Lecture: 8
Theory of mechanisms
Specified fixed pivots, path generation

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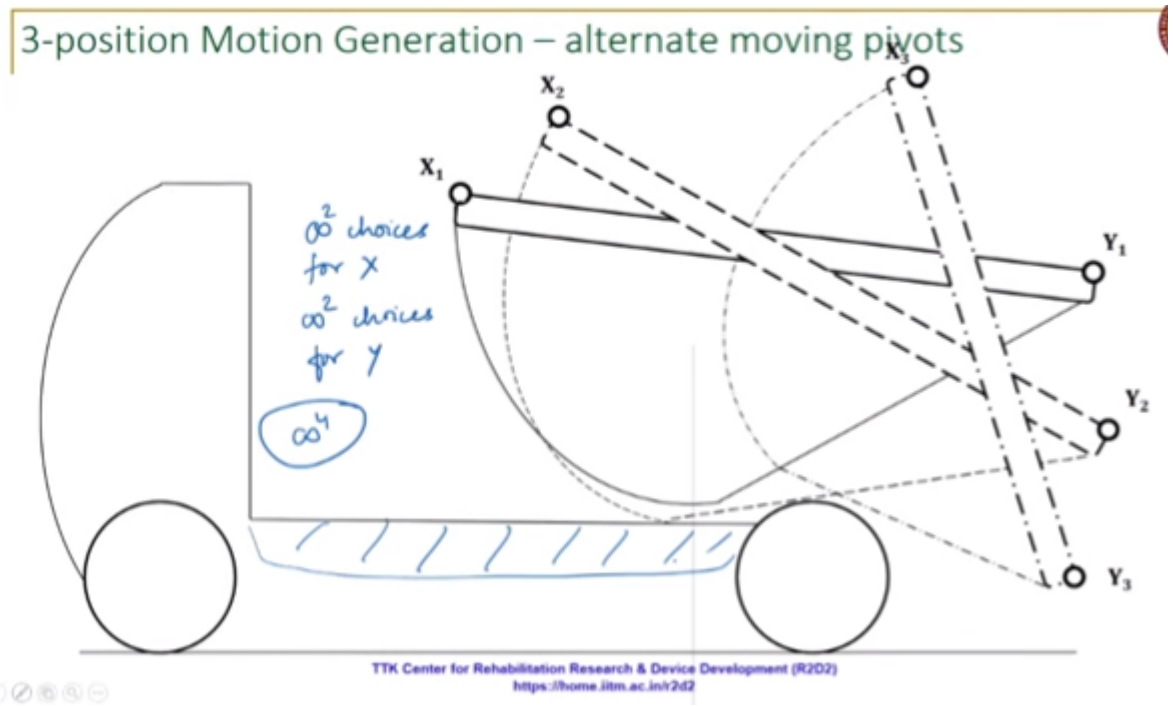

So, last class we were looking at, three-position motion generation and essentially, if your first choice of moving pivots, doesn't give you suitable fixed pivots then you have infinity square choices for said so, for it for example in this, example of a dump truck. suppose, suppose the choice of X and y ,as your moving pivots, gives you fixed pivots that say, fall below the ground or you know, fall somewhere below the truck. so ,that it may obstruct if it's going over a bump or something like that, you may it would be difficult to do that in which case you may have to find other moving pivots, on the bin or you could possibly extend the beneficiary to find suitable moving pivots so, you would have infinity square choices, the x and y coordinates ,for X and similarly an infinity square of choices, for y. so, together you actually do have even for three position generation the choice of the moving pivots gives you infinity to the power four choices for your pivots, how many of those are practical is a different matter, okay. the fact is you do have those choices so, anywhere in the plane is what we say, we can take these moving pivots to be, it is more likely so, for instance, that you may have constraints on where you locate the fixed pivots, okay. it's more likely in real life that you will have constraints so, if this is you know, you may say, that this, is the area, in which I could possibly locate the fixed Pivots, okay .so, I may choose fixed Pivots, in those places in that area and Now, my task becomes.

