Lecture – 27

Theory of mechanisms

Velocity Analysis: Auxiliary Point Method

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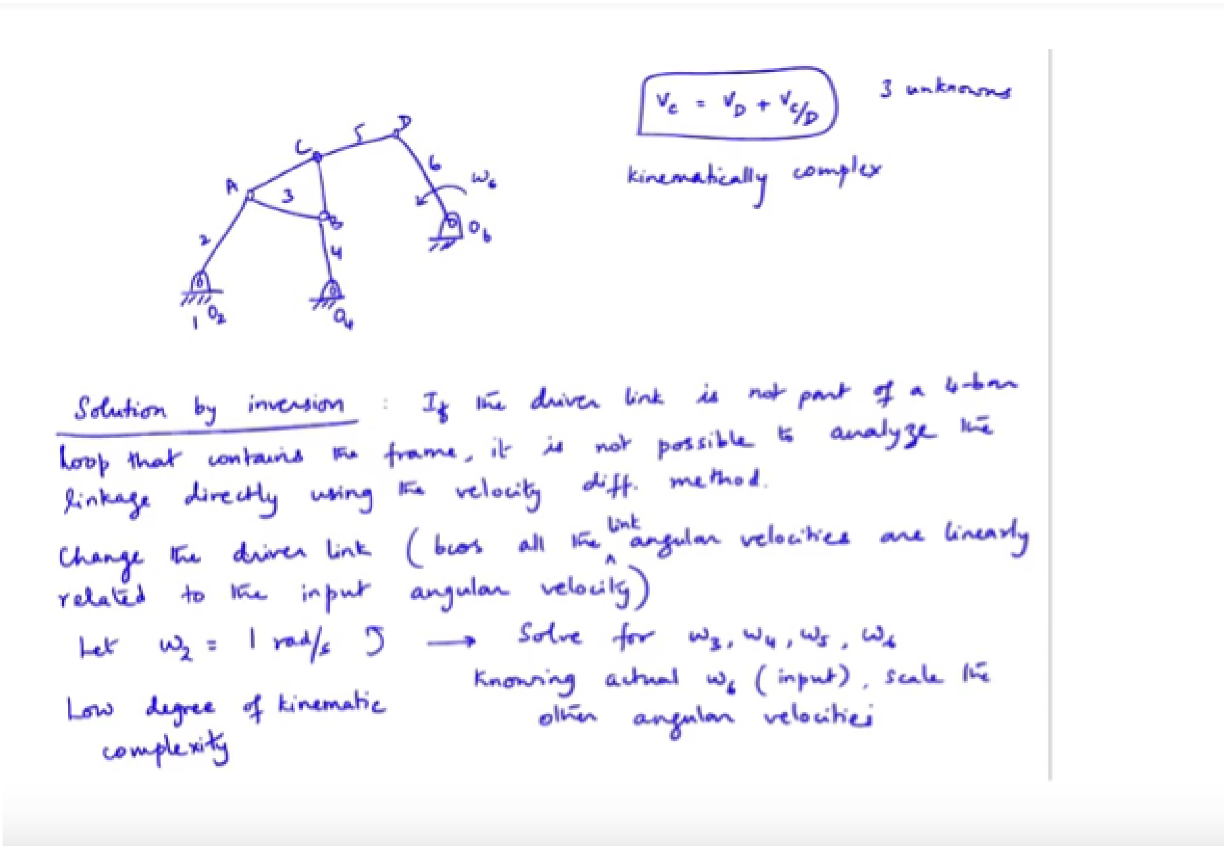

