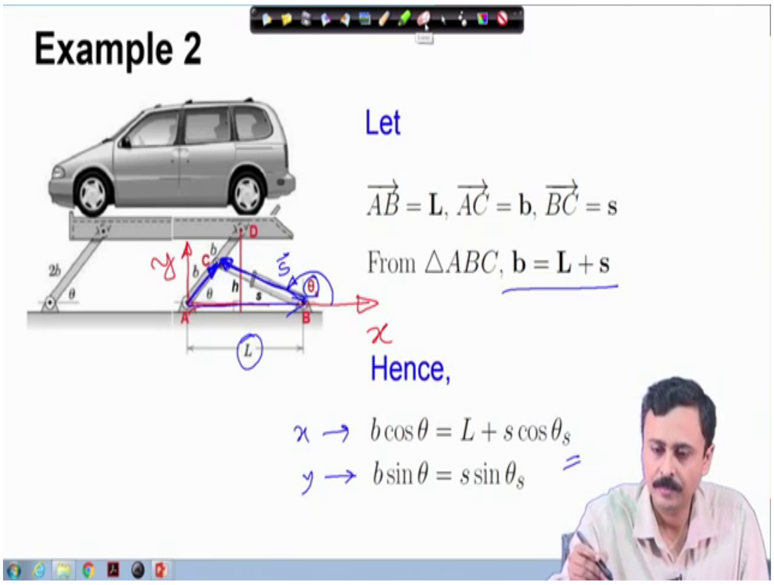

We define these vectors in the coordinate system x y with origin at A. So, this vector is the L vector, AC is this vector b and this vector is vector s. Therefore, from the vector loop equation we can write b as vector L plus vector s.

Now, if you look at the components, if you look at the components of the vector B L and s from the x component we have the first equation and from the y we have the second equation, here we involve this angle theta s. So, this angle is theta s ok.

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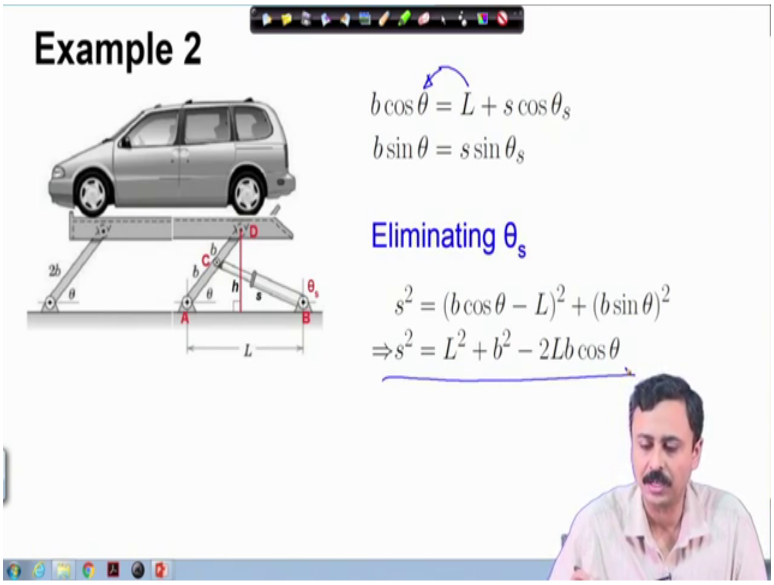

So, these are our relations, if you eliminate theta s then in order to eliminate theta s we take l on this side square and add and we have this expression of s in terms of theta.

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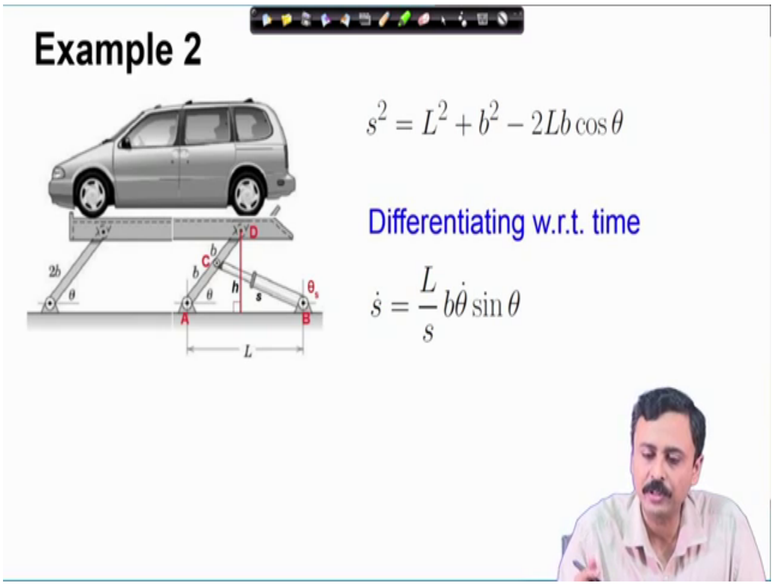