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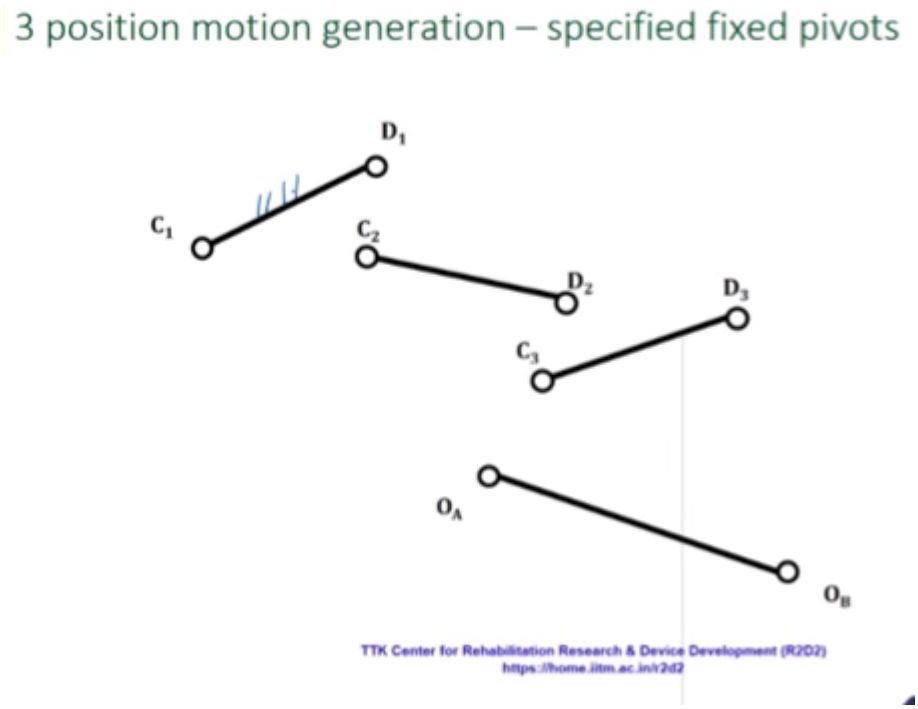

so, for the same so, I have C1, D1, C1 D2, and C3, D3 and say, I'm given the locations of the fixed Pivots, notice there, O a and OB it's very likely, if I connect OA to C1 and OB to D1 it's not going to C 1, C2, C3 will not, lie on a circle with Center at away, similarly D1, D2, D3 will not, lie at the center at OB. the chances of that are pretty slip. So, basically you want to do the reverse of the problem, you are given the fixed pivots, you want to find where, on the moving body, you locate the corresponding circle points so ,that for the three positions shown, those three points should move along the circle centered about, O A or OB respectively, okay. So, that is what? We are trying to do here, and for that, we will now use the principle of inversion. So, inversion tells me, that the relative movement among the links does not change, okay. So, I can change my frame of reference, without affecting the relative locations of the links so, in this case I am going to say, okay. Instead of my being on OA, OB my fixed frame of reference instead let me, sit on CD at the first position, okay. So, the coupler is not moving, okay .I am sitting there, that is my reference point, and I am , going to look at how ,they frame or this, OA, ob how ,that is going to move relative to me, if I had the same relative motion, okay .so, by inversion I am sitting on say ,the first position of c1, d1 and I Am, going to look at how OA, OB will move, with respect to me, if I Did in move but, OA ,OB moved Instead. So, that the relative motion remains the same, the relative locations remain the same.

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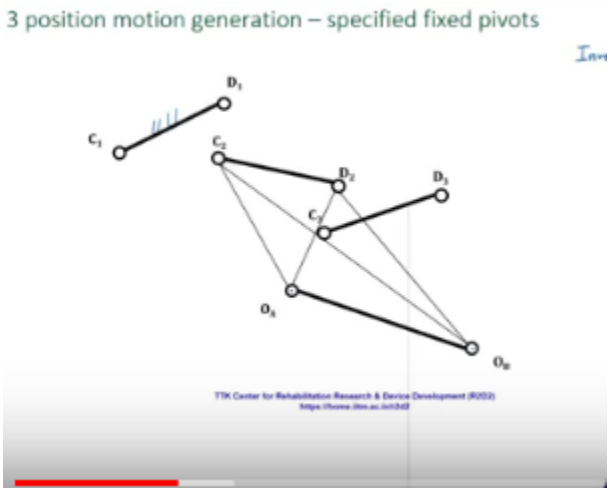

so, if I look at the location of OA, OB with respect, to the second position ,okay. So, away with respect to the first position, okay. This was C 1 D 1 this, is OA OB, with respect to this, instead of my moving from C 1 D 1 to C 2 D 2 how, do I move OA, OB. so, that it maintains the same relationship in the second position, okay. So, with respect to C 2 D 2, I can find the location of OA and OB like this, I basically measure the distances from so, I can look at OA like this with this Triangle, I can look at OB with this Triangle, now, I transfer that, because I am not moving, I am on c1 d1 ,I transfer that on to that first position.

