

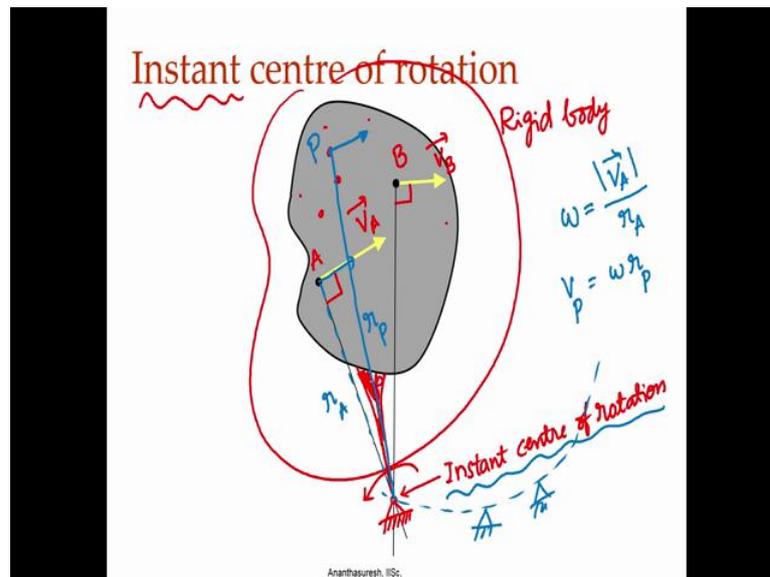
**Compliant Mechanisms: Principles and Design**  
**Prof. G. K. Ananthasuresh**  
**Department of Mechanical Engineering**  
**Indian Institute of Science, Bangalore**

**Lecture – 49**  
**Introduction: Motivation and Overview**

Hello, we have been discussing design methods for compliant mechanisms. We have discussed so far five different design methods, and today we are going to discuss a fifth one. And then in the next two lectures we will discuss a sixth one. These are the ones that one can say that distinctly different from one another and that are why we have chosen to discuss these. Today's method is a very elegant and very simple method, it has its own limitations, but it is something that we can teach even high school students how to design compliant mechanisms. The concept is something that everybody learns during their undergraduate education and mechanical engineering when we learn kinematics, but that is very cleverly adapted to design compliant mechanisms as we seen today; it is called instance centre based design method.

So, it is a graphical method, so something that we need to notice it is a graphical method. One can actually do it on a piece of paper maybe with a ruler or some measuring thing, but you do not really need anything analysis to design compliant mechanisms using this and even the concept of instance centre of rotation. We did not write the rotation here, but actually instance centre of rotation of a rigid body that is again a kinematic concept.

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So, first let us discuss what instant centre of rotation means. If I take a rigid body, so what we have shown like here like a potato is a rigid body something that your swing does not elastically deform. When you have such a body, let us say there are 2 points let us called an A and B; does not matter these labels, let us say that point A has a velocity  $V_A$  indicated by this arrow here point B has a velocity which is indicated by this arrow. So, have a rigid body in a plain planar motion, we have two points which have velocities as shown here.

If I take some other points and this rigid body, we can actually compute the velocity of that by knowing the velocity of two points in a rigid body in a plain moving in a plain. It is a planar rigid body moving in a plain. Once we know 2 points and their velocities we can get the velocities of any point on the rigid body, it is a nature of the rigid body. How do you find that? There is one concept that every rigid body will have a point which may not be inside the point when you say it a rigid body it can be bigger, it can be this and that it can be entire plain. So, if you think of it that way there will be a point in the plain which will have 0 velocities. That means that, at that instant it will not be moving. So, if I take a this point it may have some velocity this may another this may another velocity, but there will be one point which will have 0 velocity. If you look at the rigid body motion from that point it appears as if rigid body is rotating about that point at that instant; that is why you call it instant or instantaneous a short hand form of that

instantaneous centre of rotation. At this point rigid body appears to be rotating about that point on.

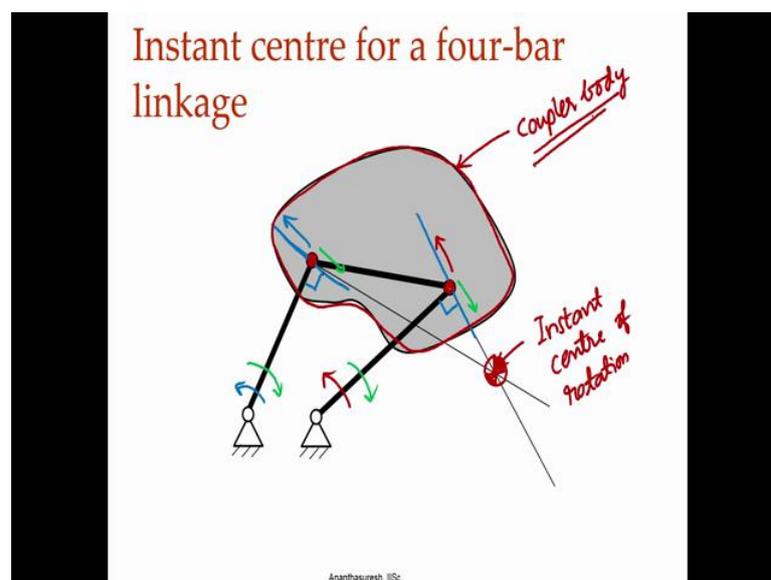
In order to compute that such a point which has 0 velocity, what we do is we draw a perpendicular at point A to the direction of the velocity, velocity  $V_A$  is there. So, it appears to be moving in that direction instantaneously that is what velocity means right magnitude does not matter here it just that it is a direction matters and you draw a line perpendicular the direction that is one line. Similarly at point B we draw another line again perpendicular to the direction of the velocity of that point they both will meet at a point these two lines definitely meet at a point and less than parallel to each other in a plain.

