Lecture – 24

Theory of Mechanisms

Cognates

So you locate OC, by constructing a triangle, OA, OB, OC, which is, similar to AMB, but that is, with the actual locations, of OA and OB. Okay? To determine the link lengths, it's easier, to do it, using Kylee's construction. Where essentially you first.

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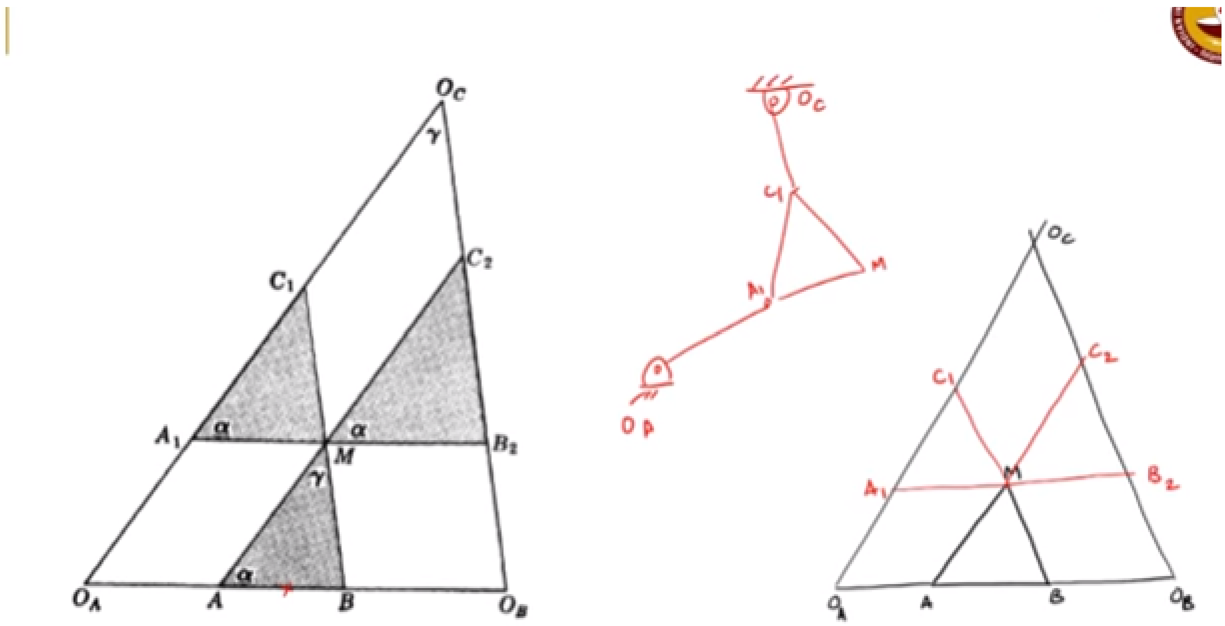

You have your coupler triangle. Okay? Which is AMB. Okay? And then, so then you have, you take the length of, OBB and make it in line with AB, to do the Kaylee construction. And similarly, for OAA also, you do that. Then you construct a line, from OA, that is parallel to, AM. Okay? Construct a line, from OB, parallel to, BM. Okay? This you mark as OC. But that is not the actual location, of OC, you should. Now you just extend M and this parallel. from M you just extend this and you extend this. Okay?
And then through M, you draw a line, parallel to the base. Okay? So this will be a1, this will be C1. Okay? This will be B2, this will be C2 and the link lengths therefore will be, so the coupler base, you can get the link lengths, off of this, construction, for the two cognates. And then when you construct it, you would actually construct it, as, okay, if this is the location, actual location of OC, then you know, your C 1, may be here and this will be, sa,y the actual location of OA, so a1, C1 and this would be M. So your actual link would be, something like this, the cognate. Okay? In space it would be located, such that, it is at the actual locations, with link lengths, obtained from the Kaylee construction. Okay? So because there were some questions after class, about this, I thought I'll, repeat that. Now this, so if M is away from the coupler base. Right? So that AMB forms a triangle, this is valid. Suppose M, lies on AB. Okay? Either between a and B or beyond a and B, this is still valid, the cognates still exists. Okay? The construction, is slightly different, you have to do it. Because doing, this essentially means, this triangle is essentially collapsing. Okay? Because M, lye on a B, then everything else also. So how do you determine the link lengths, for that case?