We looked at, the Stevenson mechanism, which we saw could not be analyzed, by the velocity difference method, if so, if link six, is the input. Okay? Then I don't know, I don't have enough information about the part, of point C, to be able to solve my vector equation, involving the velocities of C and D right? So, because if I write, velocity of C equal to, velocity of D plus, velocity of C relative to D then, I have no idea, about the motion of C, I know neither the magnitude nor the director. Okay? Therefore, this vector equation now, has three unknowns, and cannot be solved. Okay? So, what we did last time was, we looked at instance centers, using instant centers, and we were able to solve it, for by using instant centers. so, that's another option to try to solve but, in some cases or in some configurations of the linkage, the instant Center may be outside your working area, and it may not be able you may not be able to use, that method either in order to solve, for the velocities of this linkage. So, there is another method called, solution by inversion, which is used for cases like this, where if the driver link. So here, the driver link six, is not part of a code bar, loop that contains the flavor, if that is the case then we saw up here, that it is not possible to analyze linkage directly, using the, using the relative velocity or velocity difference method because, the vector equation cannot be solved for three Analysis. In such cases, we can solve it using the previous techniques but, we make a change. So, what we do is in the same linkage, if I make O2 a link to or link four the driving link. Okay? Instead of link six, being the driving link, I invert the linkage to make something else, the driving link. Okay? And then because, if you look at it all the angular velocities, if you look at the way, we drew there, when you look at the velocity relations, they are all linearly related to the input angular velocity. Okay? All the angular velocities in the linkage are linearly related to the input angular velocity. Okay? So, we use that fact we change, the driver link because, all the angular all the linked angular velocities. So, let me say, let's say, I say, let Omega 2 equal to one Radian per second. Say counter instead. Okay? Omega six, being main input, I say Omega 2 is my input. Now, can I solve the linkage, straightforward right? Because, I can find this is a four bar Loop, with the frame as one of the links in the roof, loop I can solve for velocity of B velocity of A, by image I can find the velocity of C, once I know the velocity of C, I can find velocity of D, N all the omegas now, whatever Omega six I get, I just have to scale it, by what my original Omega six. So, I scale everything apart I can solve for the using the existing methods. Okay? So, this is solution by inversion, it works for so, if a mechanism, can be solved you know by, by inverting it, So, if the original mechanism. So, it's called if it's not easily solvable you know, if this equation by the velocity difference method, it's called a cinematically complex mechanism. Okay?

So, the mechanism they say is, it cinematically complex mechanism because, you don't know, the part of some points that you require as you apply the velocity difference method. If by inversion you can convert, it into a simple mechanism it's called up, it's called low kinematic, low degree of complexity. Okay? So, in this case if I can solve by inversion, I can say that this mechanism, has a low degree of kinematic complexity. We'll encounter some mechanisms, where even by inversion, I cannot solve it, Using the velocity difference method, yes. So, inversion not in the, inversion IS I'm using something else as the input Link, our original definition was of inversion was, we fix something else so, it's the same thing, it's just you know you're not changing the fixed link here. But, you're changing the input link. So, inversion has a slightly different meaning. Okay? You're essentially changing the input link. So, with this here now you solve for, Omega 3, Omega 4, Omega 5, Omega 6, and knowing actual Omega 6, which is the input scale the angular. So, this is the method of inversion, which you could use to solve certain mechanisms.