So, we have this point this now is the instant or instantaneous centre of a rotation that is the instantaneous centre of rotation for this rigid body at that instant what is the instant is points A and B have this velocity that are shown here in those directions. Now this point will have 0 velocities, it does not move at this point but rigid body appears to be rotating about that point instantly. Why do we say that because if this is the point that is like few at almost, but that instant because that is not moving its velocity 0 like a few word the whole rigid body if I want to connect it draw it some rigid thing that is all connected to rigid body at this point appears to be rotating about that point. Since rotating about it is rotating about that points if I take this line.

So, the line that we have just drawn if I take this line right, since this is a fixed at that instant the velocity of this point has to be in that direction and. In fact, we can find the angular velocity of the rigid body at that instant, because we are given velocity  $v_a$  and we would know this  $r_A$  that is from this instant centre to point A correct actually find the angular velocity because  $r_A$  times  $\omega$  will give you  $V_A$ . So, we can actually find the angular velocity once the angular velocity any other point I want to take I join that to the instant centre then it is going to be perpendicular to that it is going to be that. So, again we have let us say I call this generic point P then I will have  $r_P \omega$  times  $r_P$  which  $\omega$  we already got again  $\omega$  is a magnitude of  $V_A$  direction already now using magnitude divided by  $r_A$ , we got  $\omega$  once you know  $\omega$  velocity of any other point P we can write it as this  $\omega$  times  $r_P$  that is distance from the instant centre to that point.

But our idea now is only to calculate instant centre because at that point it appears to rotating about that our interest we are not interest in  $\omega r$  finding velocity of any other point we just want to find this instant centre of rotation and that is a consequent to understand. So, when you have a rigid body and you have 2 points whose velocities are known instantaneously this true only you can instantaneously after that rigid body move some other way instant centre may move from that point to another point another point and if you join all of those that becomes a locus and that has its own significance kinematics. That is if you take this rigid body if you roll it along this you actually get the same motion rigid body as this one does all that is not of our interest our interest only to understand and what is instant centre of rotation is you have two points and you just need to draw perpendiculars to the directions of velocities of those two points then we get a points intersection that is instant centre of rotation that point at that instant will have 0 velocity.

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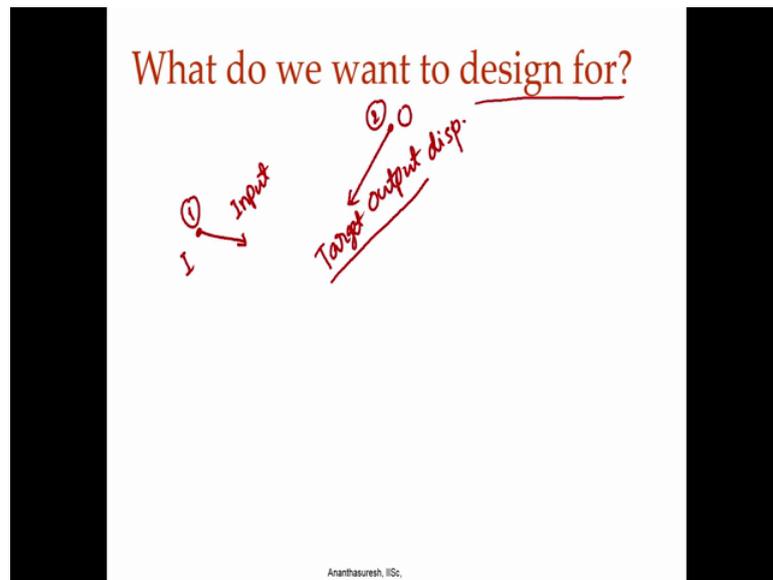


Now, let us look at the 4 bar linkage now we are this is a concept that came from linkages or rigid body kinematics we have a 3 bar linkage. So, we have input and output we can see that then this moves at that instant. Let us say it is moving or rotating from that its velocity of this point is going to be that way. In fact, whether it is moving that way this is a less a does not matter it is just that direction of this point is going to be along that line, because it is fixed here it has to be that way.

Similarly, if draw a perpendicular again this is perpendicular to this point it has to be that way. If it moves like that velocity will be like this if it moves let us say the other way then velocity will be this way, but direction is that similarly here if this moves like this point will move like that if it a moves the other way then the velocity will be like this, but direction will be the same. Now what you see here is that in a 4 bar linkage this is what we call a coupler body, because everything is rigid there. Again as I said when you say something is rigid between two points you actually can in imagine infinite lamina or a planar sheet which is connected to those two points. So, even though I have shown only this much here this one this has really no significance you can make it as large as you want.

Now, if you see we have the same concept we have a rigid body where we know the directions of two points direction of velocities of two points that is this point and this point, when you have that we can do the same thing write drawing perpendicular for that point and then this point then we get the instance centre of rotation. So, this coupler body at this instance appears to be rotating about this point that we have just found. So, this will be our instance centre of rotation. So, the whole rigid body that is the coupler body appears to be rotating upon that point this is the concept that has been applied to 4 bar linkage also even bigger linkages whenever you know the velocities of two points in a rigid body you can find it instance centre again at that instant. So, this is the concept that applies to four bar linkages also based on that one can design four bar linkages graphically.

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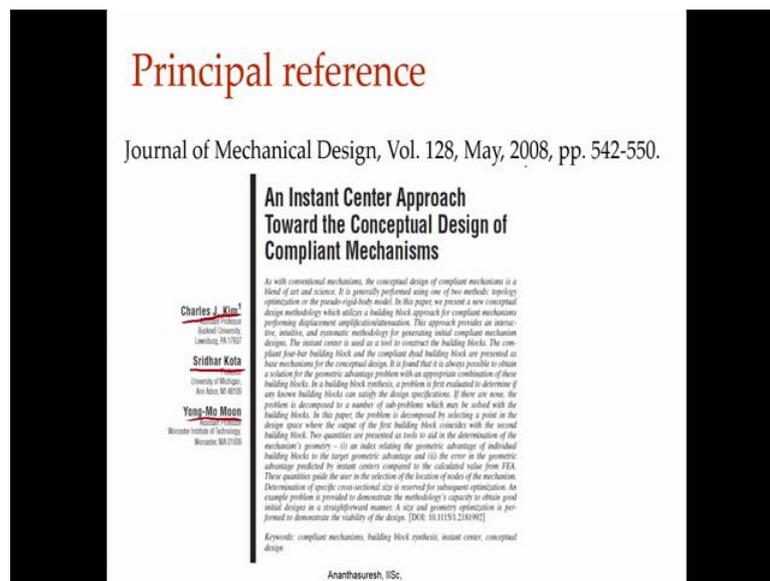
So, here in the context of compliant mechanisms, what do we design for what do we want to design for if you recall. So, for our interest has been function generation that is if I have one point and another point, I said my input is in that direction if apply input in that direction I want; let us say output in that direction, that is the kind of problems we have solved with pseudo rigid body modeling based design method as well as structure optimization based design whether it is especially the topology optimization method that is what we had done.