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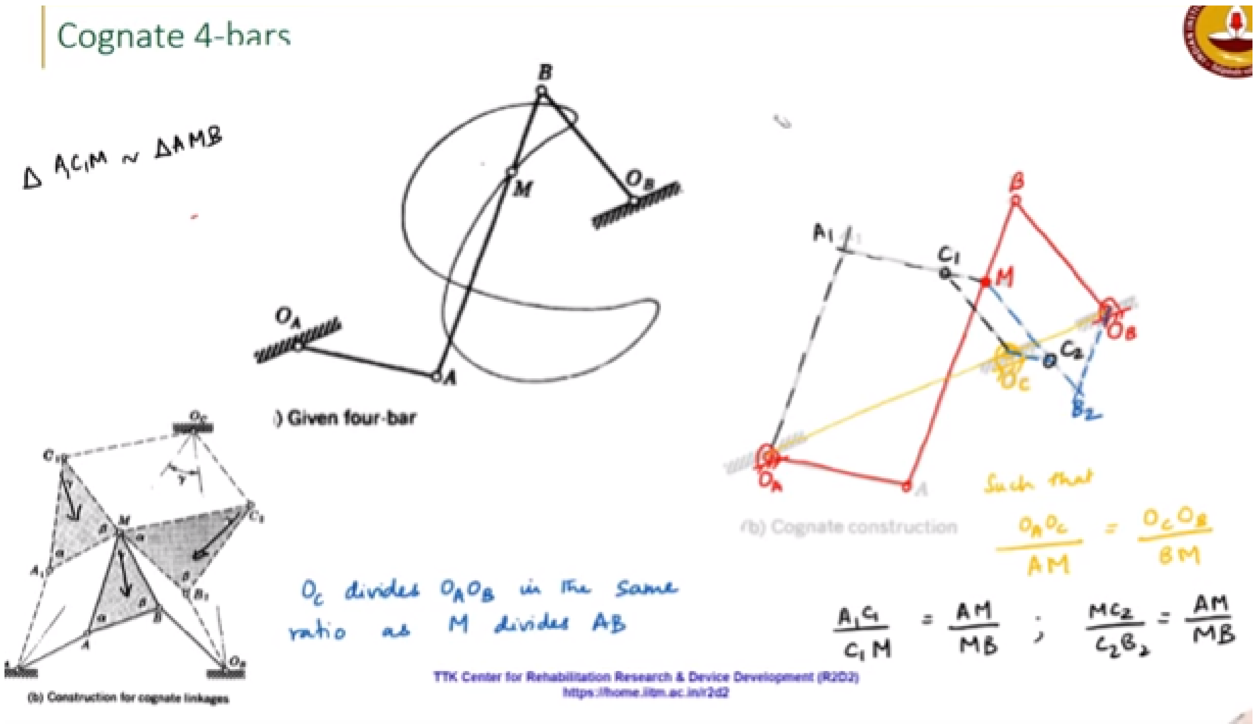

So we'll do an example. So here is a given 4 bar, OA, AB, OB and you're given a coupler point, M, which traces this coupler curve. Okay? You want to find the, cognates, that corresponds to this, four bar, that will generate the, same coupler curve. Okay? So this is the procedure. Okay, so from, you have OA, you have OB, the original linkage and this is your given linkage, this is the point M, I shouldn't put, I should just put a, first we use the open circle for the pivot, this is just the coupler point M. Okay?

Now you want to construct the cognates for this. So look at this here. If you look at the original, let me copy that over. So you'll construct OA, A1. Okay? parallel to AM. Yeah? Okay, and from M, MA1 is parallel to OAA. Okay? So from here, this will help you locate, the point a1. On the other side, from OB, parallel to OB, you have parallel to BN. Okay? So you have this. So B1 will lie here and then from M, parallel to OB. So this intersection will give me, B2. Okay? Now I need to find, this, OC, c 1, c 2. I don't have a triangle anymore to construct OC. But I know that, OC, will divide OA, OB, in the same ratio, As, M divides AB. Okay? When you collapse. Okay? So I use the fact that, OC divides, OA, OB, in the same ratio, as M divides AB. Okay? So if I take this distance? Then I locate OC here, such that OA, OC, by AM, equal to OC, OB, by B. Okay? I still need to find C1. Okay? C1 and C2 Which, you can see here, c1 is parallel to, now, let us say, we created so c1, divides a 1m. Again the same thing, if you collapse this triangle. Okay? Just as, because M is now collapsed, onto a b, c1 will divide, divide a 1m, in the same ratio as, M divides a B. Do you see this? This, these two triangles, a 1, C 1 M, is similar to aMB. Okay? Therefore, c1 will lie on M, such that the ratio, a 1, C 1 by C 1 M, is again the same as, a M, by MB, a M by MB, same ratio you will look at C 1. This is, this is collapsing ,onto this. Just as M collapses onto a B. Similarly here, C 2 will collapse onto MB 2. So if I have MB2, have C 2 here. Such that, MC2 by C 2, B 2, equals a M by MB. Okay. We'll OCC should be in black, this is that and OCC2 should be in blue. So now my two cognates are, OA,