So, this is our relation of s with theta, if you differentiate this with respect to time and simplify we involve s dot and theta dot, L and b are constants therefore, this involves s dot and theta dot. And it also involves s which we already know.

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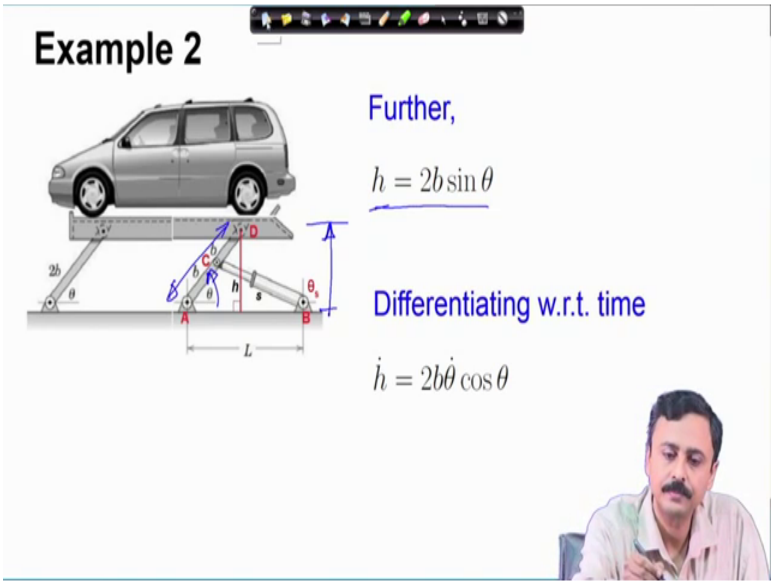

Now, here we have another displacement which actually gives us the motion of the platform which is h. So, h can be related in terms of this length AD and the angle theta and is given by 2 b sin theta and if you differentiate this, this is going to relate h dot and theta dot.

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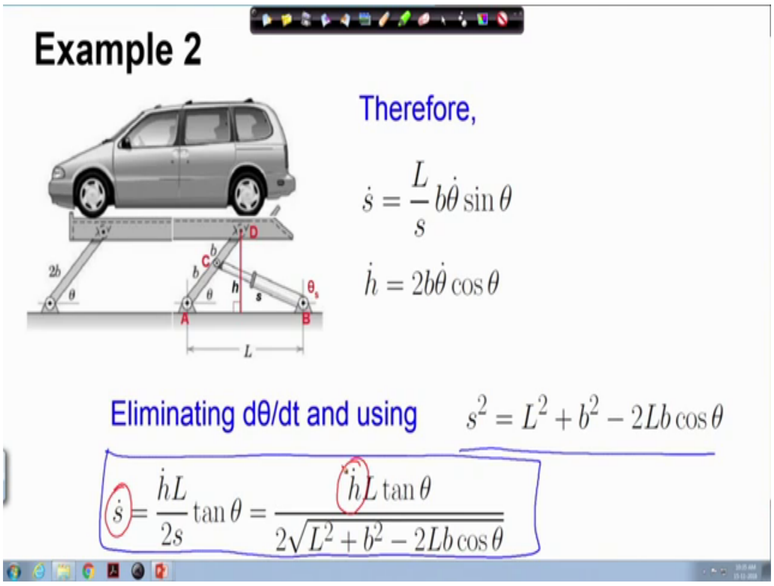

Now, we have two relations one is involving s dot and theta dot the other relation involves h dot and theta dot. So, if you eliminate theta dot and use the relation of s and theta then you come up with this expression, now here we have s dot related to h dot in terms of theta. Now, from the displacement analysis we have already found out theta.