With regard to other design methods it was different, but every where we had this motion that input given in one direction we have desired outputs some of the other target output which use the point if it is input point output point you want this. So, can we get this now we can see how that instance centre of rotation concept could apply, because we have 2 points this is point 1 which is the input we have point 2. And we know how they should move instantaneously meaning when you start applying force in a compliant mechanism we would know that the direction of the velocity, because we are applying input of the direction target output in one direction, because when you say point has to move you want to apply force in that direction and you want target output displacement this will be the displacement in a particular direction.

So when you have these two, we can actually apply that instance centre concept. In between what is there has to be rigid for this into work now we do not have a rigid body

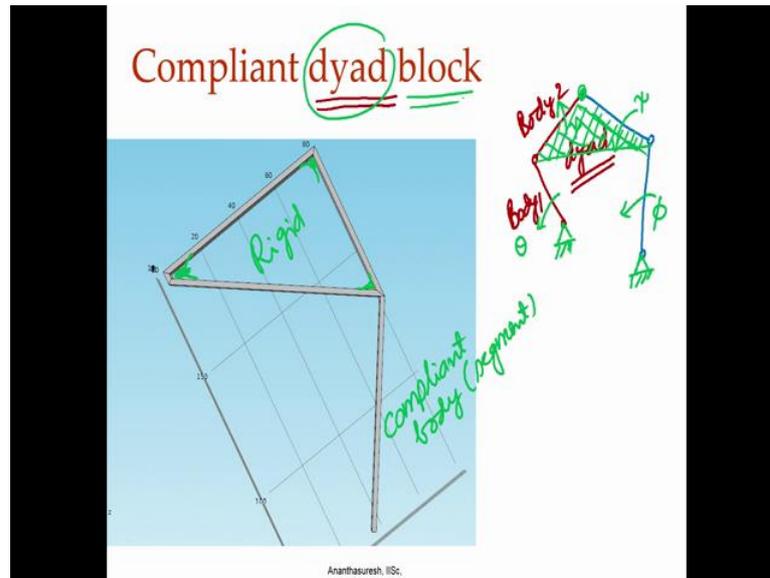
yet instantaneously the concept works that is the basis for the instance centre method, we have two points input 1; we know which direction it has to move and output point which direction it has to move its our target or objective and we try to design a compliant mechanism for that that is what we design for.

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So, let us a look at that method the main reference for this work principle reference is the work of a Charles Kim and Sridhar Kota, Yang-Mo Moon and this appeared in journal of mechanical design in 2008, 8 years ago which are very simple and an elegant and easy design method you can look up for more details in this reference.

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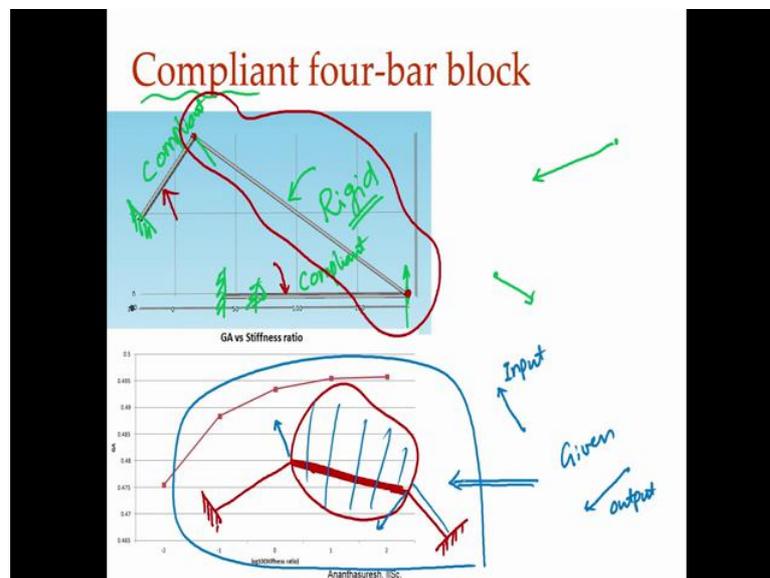
Now, let us look at what they have done they defined something called compliant dyad again the concept of a dyad is also taken from kinematic literature. So, when you have one body you take another body this is a dyad because it has 2 bodies this is a body 1 and this is body 2 that is a dyad and this what is used in kinematics synthesis of rigid body linkages, because if I have 1 dyad. And then let us say I take another dyad like this now I have 2 dyads and I would design these dyads in a way that I have specified some location for this, let us called this data; let us say we call this rotation psi then I would actually design. So, that the other one also has a rotations psi and this one has some rotation let us call it phi that is we designed this dyads.

First we do not design a 4 bar linkage we will see how 4 bar linkage comes momentarily we designed dyads in kinematic literature where we take 2 bodies. One of them is specified to have some theta rotation theta 1, theta 2, theta 3 and so forth. And other one we have psi 1 psi 2 psi 3 along first position to second, first to second, third and first to fourth and so forth we have this angles of rotation. So, when we do that similar to the precision part synthesis we had discussed. In the first design technique we discuss in this course we will get lot of dyad solutions one will be theta and psi other will be phi and psi. So, both of then psi is common and if you join then at this point then that becomes more like a rigid body because they it undergoes the same angular rotation and one point is common to it.