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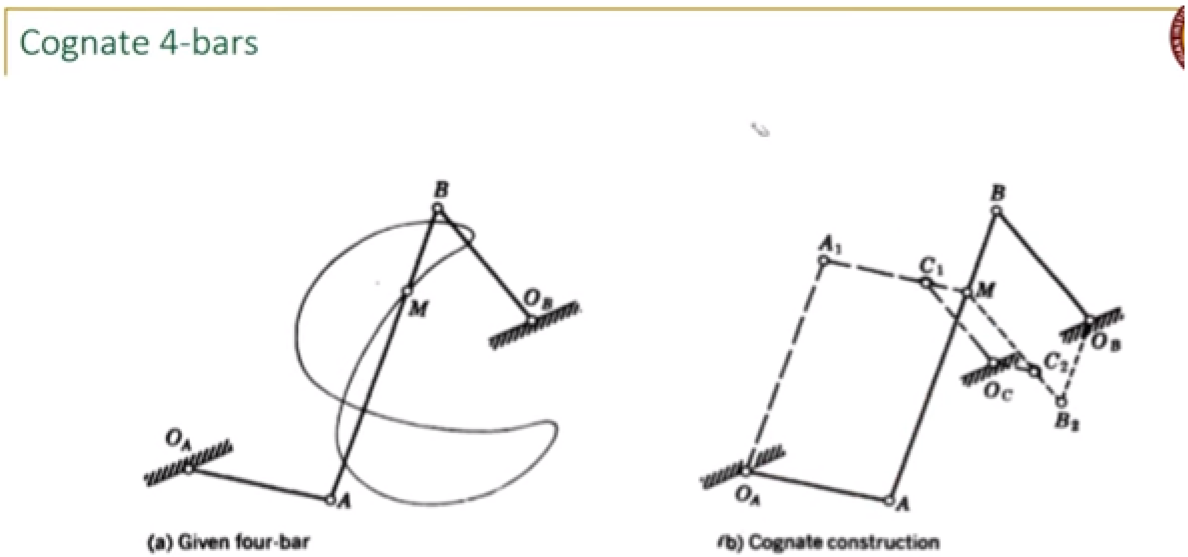

I think I have them separately here. So this is the construction

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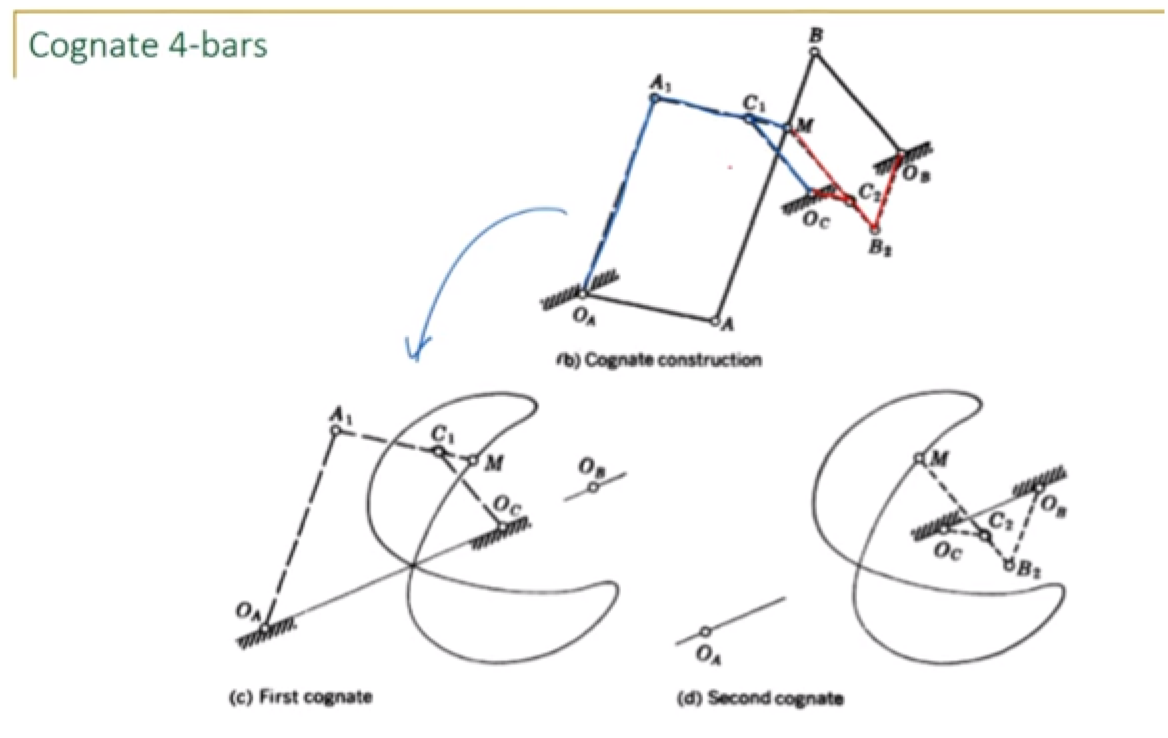