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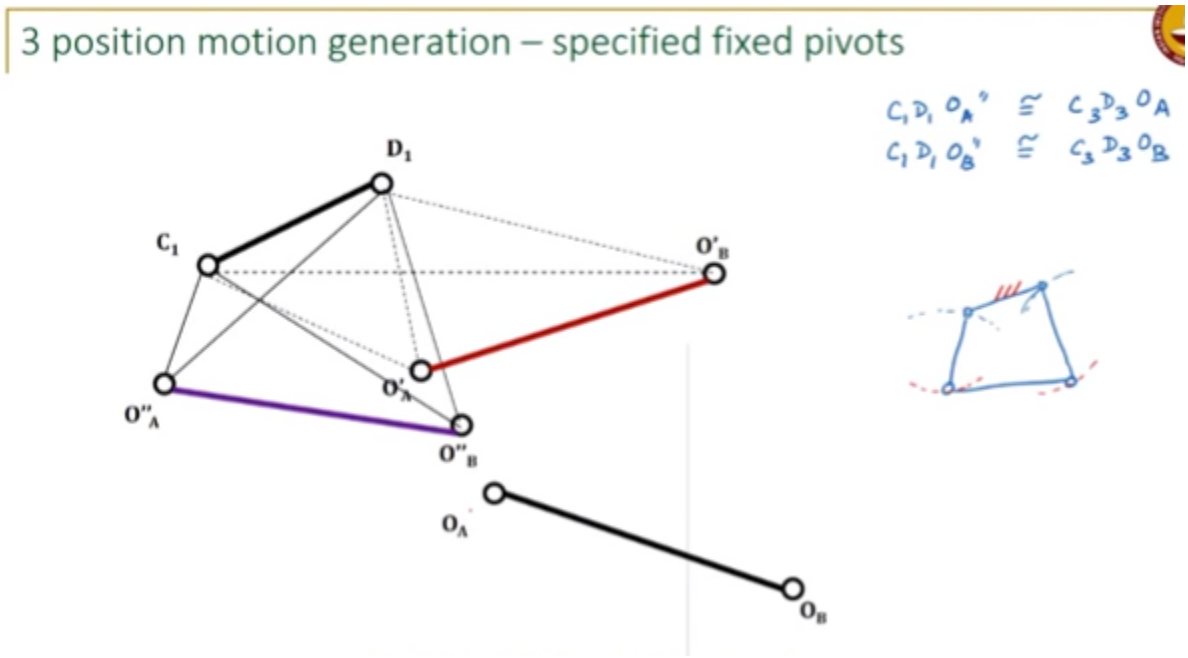

So, these triangles will be congruent to this, C 2, OA, d 2. So, C 1 D 1 OA dash, is congruent to C2 d2 OA and similarly, C 1, D 1, OB dash, is congruent to C 2 D 2 Ob ok. So, I construct that, which means

now, even though I haven that moved, if OA OB moves to OA dash, OB dash, I maintain the same relative Position, that is the same as OA , OB remaining fixed, and C 1 D 1 moving to C 2 D 2, ok similarly for the third position, I find out where OA, OB are located with respect to C 3 D 3 and again.

Transfer that relative location, to the first position. So, OA dash, Ob dash now, I have a OA double dash and OB double dash. So, OA double dash, OB double dash will be from triangle C 1 D 1 Oh a double dash is congruent to this should be, C 3 D 3 Oh a and C 1 D 1 OB double dash , be congruent to c 3 d 3 OB, okay. So, what I have done is, by inversion I know That, if i sat on c1 d1 and then move o a OB, should move first OA dash, OB dash and then move OA double dash OB ,OB double dash, for me to have the same relative motion. Now, look at this, if I have a four bar, at me if I had to have a four bar chain, if I fix this, with respect to this, this is going to move ,these two pivots are going to move in circular arcs about these points, okay. Instead if I fix this, okay. This is going to move, with respect to those pivots, in circular arcs. So essentially okay? I sat on this is the fixed link, okay and I this, move from this to, this to, this okay. I want to find out where is the location, on my fixed link about, the points about which these, three so, OA, OA dash, OA double dash a. what is the point about, which those three will move along the circle, what do I have to do? Basically construct the Perpendicular by sectors.