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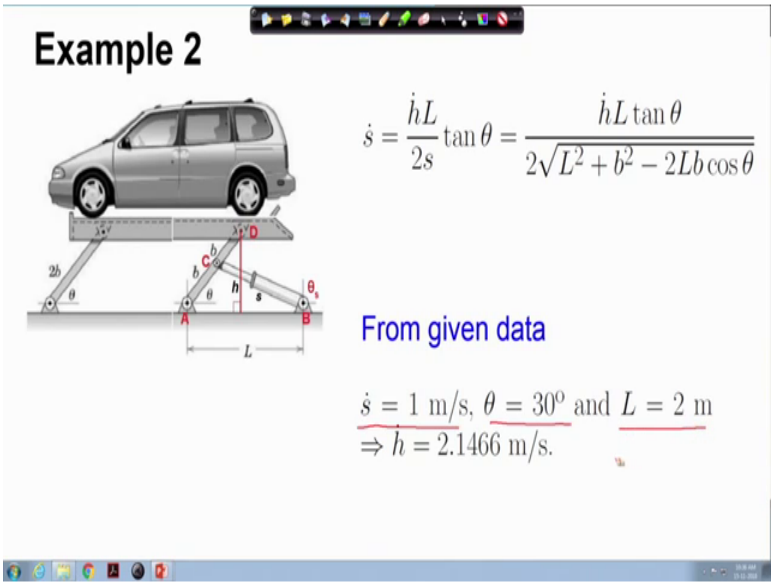

So, we are given this theta as 30 degree. So, at theta equal to 30 degree we are given s dot as 1 meter per second other data the link length data are all given therefore, we can find out h dot which turns out to be 2.146 meter per second.

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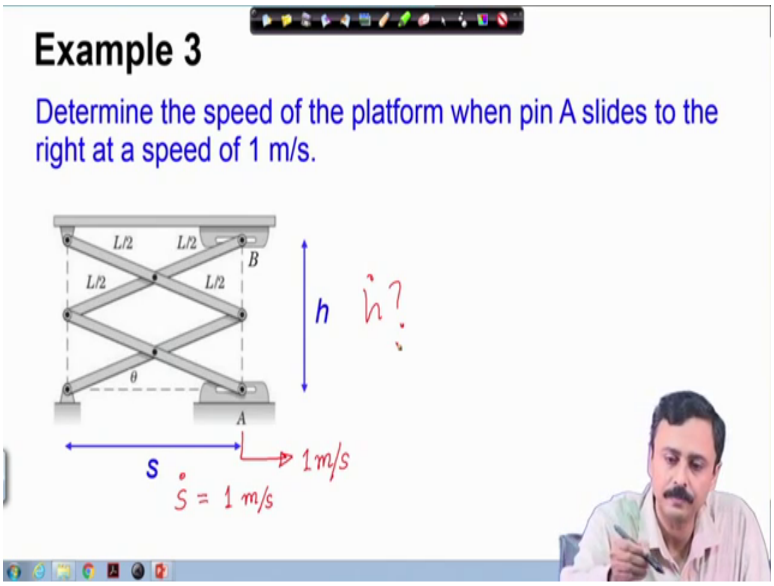

Next we look at the Nuremberg mechanism which you have discussed before in the context of displacement analysis, here it is given that the pin A slides to the right at 1 meter per second. In other words s dot is given as 1 meter per second we have to find out h dot, basically the speed of the vertical travel speed of the platform.