and the two cognates are, OA, A1, C1 and now, M actually lies, outside of AC. Okay? When we divided that . And then, the other cognate, is OC,C2,B2, OB. Okay? You have, what I had as the black one here.

This is one cognate, this is, this cognate and this, is this cognate and this is the coupler point there. So you can see here,
that this linkage, is a lot more compact, than the original linkage, that we started off with, you can see. Because OB, OC, are really close together, here. So this is what we meant by saying, that it can give you something, with a more suitable sizing, for the space, that you have. So this may be more suitable, it really depends on the application, but, you can explore alternatives, by using the Roberts chebyshev's theorem. Okay? And so in your original coupler, the point was actually between a and B. But in your two cognates, it can be, located outside of the coupler base, that you get, that doesn't matter.

Similarly you can find cognates, if I give you this linkage, it will give you, these two as your cognate. So I can construct the cognates, using whatever I want as my original linkage. I'll get the same, I'll get the same three, in the set of the same three, linkages. Okay? No matter which one I, start from.

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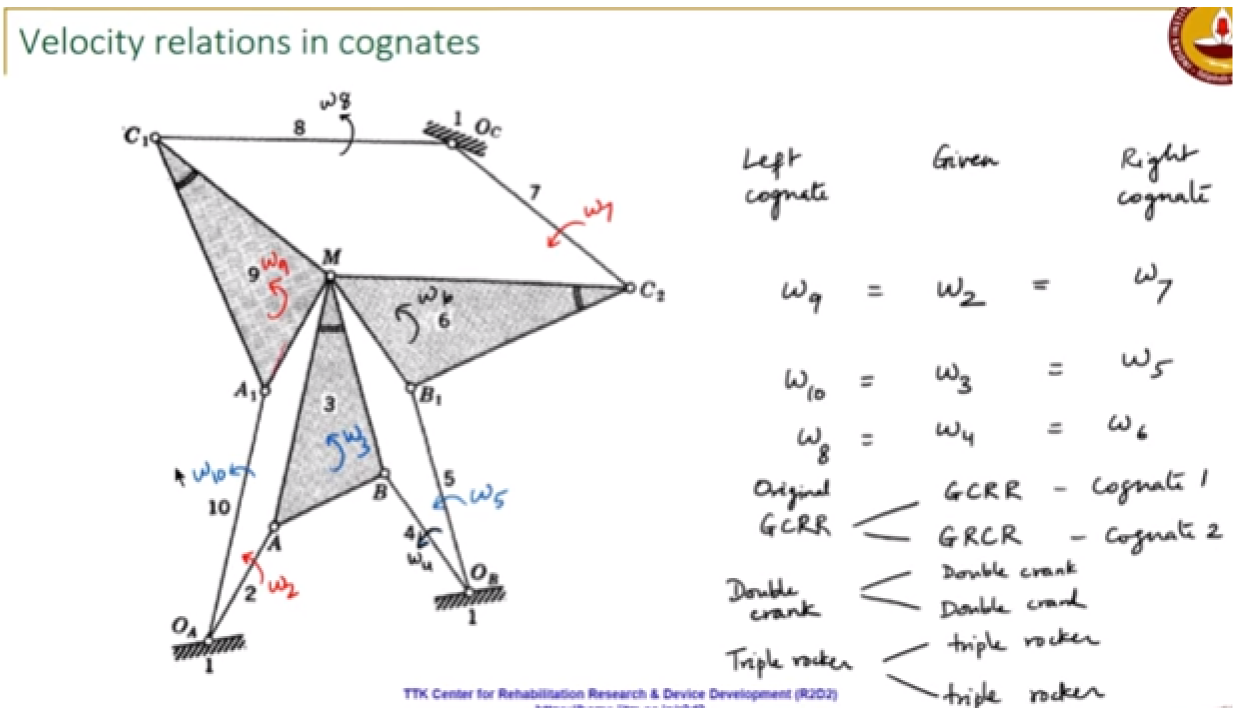