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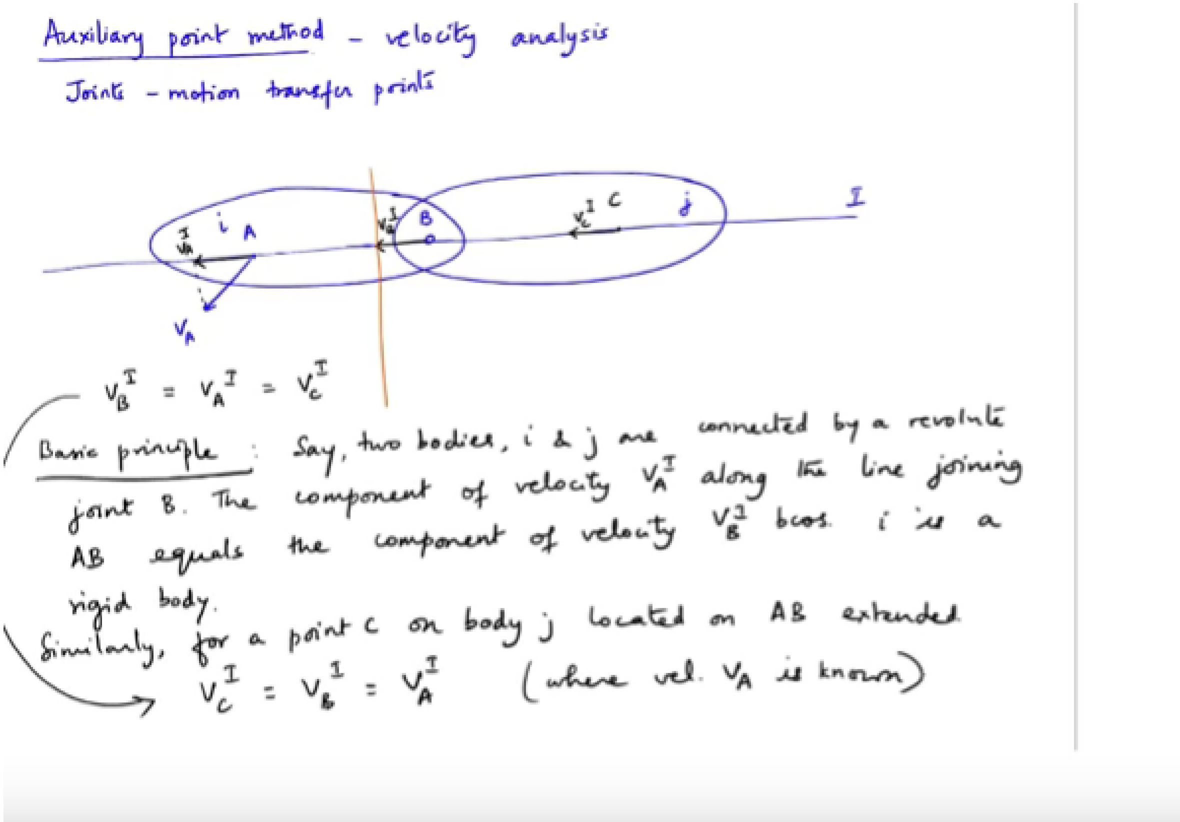

we will look at ,another method ,that is quite useful even for mechanisms, with a high degree of complexity ,it's such it's a versatile method called the auxiliary point method, this can be applied ,to most complex mechanisms ,all simple mechanisms and most complex mechanisms ,and it's based on this, auxiliary point method, for velocity .so, let's look at that now, okay .so ,suppose you have two links that are connected by a revolute joint right? Which is what we encounter, all the time? Okay? It's based on this basic principle. So say, I have a line. Okay? passing through that so, these joints are called the motion transfer points. because, that's where motion is transferred from one link to another. Okay? So, the joints are called the motion transfer points. So say, this is body I, and body J now, suppose I know, the velocity of some point a .okay? On body I. okay? Say I know this, velocity. Okay? I draw what's called an auxiliary line, joining point A and B. okay? B is the motion transfer point, to link check from I to J the motion is transferred from through joint B. okay?

So, I draw line through this now, if I so b is a point on link i and it's also a point on link chain .okay? So, if I take the projection of this velocity. So, I take the component of velocity, along this line i okay. Now, because A and B are points on the same rigid body. Okay? I can say, that the component of velocity of B along this direction, is going to be equal to this, make sense because A and B are on the same rigid body. Now, let me take a point C on this auxiliary line but, which lies on J, I can also say because, again that same velocity is transmitted right? So, I have velocity of C, velocity of B and this is also equal to velocity of C along I. okay? So, I know one component of the velocity of point B and of point C. so, that means, if I draw a perpendicular to that right? The actual velocity of B its head necessarily lies on this perpendicular right? Because, I can split it into two perpendicular components, I already know, one component .okay? so ,if I have some additional information I know that ,this so, if I know two components along two different directions, of the velocity of B then I construct perpendiculars to do those two components, wherever they meet ,that will give me the head, of the velocity actual velocity vector of that point B. okay? That’s the principle, that it's similarly for velocity of C .so, let me just write down a couple of things, and then we'll do an example to make this so, this is the basic principle. Say two bodies, I and j the component of velocity V, A, I. so, d, a one along the B equals because, similarly once in Body j located on AB. So, this it’s okay.