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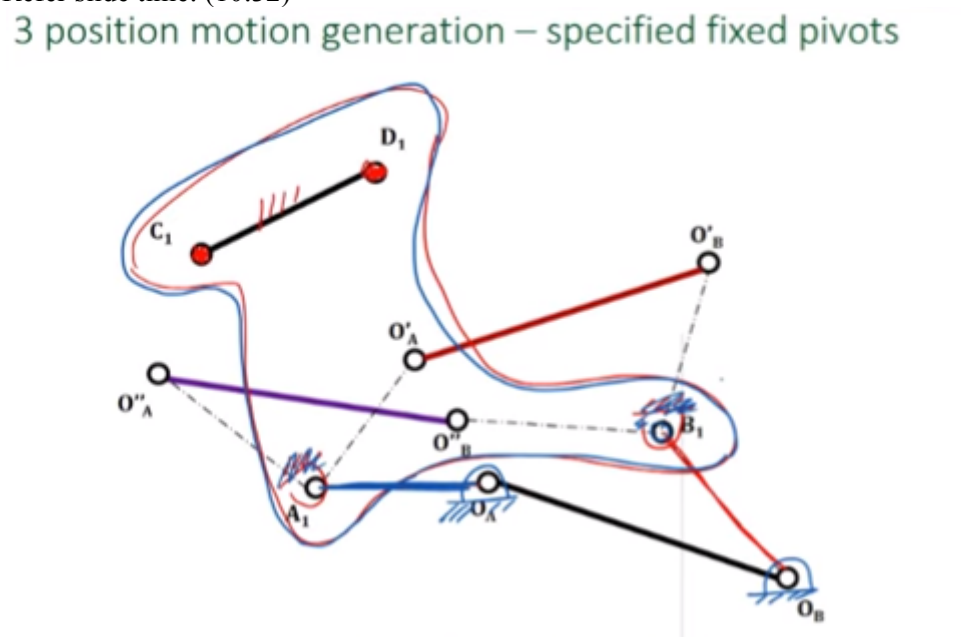

I think I have them so, these are the three positions so, and this becomes what? This becomes my moving, it becomes my three position problem with respect to CD. It's essentially the three position motion generation problem with respect to CD, c1 d1 so, the point a1 if it was located on this body, okay. would be the point about which ,OA Moves about a circle, okay. Similarly b1 so, if my body was shaped like this, okay. That right now, that is my fixed link, okay. this is where I would have to look at a and B

so, that OA dash moves ,along the circular path from OA , OA dash, OA double dash, right and similarly, if I pivot it so ,if I connect this would be my linkage, if I do this, then this, would be my fixed link so, I would connect so again this becomes my fixed pivot actually so, my link will not be the c1 d1, okay .it would not be those would not be the pivots right, these would be the pivots, on the fixed link. And if I connect a 1 2 OA and B 1 2 OB, okay.

Then it moves, OA moves to OA dash to OA double dash, similarly OB moves to OB dash and then OB double dash, okay. So, this said these are not pivots anymore, this would be my a, but this is actually the inversion of what I want? Okay. OA, ob are my actual fixed pivots, so this is, actually the opposite of what you want? Okay. So, my actual linkage it IS the inversion of I have o A and OB as my fixed pivots, okay. So, my actual linkage, is this I pivot it at a and B, okay. And my coupler is shaped like this, or some whatever shapes that includes this. So, basically I have found what are the Points? For which OA and OB, are the center points, I found the corresponding circle points, on the moving coupler, I found the moving Ravens, Okay. Hopefully these will be in a location that is suitable for my application, okay.