So, we can actually join this becomes one rigid body that becomes our coupler body, that we discussed in the previous slide. So, we get this rigid body connected with a 2 many things here if I put a pivot here and a pivot here I get a 4 bar linkage. So, the dyad concept came from kinematics where you can put together 2 dyads and make up a 4 bar linkage provided you use the same rotation and have a common point for the second or floating body sometimes we call a floating body also that is how it is done.

So, here when you look at this compliant dyad what these authors mean is that this one is compliant, one compliant body or what we are calling segments in this course one compliant segment. And this one is more or less rigid because whenever you make a triangular frame they are all joined here this becomes rigid. So, they say that if you have a compliant segment and rigid segment you can do something with it. So, this is one concept that proposed it is like a building block dyad block and then they also go to that 4 bar linkage, but now it is compliant. So, this is compliant, but this one they want to be rigid that the segment.

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So, now if you were to fix it here and fix it here these are all these two are compliant wise this is compliant, this is compliant in between you have a rigid one. So, we know that whenever you have a cantilever beam like this instantly no matter how you apply force here, if you has any component in the transfers direction that is in that direction we

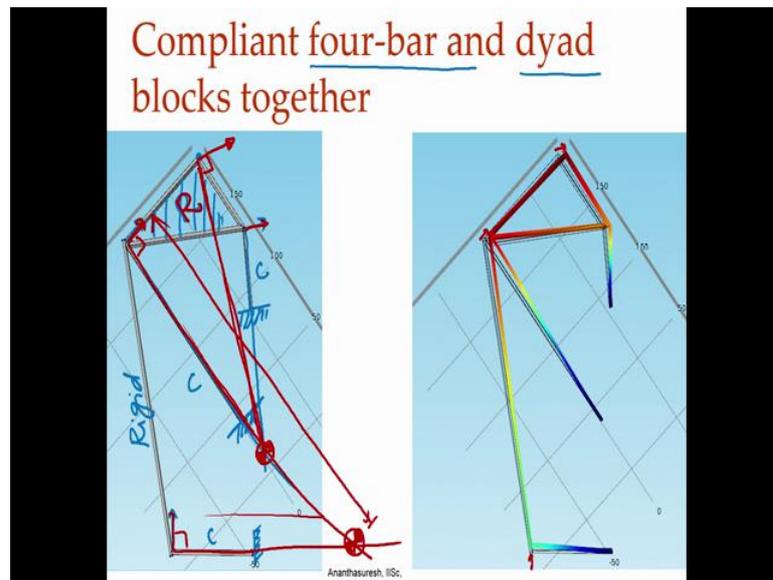
tend to move like that, because with pseudo rigid body model we know that five sixth of this length it appears to be reverted there.

So, it is going to move like that similarly this going to move like this like which way this way or that way does not matter. So, this is the general direction. So, once you have this if you make this rigid you have something that you want that is given two points input output that is our design specification and the direction that we want let us I have one here another one this has to know like this has to move like that, if I get this compliant four bar block then I would actually be getting a compliant mechanism that is the simple concept here. So, that I have again two things and they belong to a rigid body a rigid body is connected to two compliant segments.

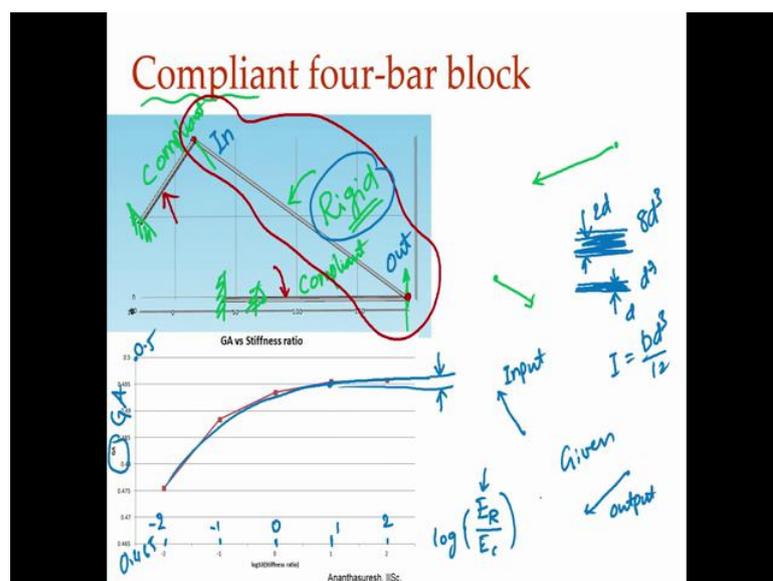
So, what is the rigid body here if I look at this particular one there is this point there is no joint there no kinematic joint this is the rigid body again rigid body can we as large as we want that rigid body is connected to 2 compliant segments. So, one is this, one other is that one , that is the concept here. So, I have a rigid body is connected to one compliant segment another compliant segment in between what we joined we just at a presentation for that rigid body which we can show as if it is rigid one by joining a thick line wide line. So, now, when apply force on it let us say I apply a force on this one this point will tend to if apply a force somewhere so that not there actually may be more like I could say let me draw that in a segment.

So, let us apply a force somewhere here like that why it is going to move instantly that is kinematic constraint at that point we move like that then this will move perpendicular to that, let us say we do not know this right somebody gives there is point here when this is the input and they would say this point has to move like that output let us say we do not know this somebody gives you this can you get this is the question that is this method. So, if you know this how it is going to apply force there these all rigid which we shown with thick line this will move like that because the constraint here is such that it will still make it go like that, but given here can you go there that is what the design method tells you.

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So, the method here is that there is one more point for which a I have arise on this there is a little graph that came up. What this says is that we said it is rigid, but how rigid is a question, how rigid because there is nothing like a rigid body, so for that what has been done here which is too small for you to read this is log of the stiffness ratio. So let us say I take Young's modulus of this compliant segments and rigid segments this is a stiffness ratio of what suppose to be rigid one to what suppose to be compliant  $E_R$  by  $E_C$  that is a  $\log 1$ .