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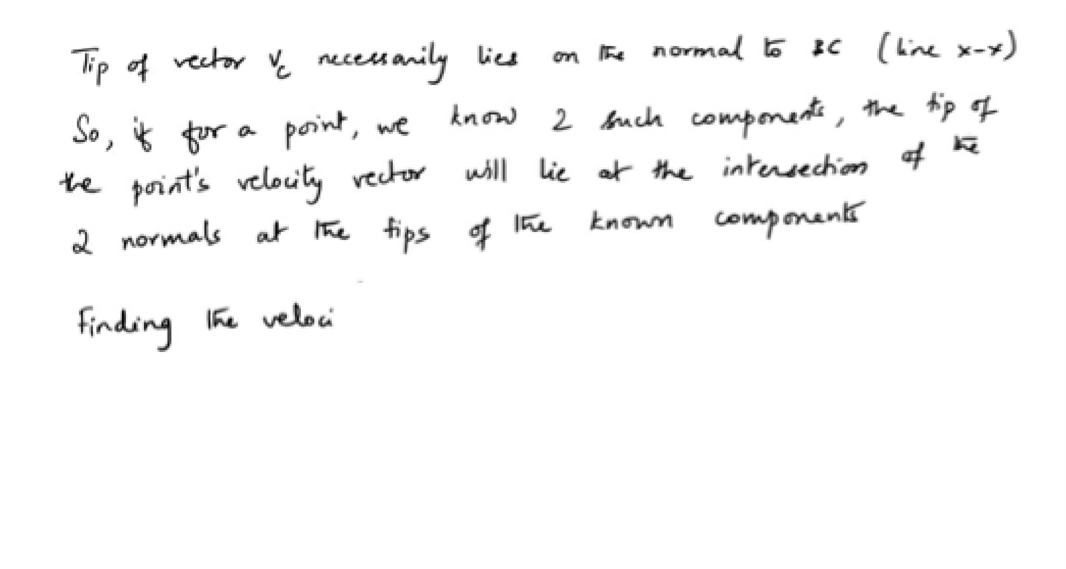

Then, the tip of vector BC necessarily lies on the Normal to BC. Okay? So, that would be here Call, this land success. So if for a point, we know to such confidence, the tip of the point’s velocity vector, the lie at the intersection, of the two normal’s at the tips of the known compounds. Okay? So, if I can find the velocity of two such points on a link then I know everything about the velocity of that link right? because, if I find the difference then I know the Omega, of that okay?

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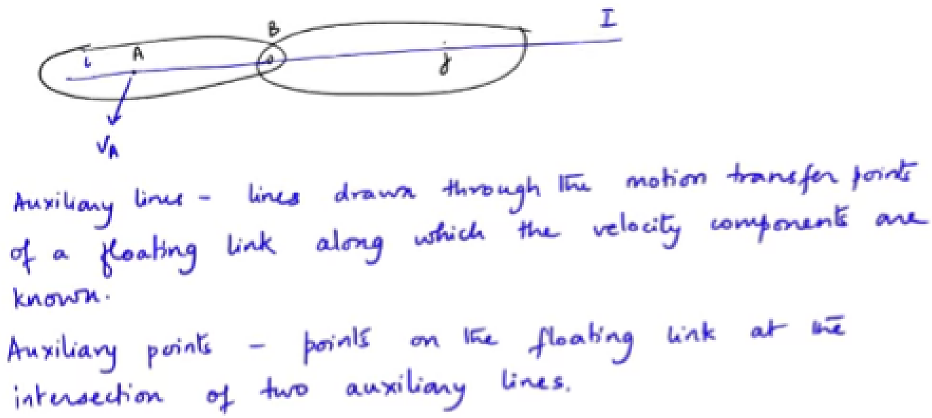

So, if you know the velocity of two such points, let me just draw the I will do an example of so, let's just say so, these the line a B that's called the auxiliary line, if I have link I connected to Little J ,motion transfer point A, question ?yeah. So, if I know the velocity of point A .okay? Or I know the component of the velocity .okay? I will see in a second, when I do an example, let's just say I know the velocity of point A. Okay? And if I know this, I can take any line through A and B and do it like that but, in some cases, I may not know the full velocity of a but, I will know a certain component of a.