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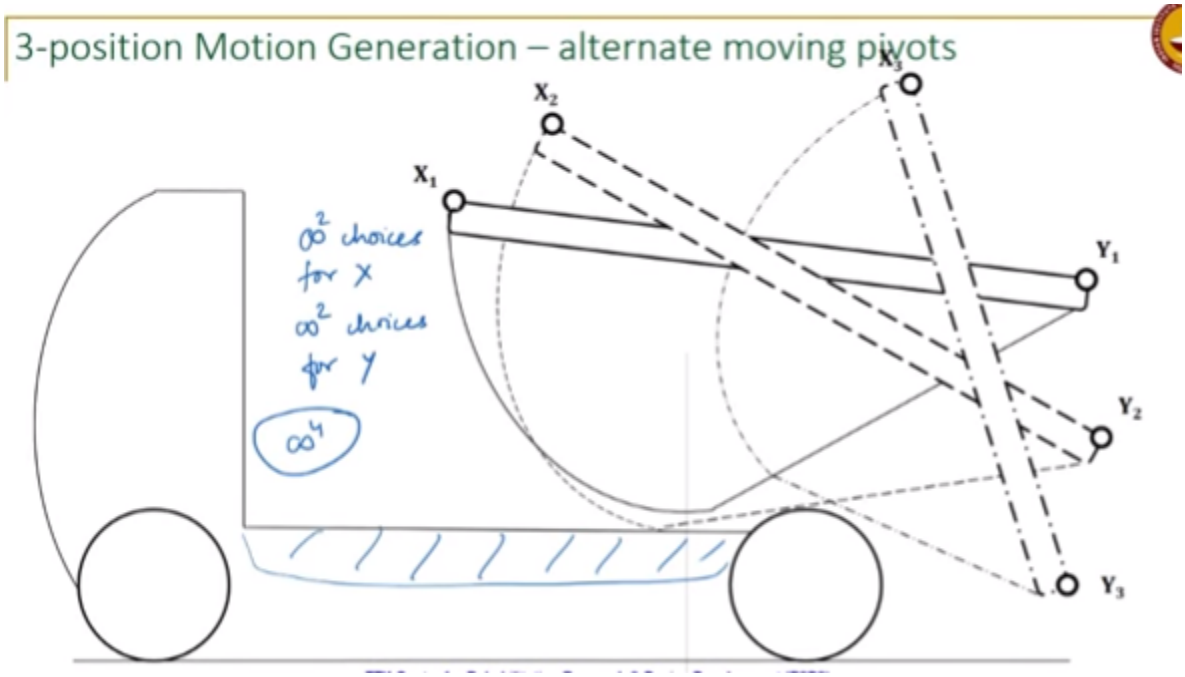

But, like in the case of the bin, it Is very likely that they move, I can if I locate fixed pivots, here I may find something, somewhere on the bin, that would be suitable for my moving pivots because, I have a larger area to work, with or even if I have to extend it you know, if there's no other obstruction, then I have more flexibility, to come up with the mechanism. So, in many cases because, you may also have a motor that is you know you may have a driver diet connected so the fixed pivots will be the ones that are more constraining in the design.

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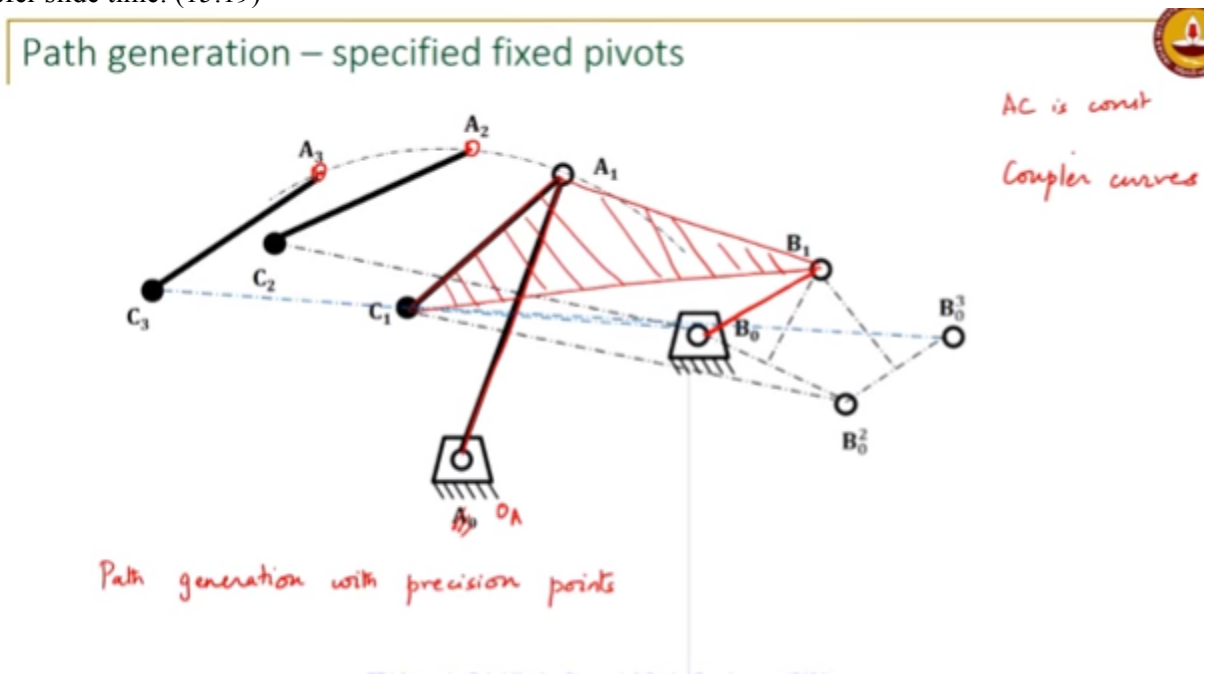