So, the 0 is somewhere here and then there is 1 here and this is 2, this is log scale this is minus 1 here and this is minus 2. You can see how the geometric amplification the  $G A$  this one is  $G A$  that is output display this is the input here, if I call this input and this output; what is  $u$  out by  $u$  in displacement the output divide displacement input  $G A$ . Again you cannot read these numbers this is 0.465 and goes up to 0.5, meaning that a little change. So, as you can see if I make this more and more a bigger compare to the stiffness of the compliant segments it kind of tapers off after a while it goes there after a while 100 times bigger if you do then that is good enough. You can make that this stiffness should be so much bigger the geometric ratio will just know whatever that this are going to 0.495 approaches little more than 0.495.

So, relatively rigid means that if you make it 100 times that is good enough. You make it 10 times that is somewhere here that is also good enough, because the difference geometrical ratio from here to here is very little. So, 10 times is really easy you just make it if you have some in plain width for a what is suppose to be a compliant segments you make it twice as wide that is the depth of the beam, let us say this is a  $d$  to make it  $2 d$  when you think about second moment of area that is  $b d^3$  by 12 that is  $2 d$  or it becomes  $8 d^3$  whereas, here it will be just  $d^3$ , so we get eight times. So, getting 10 times or 100 times is not that difficult you do not have to really change material as is intended here.

So, relative rigid when you say it should be 10 or 20 or 50 or 100 times more rigid than the compliant segments stiffer than compliant segments. Using this compliant dyad and compliant 4 bar this paper puts forth a method where if you have something like this you can fix there and fix here and fixed here, since it is fixed here this point will move in that direction if that is a input. In fact, for these things if you put forces here or there its motion is kinematically determined instantaneously again not for large displacements, this moves like this. Since it is fixed here this point is fixed there this point has to move like that perpendicular to that.

When this moves like that now, if you look at this 1 over there this will move like that and how does this point move then you can see that if you consider this as a rigid body which it is and so is this should also be relatively rigid as we just talked. Compared to the other segment here, this is the compliant segment, compliant segment, compliant segment, this is rigid and this is also rigid. When it is rigid we can see how this points

moves because we have if that point is moving like that we have this line and this point is moving like that you have this line. Now this one here will be our instant centre of rotation that is our instant centre of rotation.

So, it appears to be rotating about that what appears to be this rigid body. So, I can join from here to here and this point will move in that direction because now rigid body this is moving this direction this is moving this direction perpendicular to that this is moves in this direction we can even compute how much it moves.

So, by using this compliant 4 bar block in compliant that block we can put together and get more and more amplification there is some amplification that comes from here to here in this case it appears to be amplifier literally, because between here and here also there will be instant centre that you can find which you can find by extending this perpendicular to that and extending this again perpendicular to that this is the instant centre for the first thing that is complaints 4 bar instance centre is this right. So, this is moving like that and that is moving like this how much mode we have the distance from here to here whereas, this one is from here to there. So, there is amplification from here to here again will be amplification.

So, let us look at the finite element analysis that here we can see that this point has moved there this point moved a little bit more and based on that distance now, we had the instance centre here compared to this and this there is not that much difference how much ever this is moving it is also moving like that it is also moving like that. So, we can do this a very easily.

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## Key assumptions

- Rigid coupler body
- True for only linear (small-displacements) range

Ananthasuresh, IISc.

So, now let us look at a first assumptions made in a coupler body assumed to be rigid we have to make it much stiffer than the compliant segments here and its true only for linear; that means, that small displacements range not for large instantaneously it applies it works that is why called instance centre method and it is a good way to generate initial a guesses for optimization methods or for that matter pseudo body model based methods also.

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## Instant centre method

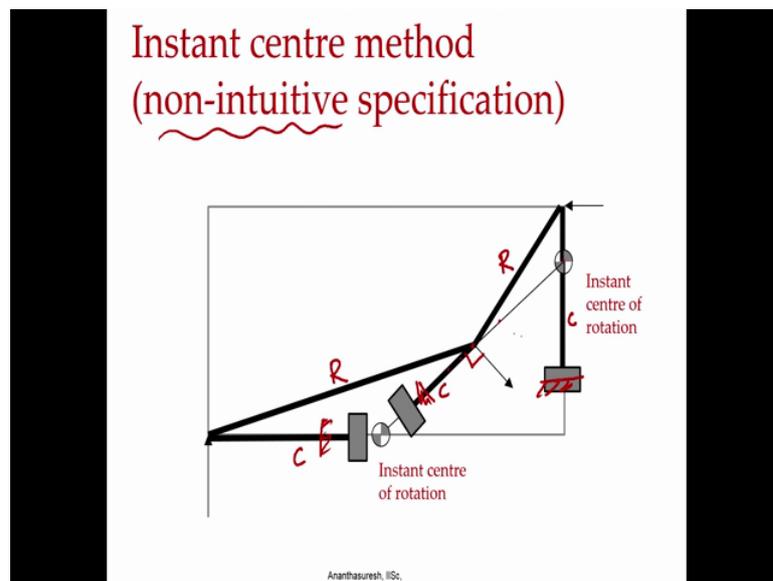
Ananthasuresh, IISc.

So, let us take a few examples now if somebody gives us a problem where, this is input and this is output target output you wanted to move like that apply a force input direction again always this is what we want to get out of compliant mechanism, then this method says that you draw a line perpendicular to it here and you draw a line perpendicular to that you get the instance centre. So, this is our instance centre and once you have it that instance centre rotation and you can actually pick any point here.

So, this is fix, now this is fix, now whether you fix it here or here does not matter instantaneously wherever you fix this compliant segments will have the last in the direction and same thing here you can fix anywhere that does not really matter for instantaneous motion that is how you get this.

Now, let us suddenly asked the same problem we have input in the same direction output point is a same, but you just want the output.