So, in that case I will draw it along that component, which I know, which we will see when we do the Example. So, in this case in the general case like I could essentially take, line passing through a and B. okay? And C would be another point that I take on the same length. Okay? So, let's it better be, okay. So, auxiliary lines are the lines, drawn through the motion transfer points, of a floating link, along which the velocity components are known. Okay? And auxiliary points are points, on the floating link, at the intersection of two auxiliary lines. So, let's consider, if it is fixed to a will not then it's not transferring motion know, it's a motion yeah. It's a motion transfer point

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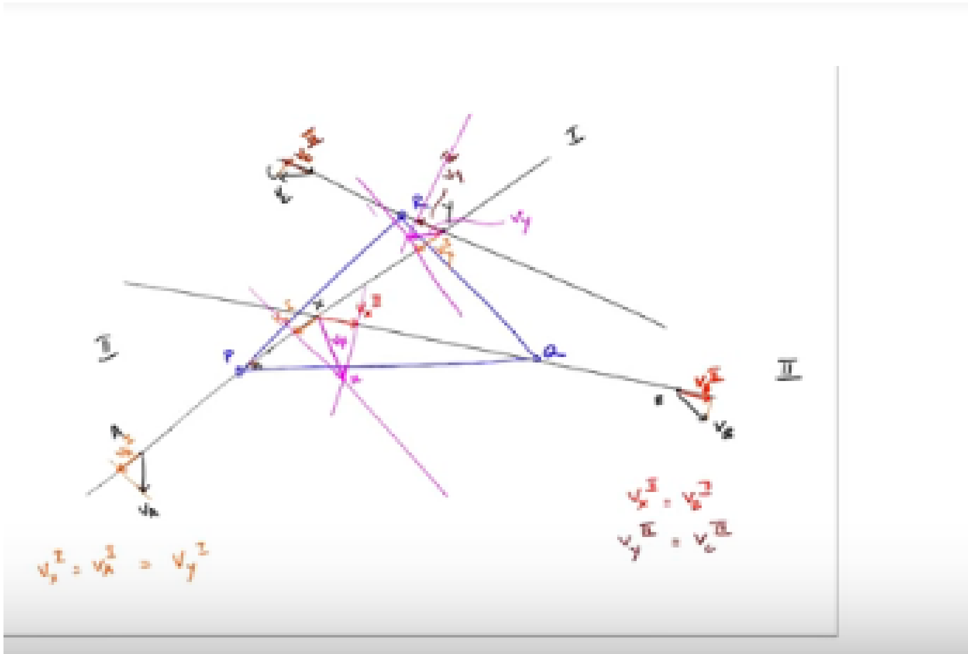

So, let's say we have a floating link or ternary floating link. Okay? I'll wait let me call the speak you. Okay? I have a ternary floating link and I have a point A. okay? Whose velocity I know. Okay? So, I take an auxiliary line that passes through a and P .okay? Some auxiliary line that passes through a and p, similarly I mean know, the velocity or a velocity component of point B let's just say I know, the velocity of point B .okay? So, I take another auxiliary line passing, through this motion transfer so, often passing through this, other motion transfer point for this. Ternary link and then, ice let's say I have a Third Point C, whose velocity I know again, I take my third of the auxiliary line, through that point. Okay? so I need only two points to completely define the motion of the link, right? So, let me say that say x and y add my two auxiliary points, if they let lay outside you will assume that daylight still lie on the Capitoline. Okay? Here, I got my intersections for x and y, inside this boundary P,Q,R but they, could very well lie outside that but, it is still considered a part of this floating link, for the purposes of analysis. Okay? So, actually let me draw all of this motion transfer pods yes.