So, in those cases what you basically have to do, is use inversion to find your corresponding moving pivots, we lose inversion over and, over also for function generation. So, you have to be very clear, it is very clear about the concept. Now, the third class of mechanisms would be your path generation mechanisms. So, usually when we look at path generation, we are looking at a point on the coupler moving through certain point's .so, now you are not worried about the orientation of the coupler, okay. you only care about certain points, on the coupler hitting certain points in your workspace, okay. You, want say, you want a coupler point to come to C 1, C 2 and C 3 if that is your design requirement ,then it's actually easier, than in the case of motion generation, it's less restrictive because you don't have the coupler orientation to worry about. So, C may or may not be, a pivot it first of all can c be a pivot can c be a moving pivot if you say yes, you have to tell me under what conditions? Can c be a moving pivot, if c is a moving pivot what do? I have to do so, i have to find the corresponding fixed pivot that, is that so that c1, c2, c3 lie on a cycler.

I could have more than, if I have more than three points then that becomes a problem. But, i could still have ,will see later that you can synthesize for more than three points, for path generation with graphical with motion generation the three points because, on both the moving pivots you have that, constraint you could no longer find a circle that passes through those three, three points is the limit to find a circle to pass through this so, you could have c as one of the moving pivots, in which case you would do your typical, and then you choose as another moving pivot and you can synthesize the linkage, okay. So, path generation is fairly simple and again limiting positions driver diet the same things apply, to all of these. Let's go to the case of path generation with, specified fixed pivots say, a naught and B naught are my

fixed pivots, okay. and I'm telling you that, I want c1 to move to c2 to c3 so, choosing C as a moving pivot is no longer an option, okay. Then, what do I do? So, I have I can pick some point a say, I'm given in a naught a 1, okay. I'm given this now, I want to find out how do, i specify design this for specified fixed pivots. So, that it generates this path, c1 moves to c2 moves to c3 where C is a point on the coupler, okay. From this, definition of the problem, okay. I'm given one moving pivot, what do I Know? That, I could use to design this Linkage, what are the conditions on a and C? I am giving you a hint. What did you say, a c because, it's on the same rigid body so, and your distance AC is constant good. A naught a 1 is constant. So, what does that tell you? how ,will I know the orientation so ,that means you are saying a 1 follows a circular path yeah ,yeah so a 1 follows a circular path, ok. So, a 1 follows a circular path and, and your distance AC is constant .so, a 1 C 1 will be equal to a 2 C 2 equal to is a 3 C 3. So, now I can find the location of, a 2 and a 3 on this part, okay. So, that So, a1 is a moving pivot so, now what is this problem reduce to, it reduces to the three position motion generation, 3 position motion generation now, you have to move a 1 C 1 to a 2 C 2 to a 3 C 3 and you're given the fixed pivots. So, what would I do? in version, do I have to sit on the first position, or could I sit on any of the other positions, I could sit on any of those positions ,if I sit on a 2 C 2 then, I transfer the relative locations of a1 c1 with OA or a naught, a B I don't know why I used a different, I should just go with the same OA, O B and then for the third position, and then put that with respect to the second position, if that's the position that's not moving, okay .so, I could sit on that invert the mechanism find the relative locations of OA OB with respect to those, positions sorry, in this case yes, absolutely good. Yeah, in this case, you already have one moving permit so, you only have to do for OB, okay.