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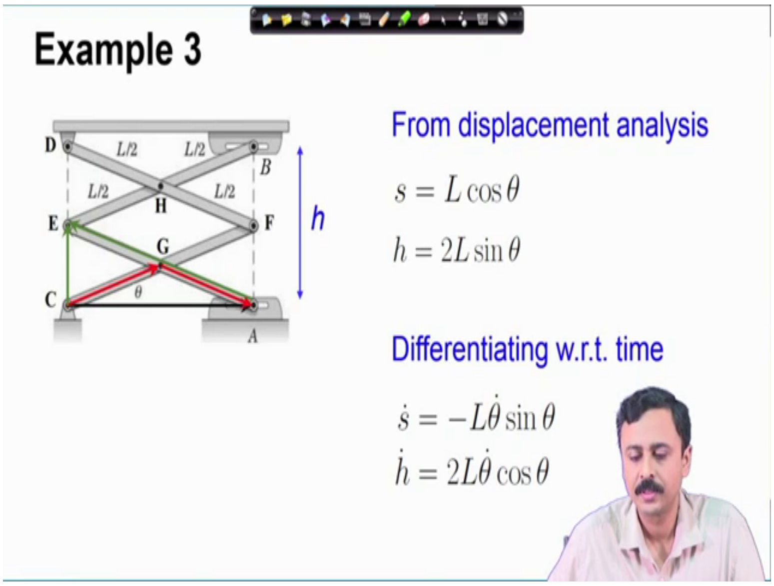

Now, we have looked at the displacement analysis of this mechanism before and we are related s and h in terms of theta which are shown here. Now once again if you differentiate these two expressions you involve s dot and theta dot and s dot and theta dot.

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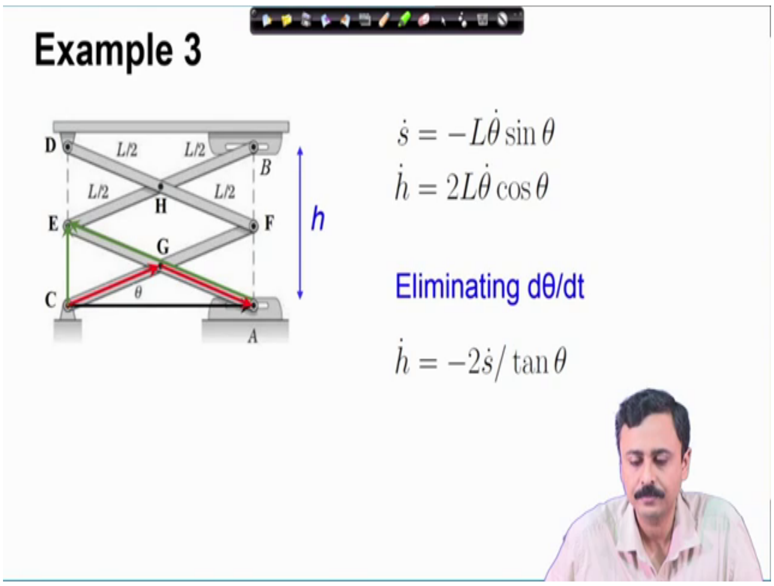

If you eliminate theta dot you relate s dot and s dot.

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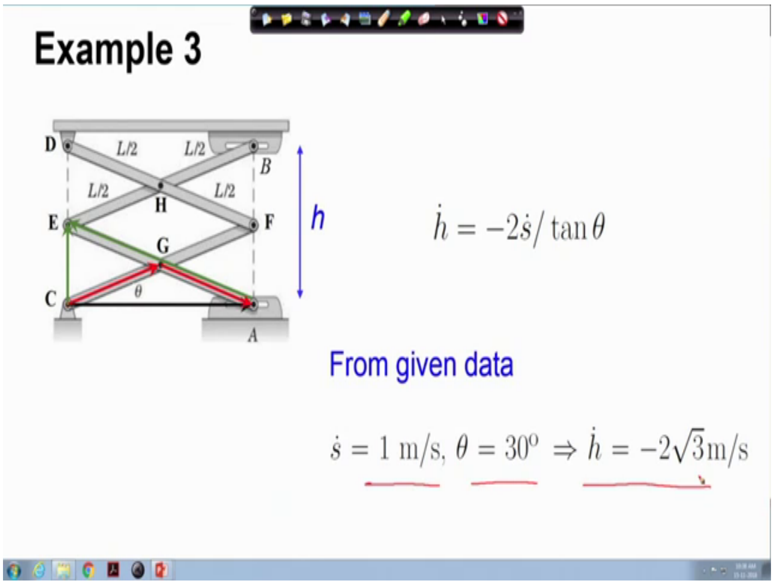

Now, when s dot and theta are given; so, here it is given as 1 meter per second and theta is given as 30 degree you just substitute you will get the expression of h dot.

So, that completes this example, with that I will close this lecture.