So, it's a ternary link, hmm. It's a ternary link, it's a ternary link. So, it's connected to three different links, and let's say I know, something about the velocities of let's say, in this case let me say I know, the velocities of a, B and C and I want to find the velocities of this auxiliary points. Show you, that Y can be outside; it's not necessarily, that it's the Point c, velocity analysis. Okay? So, now I have, since these are known, I know the components if this would be BA along height, this would be VB along 2 should be one country, and I have VC I know, the velocities in those Directions. so now, if I move this to this point X ,the velocity of X will be equal to this, velocity V X along I equal to VA sorry, V X around 1 equals VA along one ,the auxiliary line one. Ok? Similarly I change the lines. Okay/ so, this is ignore this one. Okay? So, those are my two auxiliary points is misbehaving. Okay? So, I have X this is VX along 1 right? Which is equal to? V, A along one. Now, this tells me that, the head of the velocity of X, should lie on the line that is perpendicular to this so let me look at I need one more component okay if I look at this X also lies because X lies at the intersection of two auxiliary lines so if I look at line two I don't know another component of velocity here right so here I have so let's say let's say this is B be along to then velocity of X along two equals VP along note okay and I know that I construct a perpendicular to this what would this point be velocity of X .okay? So, this is the velocity of X. okay? Because, I can either split it into a pump in it, so I'm splitting it into two perpendicular components so I know. Okay? I know, components along two directions ,which means this vector will be at the intersection of the perpendicular to those two confidence, so that gives me the velocity of X, they look at velocity of Y, velocity of Y, one component is the same as along one, is the same as the velocity of A along one. Here, because my intersection with two, I need a third you know I, so here I take BC along three. Okay? So if I look at, the velocity of Y will lie, somewhere on the perpendicular to B, Y of this, then the other component, we called this, that's going to be b, c ALONG 3. Okay? Therefore now I have, I can construct the other perpendicular to this, which means, this gives me the velocity of one. Okay? I know the velocity of X, I know the velocity of Y, completely now, which means, I know the angular velocity of this ternary link and the velocity of any other point on the ternary link. Okay? We'll apply this now to that same example that we did. Okay? With omega-6 as the input, without doing inversion, let's see what it does, how we can solve it using the Occident point.

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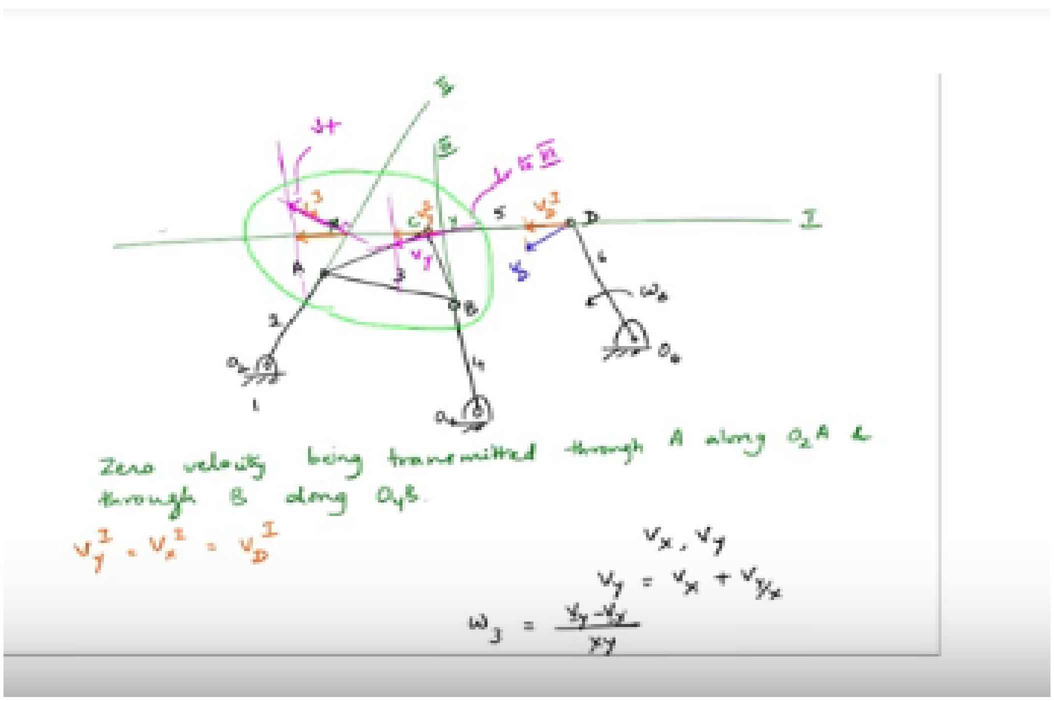