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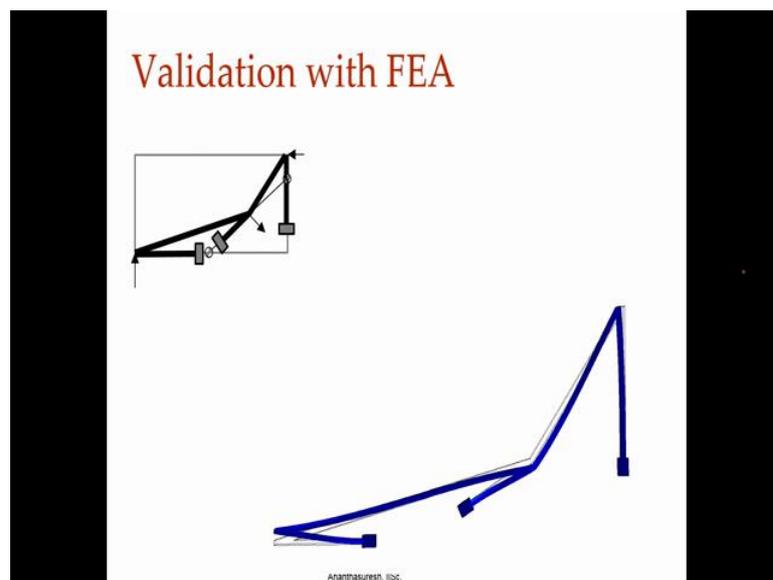


Now, to move on opposite direction how do you do that this is a non intuitive specification, obviously when I draw this line like this and like that this instance centre will not work. Now because then this points moves like that this point will move like this if we just join them. So, does not work does not do something else these we are the compliant 4 bar and dyad and this connecting them like block by block would help.

So, what we do is we take an intermediate thing and choose two instance centers one here and one there, so that we can put together two blocks to get what we want if you do that the first one and also chose a point you can choose a point here here anywhere does not matter you choose a point. First of all there is point in choosing first that direction we first choose and then the point later once you the direction instance centre get fixed then you can take a point anywhere let us say we take point over there we connect that we connect this we connect this we connect that.

So, this becomes rigid rigid compliant compliant and compliant again where you fix does not even matter you can fix it here, here, here does not even matter. So, with a 3 compliant segment and two relatively rigid segments you get the specification met here then that point in that point will move because that will be perpendicular to that thing here whether you look at from the later building block or the earlier building block.

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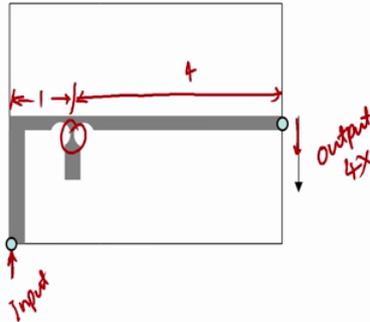


So, this is what we just designed graphically and you can see how this moves. So, this point is moving that way this moving that way just like this arrow shows and this point is moving that way. So, that a compliant mechanism in 2 minutes right even though it is a non intuitive specification when you move here how does it go you can get that. So, you can watch this for a while and study this method to understand.

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Quantitative specifications can also be dealt with.

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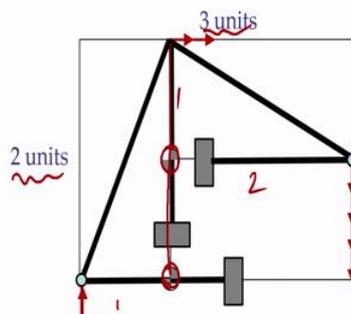


Now, let us take another one where we can be quantitative in our specifications. So, we have a here we want to geometric advantage of 4 that is this is that is say input this is input little arrow and this is output where should be 4 times start we want 4 times displacements 4 x not x 4, 4 x. So, how do you do that then we can use for example, this label that is easy where this will be one from here to here and if this is 4 times that I get this right. So, even inversion of the motion is also evident with lever, but they are not interesting because these are the weak parts. So, we are not interested in those.

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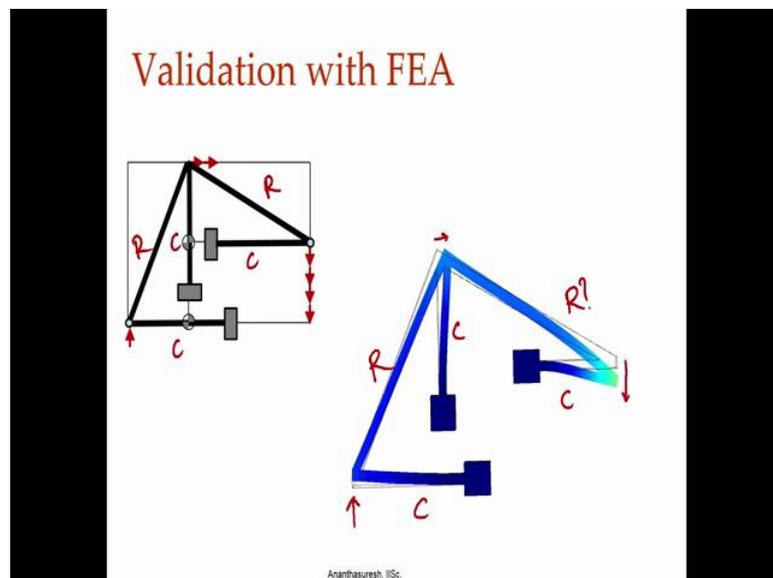
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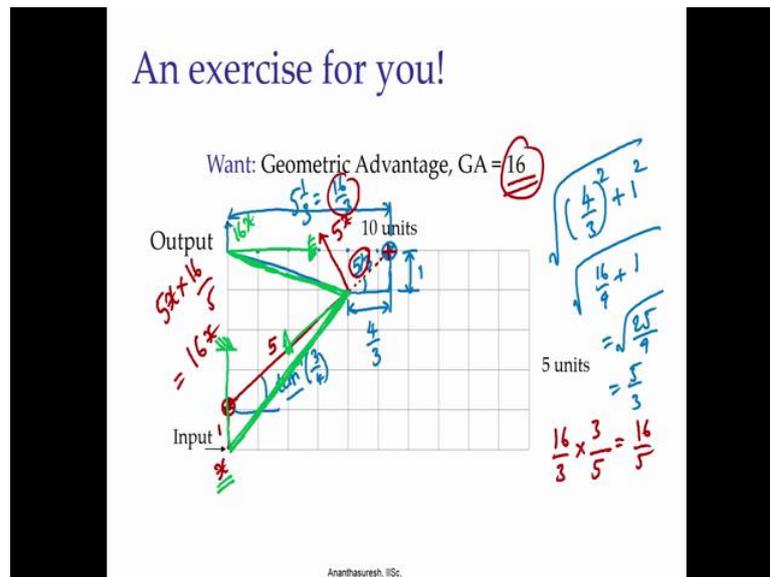
So, can we do this using this instant centre methods let us we take a design that has 2 units this way 3 units that way it is all graphical, then we can choose this 2 stage the direction we had chosen last time. Similarly in the example here we have chosen direction in 2 instant centers and connect them we get this. So, we have block 1 first one and block 2; 2 4 bar block 2 put together to get this, because this is now compared to this is one unit from here to here this is 2 units instance centre if I take this one this moves 1 this moves two here when this moves to here this moves 4, because from here to here this is this is the instance centre now this is one new unit from here to here it is 2 units again go. So, we got geometric amplification of 4 geometric advantages of 4.