So, find the relative location of OB with respect to the other two positions so, here I've done it. So, this is let me just go with since I have used B naught, this is B naught as observed from the second position, transferred to the first position. this is B naught as observed from the third position transferred to the second position. So, now these three points should lie on a so ,the usual draw the perpendicular by sectors, find the center of that and that gives me B 1. So, my linkage is pivoted at a1 and b1, okay. And this is my coupler a1, b1, c1 here's my coupler. and if I have this linkage then it will move through c2 and c3 as well so, the path generation problem essentially reduces to the motion generation yes, the distances of B yes, yes, yes because, a and B are on a and C are on a rigid body. So, I can find the relative locations this question is we can transfer the distances or the relative location of B with respect to a, you can do that, okay. So, the relative location can be from there you will still get the same moving permit B, okay. So, this is power generation we are going to spend later. So, this is just what we call path Generation, with precision points So, precision points are the points that you want to hit in your design you, want to hit those points, okay .so, we are not really looking at a path per say, we are saying, we want a coupler point to reach certain positions on the plane, and I don't care about what the orientation of the

coupler is? when it is doing that that is why, it is a path generation and not a motion generation problem ,later on we will look at coupler curves, we will look at coupler curves in more detail and coupler curves are, most path generation problems, come under this category of coupler curve .so, if you if it's not if it's not specific points but a path that you want to trace, using a four bar then we actually look at synthesis of the four bar, for certain types of coupler curves ,okay. And you know, the coupler can have very interesting motions, okay. you can have points on the coupler tracing very fancy curves, a points on the input and output links, not input the crank or the follower a pretty boring, all of them trace circular parts but, the coupler can have very interesting the curve, curves generated by the coupler can have very interesting characteristics, and we will actually spend quite a bit of time on that, later so, I will not go into path generation using coupler curves right now, okay. Because, I will finish these precision point synthesis as it's called, where you have certain number of positions and you want to basically hit those, with the mechanism so, this is path generation with the PlayStation points and we will look at coupler curves, later.

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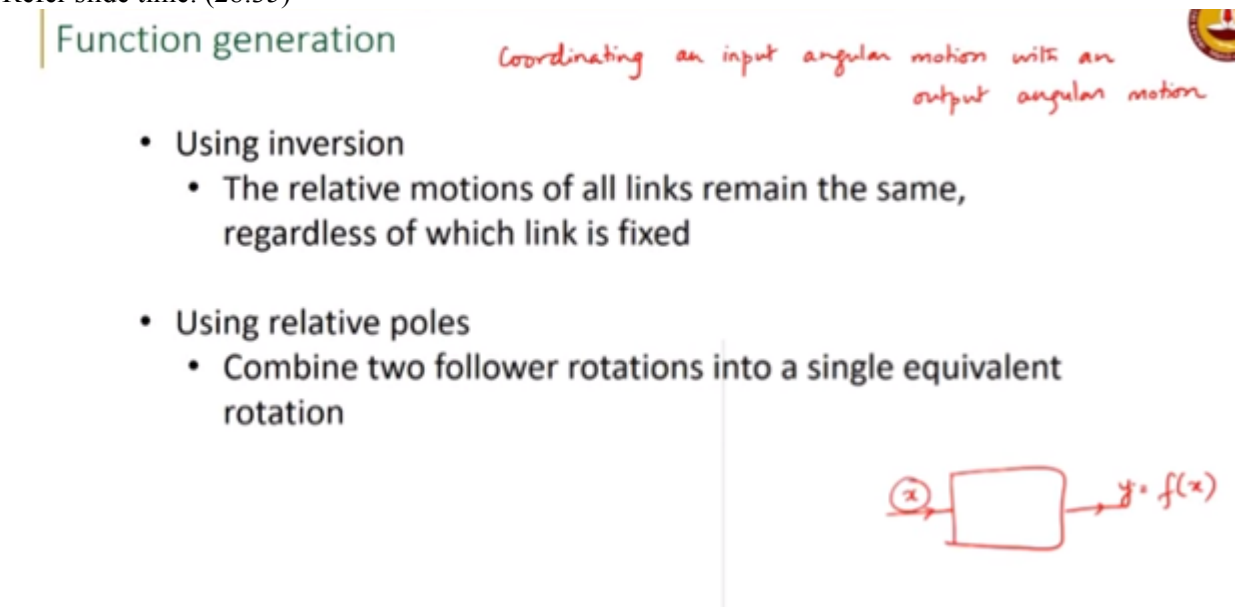