So if you look at, you have, Omega 3 and say Omega 4. I'm just assuming, they're all, it could be, the directions could be different ,but. So my original 4 bar, I have these velocity relations, I can relate those, because of the fact that they are connected by parallelograms. So if 2 has velocity Omega 2, then, a1m, which is a part of 9, will also, so Omega 2, will be the same as, Omega 9. Okay? Now c1m, is part of link 9 and it's parallel to link 7. So Omega 7, will also be equal. So those three, angular velocities, will be equal. similarly, Omega 3. Okay? It's parallel to Omega 10. So the link 3, has, any line on link 3, will have the same angular velocity. Right? On the rigid body, all, all the lines will, so Omega 3, will be the same as, Omega 10. Okay? And here, Omega 3, will be the same as, Omega 5, in this cognitive. Because, MB, is parallel to OBB1. And then, Omega 4, is going to be, because MB 1, is parallel, Omega 6 will be equal to Omega 4 and therefore, Omega 8. So in the given, left cognate, right cognate, this is Omega 2, this is Omega 9, equal to, Omega 7, Omega 3 in the given linkage, is equal to Omega 10, in the left cognate and Omega 5, in the right cognate, and then Omega 4, in the given linkage, is equal to, Omega 8, in the left cognate and Omega 6, in the right cognate. So it's, a cognate is essentially, just a linkage of different geometry, which generates the same coupler curve. Okay? So if you look at, if the original linkage, is a grashof crank-rocker. Okay? So let's say, original linkage is a grashof crank-rocker, just say. Then one cognate, will also be a crank-rocker, okay, okay, let's just say, original cognate one, will also be a grashof crank-rocker, the other one will be a, grashof double-rocker. So it will also have one link ,that makes a complete rotation, but it will be the coupler link.

When I say, grashof double-rocker, it's called or I should just use the previous notation, where G R C R, so this is. Okay? Crank rocker, rocker, crank-rocker, sorry, Rocker, the coupler is the crank, makes the full rotation, rocker. So this will be, cognate 1, cognate 2. Once you do the construction, yes. Without finding the link lengths, you only know that, these are, you and also how, what you designate as. It will depend on these velocity relationships, Right? You, without determining the link lengths, once you know, once you determine the link lengths ,then you can do it. See, these, the cognates have different link lengths, from the original linkage. So you have to determine the cognates, before you can say, which and it also will depend on, which one you give as your input. Right? Because it depends on the inversion. What you give us your input. Right? So you have, you have to determine the link lengths of the cognates, but you know that, in general you will get. So if you have, the original one is a crank-rocker, you know you will get another cognate, which is a crank-rocker. Okay? To have the same, so let's say. Link 2 is the crank, okay, right, right. So link 9 has a similar velocity, so if I give an uniform angular velocity, to Link 2? Yes, in that, in that sense, yes. So this will mean that, 9, if you to get the same, to get the coupler point, to trace the coupler curve, at the same speed, you would have to give the input to 9, the same Omega 2, if you give Omega2, here, then in that cognate you would have to give, Omega 9, to get, if you want to traverse, the coupler point, at the same speed. Because these two are equal. Right? That's the relationship you have to maintain. Okay? Or in the case of, the second cognate, you would give the input to Omega 7; Omega 2, Omega 9, Omega 7, so that would be your crank-rocker. Okay? This, in this case, this is probably, this is not a crank-rocker, the diagram that's shown here, the linkage, it may not satisfy the, grashof conditions, for a crank-rocker. It depends, Yeah, you could say that, yeah, because of this velocity relation. If the original linkage, is a double crank. Okay? Where the fixed link, is the shortest link ,grashof double crank, where the fixed link, is the shortest link, then the cognates will also be, double cranks. Okay? So if this is, G C, I'll just write it, as double crank, or drag link, because all three links, will make a full rotation, the two cognates ,will also be double cranks. And if it is a triple rocker, then the cognates will also be, triple rockers.

Triple rocker meaning, non-grashof. In this case, this is the shortest link. OAA is the shortest link. Therefore if this is a grashof mechanism, that will satisfy the condition. Shortest link has, can make the full revolution, the link, adjacent to the shortest link, is fixed. In this case, even though this is, you know, if you look at a 1, C 1, it may not be the shortest link. So I don't know whether, you can predict ,right away, that this will be the. Omega 10 and no, no, see this, this is not the right figure, to be looking at, if you're going to do it for a crank-rocker. I would suggest that you do it, for a crank-rocker and then look at, what you get. Trying to make conclusions about a crank-rocker, from this figure, is not going to help. Okay? Because, yeah, so whatever will be the shortest link, that will be the and if it is next to the fixed link, then you will get, a crank-rocker. That’s what I meant by saying, that it depends on the, inversion.