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And this is the finite element simulation like a validation of this you can see how much this is moving from this is moving and how much this is moving it moves fo4ur times. So, very easily we can do and what we said this is compliant, compliant, compliant, rigid and rigid we can actually see in this simulation also. So, this one is compliant because that is deforming, deforming and deforming these also deforming a little bit we are seen, but we are going large displacement here, but this one is relatively rigid this is actually intended to be rigid, but it is in that that sense this will be deviating from intended motion this is not really rigid this is question mark. So, that is you got a mechanism that works.

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Now, here is an exercise that we will work out. So, this is let us a geometric amplification 16 we want input is in that direction or put this here now, if I join perpendicular to this perpendicular to that, that itself we can instantaneous clearly we cannot do it in one step. So, I have to do it in two steps. In order to do two step if I want 16, so let us say we choose a point from here and here. So, I have chosen this to be 4 units this is 3 units this will be 5 units I choose this as the instance centre, this is 1 unit and a point that moves here we move 5 times if this moves by let us say let us call it x here let us call this displacement x which is in that direction this will be 5 x because this instance centre.

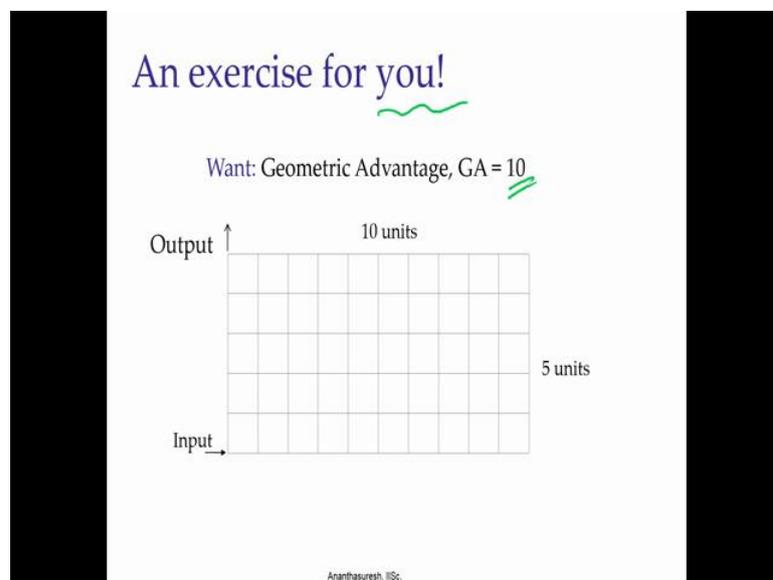
Now, if I extend this further I get another instance centre let us do that in a different color. So, I have another one here that is our instance centre and this angle here is tan inverse 3 by 4. So, we can actually get this thing here to be 4 by 3 because from here to here that is 1 unit. So, tan inverse here this angle is the same as a this one that it will be again 3 by 4 1 divide by 4 by 3 3 by 4 that is 4 by 3. So, we have this is 4 by 3 that is this is 4 by 3 this is 1 this will be 5 by 3 again Pythagoras theorem. So, 4 by 3 square plus 1 square square root that will be square root of 16 by 9 plus 1 that will be square root of 25 by 9 that is equal to 5 by 3 that is 5 by 3 and from here to here that is the second stage amplification we get to this point moves like this, this point is move like that we have to join from here to there and that amplification in that case this thing will be these are 5

units 1, 2, 3, 4, 5 then one third there 5, one third or it is 16 by 3 in the first stage we got amplification of 5 x. So, x became 5 x.

And over here now we will have this one this is 5 x. So, it will be 5 x into will get and this other amplification this is 16 by 3 that we got and this is 5 by 3, if I take this instance centre. So, that amplification will be 16 by 3 divide by 5 by 3 that will be 16 by 5. So, we get 16 by 5. So, I got 16 x. So, what our target passed this is the graphical methods now let us complete the linkage by using a different color. So, we can choose any point here and fix it the direction is important and join, join this point to that and this is again we have to choose some point here fix it like that and now this should be rigid this should be rigid and then we are joining this to that.

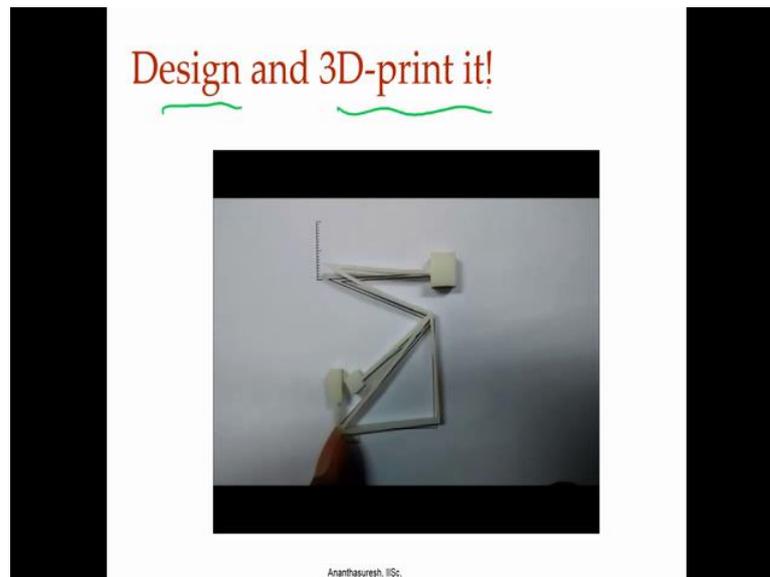
So, that should be rigid as well that is a coupler body here and then we will fix this anywhere does not matter where we fixed it that is our thing here. So, when I take this compliant mechanism which is now drawn in green color when I put some x here this point will move by 16 x as intended. So, this method is as easy as that just an a graph sheet you can do.