So this was I four, five, six. Okay? So, for what points, do I know the velocity, or velocity components Here, I know Omega six. Okay? So I know the velocity of D completely right, I know the velocity of D, I know magnitude and direction, for the velocity of D so my ternary link my floating link here is ABC. Okay? And because I don't have enough information about C, I'm not able to apply the velocity difference method. Okay? That's why, I'm instead of inversion, I want to try using the auxiliary point method, I haven't let, let me not draw all these in a straight line just to differentiate, so let's say this is my velocity of T. okay? So now I have to pick my auxiliary base right, I can pick one through B and C. Okay? So I take, that could be my auxiliary line one. Okay? Now this is the in the, previous case I said I know the velocities of three points, in this case I know the velocity of only one point. How do I pick my other auxiliary lens? I already gave you a clue, look at the other motion transfer points a and B, they are both connected, two links that are pivoted to the ground ,so which means, along the link ,do I know anything about the velocity zero. Because, for a and for B the velocities are necessarily perpendicular to those two, which means, that component that's transmitted along the length is zero, so I do know something about the velocity that's transmitted through the motion transfer points, so I can take my second auxiliary nine through that and the third auxiliary line through this, zone was passing through C, but so now, I know my two auxiliary points, I can say these are x and y. It's almost passing through C, but that was unintentional, let's see if I can just. Okay? Slightly wetter, so I have x and y, that's my auxiliary points and I have zero, velocity being transmitted through a, a long go to a and through B, along o. Okay? That's what I'm using, so I don't need to know the complete velocity vector for these points, as long as I know a component, I take my auxiliary line through that component, in order to construct my auxiliary lines. Now I have velocity of D, along one, right, that will be also the velocity of Y, along one. Right, so one perpendicular, for the velocity of Y, will be perpendicular to this, right; the other velocity that's being transmitted is zero, which means the other perpendicular will be perpendicular to the line three, right so this is. Okay? It means, that velocity the absolute velocity is necessarily perpendicular to that line, so that now completely defines, so wherever it intersects this other perpendicular, this gives me the velocity of Y.

Okay? Because this is perpendicular to this, that means the component along three is zero, which is what is being transmitted, for point X, same thing I do BX, along one, so BX, along one, is very long one BD, perpendicular to this, it has to lie velocity vector relies on that the tip of the velocity, sorry the head of the velocity vector, for tip and the other one is perpendicular to this. Right, so this is perpendicular to two, that would be the, velocity no civics. Okay? So this is the auxiliary point method and it's applicable to most mechanisms you can analyze by this method, regardless of their complex and the complexity arises because you have a floating link that is typically ternary or higher on. Right, so when the coupler link, the floating link is, a ternary or higher order link, it induces complexity in the mechanism and the auxiliary point method is a very versatile method for analyzing.

You can modify the method, you can modify the method, you may want to check gosh my nick written that book, to see if they actually have an example, if you know the velocity of, so when i say this is x and y and i say my ternary links includes, so I'm doing the analysis on the basis that, this x and y are included in this ternary link. So after this, exactly after this I'm not, yeah so once I know V, X, V, Y. Okay? How, how are they related, I can write V by s VX +, V of Y relative to X. Right, so the difference between two, these two velocities is directly equal to Omega of this linkage, times X, Y, so Omega of this link, let's, let's just call it omega-3; here omega-3 is B Y minus, BX by X Y. Right, here vectors, V by minus VX, by X. So I know Omega 3, once I know Omega 3 and the velocity of any point on a link, velocity of any other point on the length is, I just keep applying this equation, or by image I just construct the velocity image for that link, so I only need. I need two velocities, if I, if I'm looking at, so to completely define the velocity of a rigid body, I need the velocity of one point and its angular velocity, or I need the velocity of two points. because, I know the distance between those two points. Okay? So the velocity, this method gives you, more information, because I can, because you're actually solving for four quantities V, X, V but the x and y components of two velocities,, the velocities of two points, there is degrees of freedom wise .I only need three, I need the velocity of one point and the angular velocity of the link, but the method gives you the velocities of two points ,from which you can now determine the angular velocity and hence the velocity of any other point. Okay? All right.