Right? Try it, yeah try it. I'm not saying, it's not possible, I'm saying you do it, it should be possible. Take a crank-rocker, take something that satisfies grashof criterion and then derive the cognates for that. Okay?

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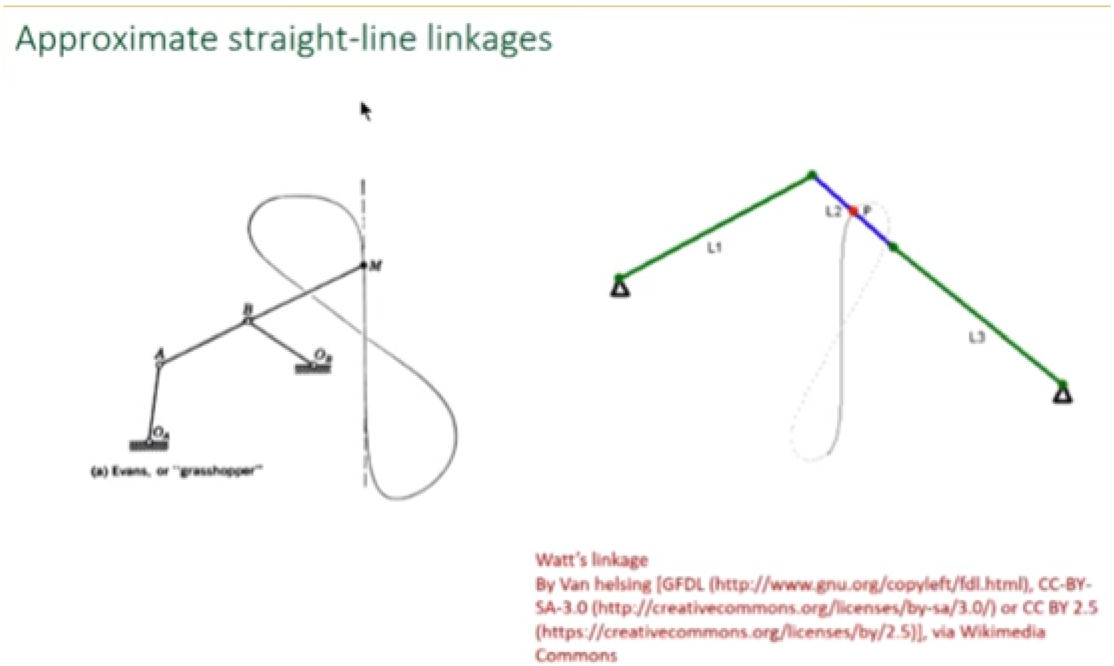

The other, common application for coupler curves, is the use, is their use as, approximate straight line linkages, so there are various versions, of these straight line linkages. So you'll have, approximate straight line portions, you will not get an exact straight line, but you could have approximate straight line portions, in the coupler curve, that you could use, as a straight line linkage, for the application. So for instance, this is the Evans or grasshopper, I think, you can see the approximate straight line portion. Here it's just being actuated between these two limits, but it, it would actually trace the, full coupler curve. They're just not showing that in the animation. Okay? So this is the, Evans or this is actually a cognate of that. Sorry, this is the Watts linkage, Sorry, which is a cognate of the, Evans linkage. You can see the coupler curve is, so this, if you imagine that this is, flipped over. Okay? So you have the straight portion, a figure 8, the, these are from two different sources, so they don't look. But the Watts linkage and the Evans linkage, can be derived as, cognates of one another. Okay? They trace the figure 8 Coupler curve, which has a, fairly straight portion.