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Now, if i change it or you should try an exercise for you now you put whatever now you put 10, 12, 15, 13 whatever you like try to see if you can get that when it was given as 10 one of my summer intense last year did that was able to design and also 3D print because that Is available for everybody you can make compliant mechanism.

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So, very quickly you can design the actually 3D print and make that.

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The slide is titled "Main points" in a red, serif font. It contains a bulleted list of four main points. The first point is "Instant centre concept applied to compliant mechanism design." The second point is "Instantaneous (linear) behavior is correct but not large-displacement (nonlinear) behavior." The third point is "Coupler body should be relatively stiff." The fourth point is "A quick way to get a concept (topology) of a compliant mechanism." The fifth point is "Could be a great initial guess for structural optimization-based approaches." The sixth point is "An excellent tool for teaching and brainstorming." At the bottom center of the slide, the text "Ananthasuresh, IISc." is printed in a small, black font.

- Instant centre concept applied to compliant mechanism design.
  - Instantaneous (linear) behavior is correct but not large-displacement (nonlinear) behavior.
  - Coupler body should be relatively stiff.
- A quick way to get a concept (topology) of a compliant mechanism.
- Could be a great initial guess for structural optimization-based approaches.
- An excellent tool for teaching and brainstorming.

So, the main points of this that instance centre concept can be apply to compliant mechanisms and we need to remember that its only instantaneous behavior that is good enough, because when you go to large deformation also it will direction will be pretty much in the same thing, and coupler should be relatively stiff we discuss that 10 times 20 times 50 or 100 times is good enough, because that the stiffer you are compare to the

compliant segments the more accurate your intended behavior it is a very quick way you can get a concept that is the idea here.

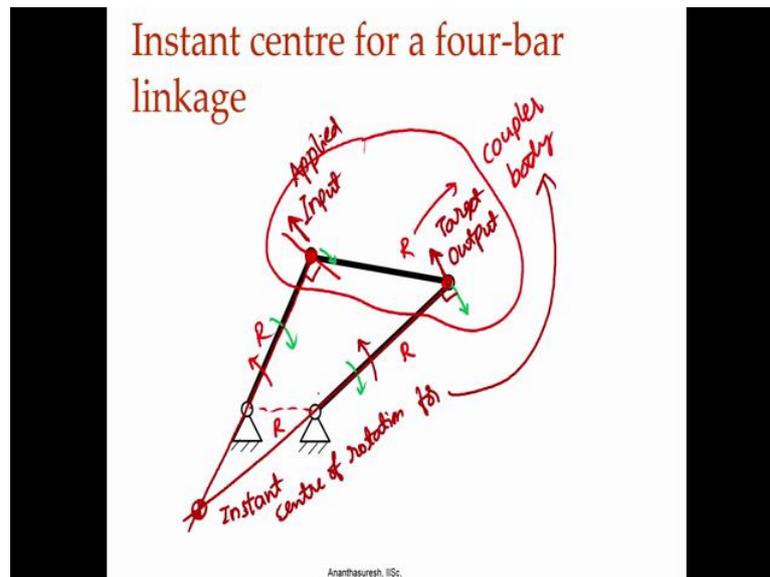
You can get a concept or what we call the topology a compliant mechanism we thought using optimization we are not saying it is a best one. It is one solution that works and this could be a great tool for generating initial guess is propagation approaches, where you can do size and shapes optimization later on. And more importantly this is a nice educational tool, so when you are want to brain storming and get something this is a great teaching tool and anybody can design compliant mechanism.

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Again that further reading this paper describes the method in detail and some example that we have included should help you or make you feel confident that at least one design method you can master without having to work very hard, but you use your intuition as to whether one stage is needed two stages are needed example that we work down used 2 compliant 4 bars, but you can also experiment with talking compliant dyad also compliant dyad. Basically, removes one grounded compliant segment and that is an only difference so we can create compliant mechanism very easily using this design technique.

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So, we took a rigid body and we said that when you have 2 points rigid body whose velocity is you know you can get the instance centre now, in a 4 bar linkage it is a rigid body 4 bar linkage; that means, that the fixed frame which is this, that is rigid and then we have this as rigid, this as rigid and this as rigid now. if I focus on this which we can call the coupler body that is rigid now, in a plain a mechanism is moving we have 2 points and you say that body is rigid we can actually imagine a rigid body.

Whatever size is entire infinite lamina you can think of that has a rigid body, when you take that the concept that we just discussed that you have two points we have point 1 and point 2 whose velocity is we know because this is a rigid tank when you rotated its direction is going to be that way when it moves like this it will be like that when it moves in the other direction it will move like that, but that motion is fixed similarly when this moves like this will move the velocity will be in that direction and when I move it in that direction it will be that way, but direction is known.

So, velocity is here perpendicular to that this itself similarly perpendicular to that this itself. So, these 2 if we join now this point here will be our instant centre of rotation for the coupler body this is the instant centre of rotation for the coupler body because we took 2 points on the coupler body that is why we can get and this point, if you belongs to the coupler body will have instantaneously 0 velocity just like we had discussed. Now, let us see when you have a 4 bar linkage where everything is rigid were able to see that

two points; 1 point moves like this other point moves like this. Let us call this input with respect to rigid body. This is output, if this is the target output for this applied input we are able to get a 4 bar linkage with the same concept.

We will see how a compliant mechanism can be also design. And that is the essence of the instance centre based method.

Thank you.