For function generation, there are two ways of looking at so, function generation is you are coordinating, typically you are coordinating, an input angular motion, with and output angular motion, we've seen a special case of this already, which is your dead center synthesis, when you have a crank-rocker and you are designing it for a specified time ratio you are saying, okay. The crank moves through this angle, when the rocker moves from one extreme to the other, then when the crank moves through the returns through the other, angle you have the rocker moving back. So, you have a rocker that's moving back and forth through a certain angle, and you're coordinating that motion with respect to the input motion which is a full 360 degree rotation of the crack .so, that is a special case of function generation but, in many cases

you may just want have you all seen these recliner chairs, in that you will have a handle at the side, you move that through a certain angle it reclines, okay. So, you have so, or you may have a valve opening, okay. You may have a handle at a particular location connected, to a somewhat farther away location where you're opening something. So, you move a handle through a certain angle and that opens something, at a different location, you can also use other things so obviously you know you can use gears you can use other types of machine elements to accomplish these sort of things but, here we are assuming that a linkage is your more suitable because they, may be separated and it may this, may be the most cost-effective way of doing it. So, that is function generation the name came about because earlier, they would actually use it so they would actually design, a function generator so, this would be like say, you give some m input X and you may get y equal to some function of X, as the output.

So, the input would be proportional to this X and the output would be proportional to Y and they, could use that for even you know before you had computers and things like that they would actually compute certain log functions, or you know ,some complicated mathematical functions, would be designed using linkages as an approximation. So, you could and it would have a dial so if you give it a certain input, you can read out what the function value is? Using, that is why these are called function generators. the angles were coordinated in such a way that they would satisfy a certain function, okay .so, there are two methods that we will look at are one is using inversion, basically again using the fact that the relative motion of all the rate links remain the same, regardless of which link is fixed right. so ,and then we will also look at a method using relative poles, where we look at that later but, essentially you will combine two of the follower rotations into a single equivalent rotation. So, we will revisit the pole that we looked at initially and we'll also define something called a relative pole. so ,these are two methods that we will use for function generation.

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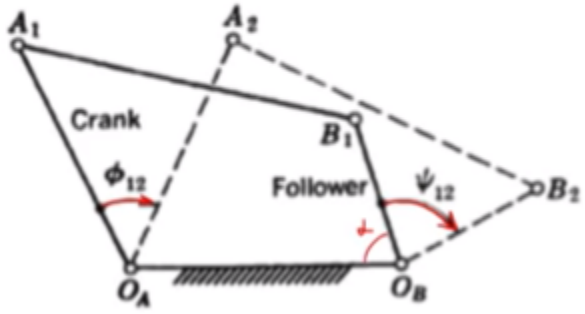
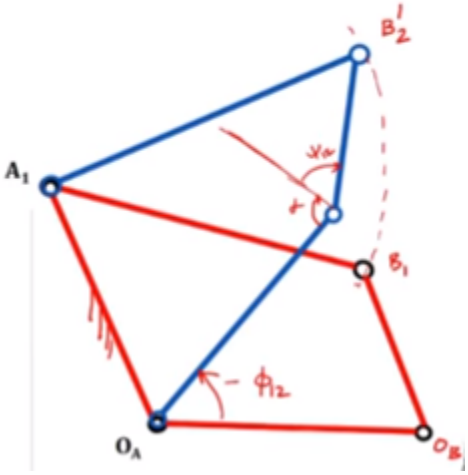
Function generation





So, functional generation is essentially if you give the crank, a certain angle if you move the crank through a certain angle Phi 1 2, 1 2 is 1 2, 2, position 1 2, 2, I want the follower to move through An, angle Phi 1 2.so, that's my design Requirement, I move the input link through a certain angle, and I want the output link to move through ,some other angle ,if I want them to move through the same angles what would I do? I would just have a parallelogram mechanism, right. I would just duplicate the motion using a parallelogram mechanism, okay. So, again we will use the principle of inversion by saying, ok. Instead of O a, OB being my fixed length I will , sit on maybe the input link, and then my relative motion would be, the frame would have moved by an angle Phi 1 2 with respect to me, okay. And then this angle, okay. Would be let is just call this alpha, this would be alpha plus phi 1 2 or if, I reconstruct, okay. So, this would be Simon, okay. So, I take this rotate, okay. First I rotate this whole thing like that so I, I could actually this, and this would be phi 1 2. So, this would be alpha, this would be this angle would be Simon. Minis bless I went this is our focus is the same, okay. So, so this would be where two be would be, if I observed it from O A, a one so I call this b2 dash. So, what does this tell me about? So, I am sitting on this, this is my fixed link now, I am just looking at this and then I will tell you, how to do thee then well do, the construction if I do this, then it means that, with respect to a 1 ,b1 to b2 dash, that motion should have happened along a circular mark , okay? In this case so, that is how, I know that a1 should be the center, of that circular mark. so, this is what I will use in my construction. Okay,