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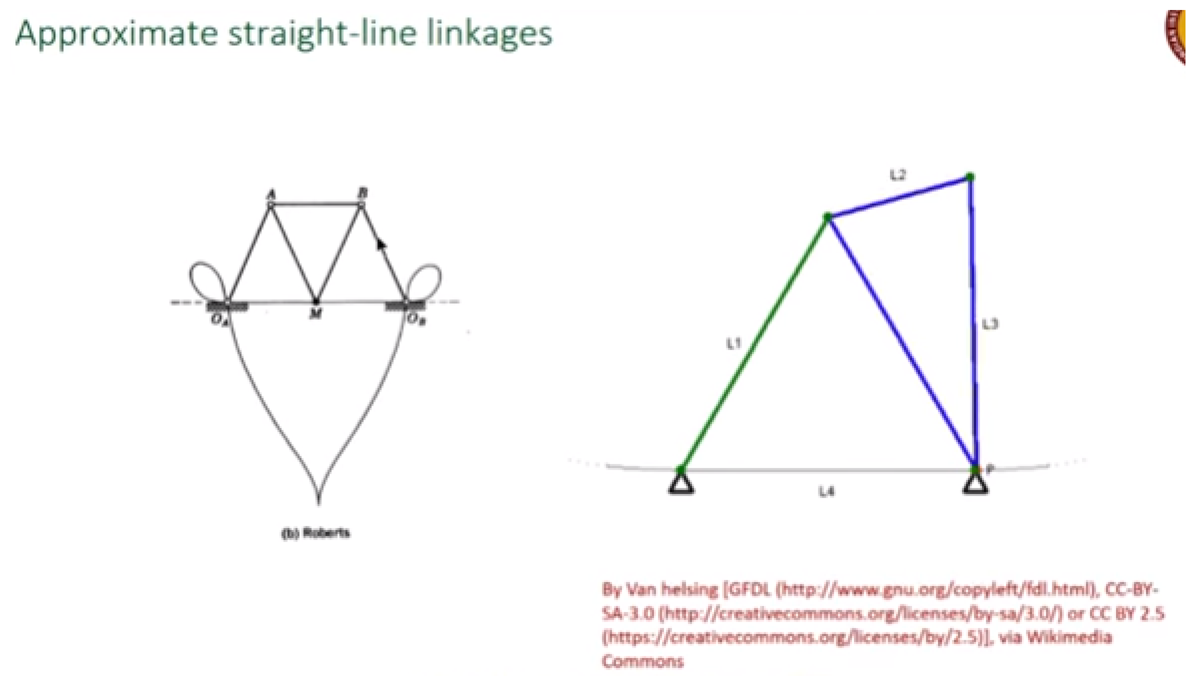

Then you have the Roberts linkage, where the point P, traces between the two fixed pivots, it traces an approximate straight line, point M,
sorry, M here B here. Okay? So that is your Roberts linkage.

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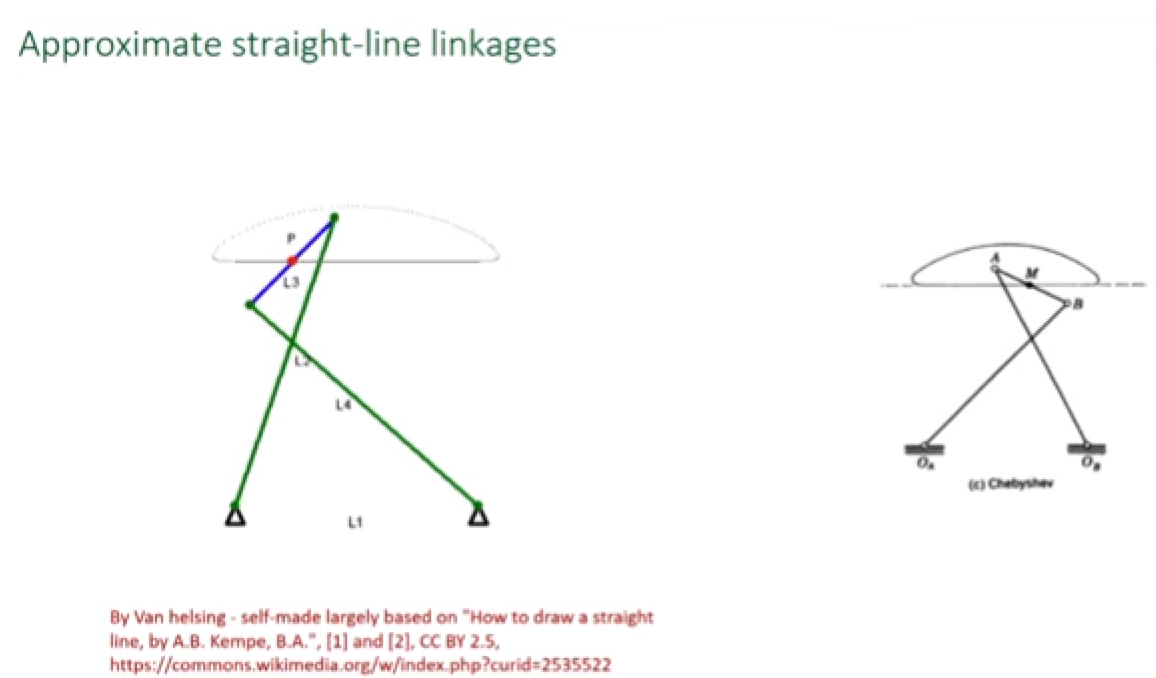

And then you have, the Chebyshev linkage, again they're only showing it, but this could actually, potentially, make a full rotation, you have, it traces this coupler curve, which has a, straight line portion. Okay?

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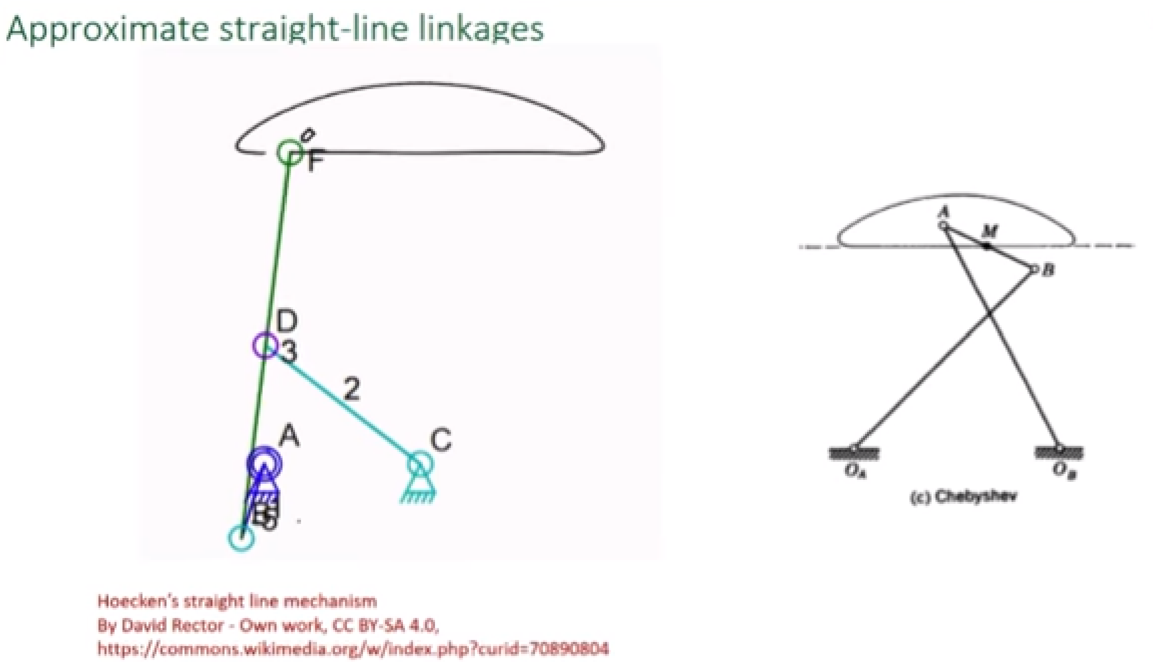

And the Hawkins linkage, is, a, cognate of the Chebyshev, Hawkins linkage, can be derived as a cognate of the Chebyshev and you can see here, the coupler point is, like we'd, like the problem that we did, where the coupler point is between, the, the points a and B, on the coupler base, the Hawkins linkage, the coupler point moves, outside that coupler base, when you derive the, cognate for that, for this linkage, and that. So these have different names, because they were independently derived, later on it was found that, one is a cognate ,one can be derived as a cognate of the other. Okay? So they were, in a, straight line motion was, something that. A coupler curve was something that people wanted to use, for approximating straight line motion. So different people came up with these different linkages and then it was found that, some of them are cognates of one another. But that's why, they have different names, they're named after, whoever invented them. Okay? If you want an exact straight line, so approximate straight lines, can be generated by four bars, using, you know, appropriate coupler curves.

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Exact straight-line linkages

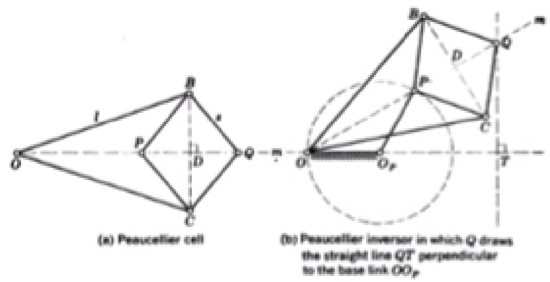
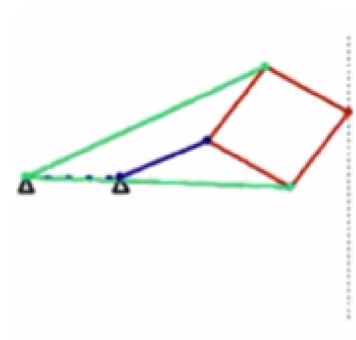


FIGURE 6-23 Peaucellier straight-line mechanism.



But if you want exact straight lines, you typically have to go to, more number of links. And one of the famous linkages, that trace an exact straight line, is called the, ‘Peaucellier Linkage’. Okay? So and it has, 8 bars actually. So this is just to tell you that, yeah, so this, you can see that, it traces an exact straight line, that is perpendicular to the line, joining the fixed pivots.