Kinematics of Mechanisms And Machines
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Lecture – 03
Kinematic Diagram

In this lecture, we are going to discuss Kinematic Diagrams. Kinetic Diagrams are line diagrams which help us visualize a mechanism.

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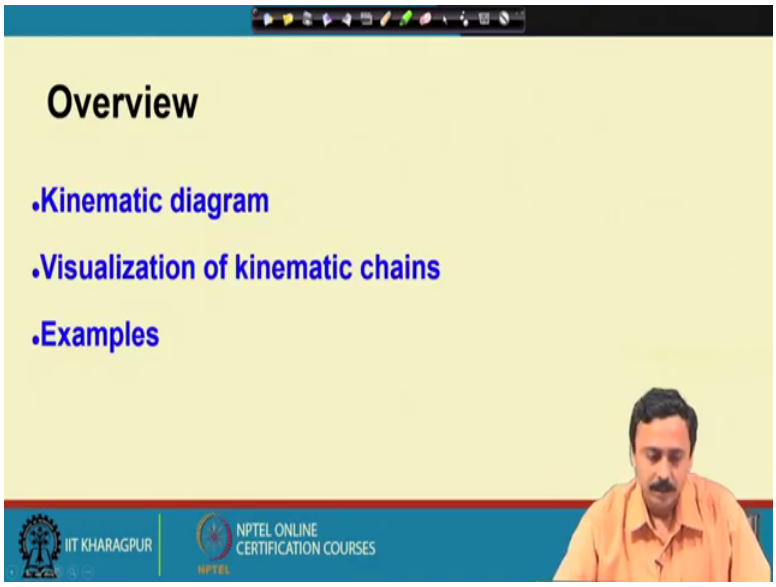

This is the overview of this lecture. I am going to discuss Kinematic Diagrams. I am going to show you how these diagrams help us Visualize chains with examples.

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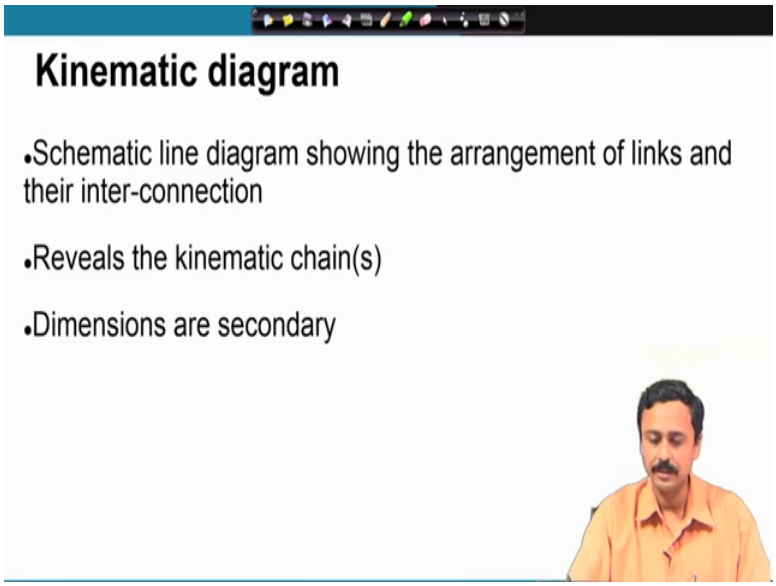

Now, this is a formal definition of a Kinematic Diagram. It is a Schematic line diagram showing arrangements of the links and their inter-connections. It reveals the kinematic chains that are present in a mechanism. Now, if you are if you look at a mechanism, a complicated mechanism, at first it becomes very difficult to visualize how the links are interconnected; how they can move?

Now, if you draw the Kinematic Diagram, then it becomes clear in a Kinematic Diagram the Dimensions are secondary. So, we are not going to worry about dimensions. We only want to understand the chains that are present in a Kinematic Diagram. Let us start with some examples.

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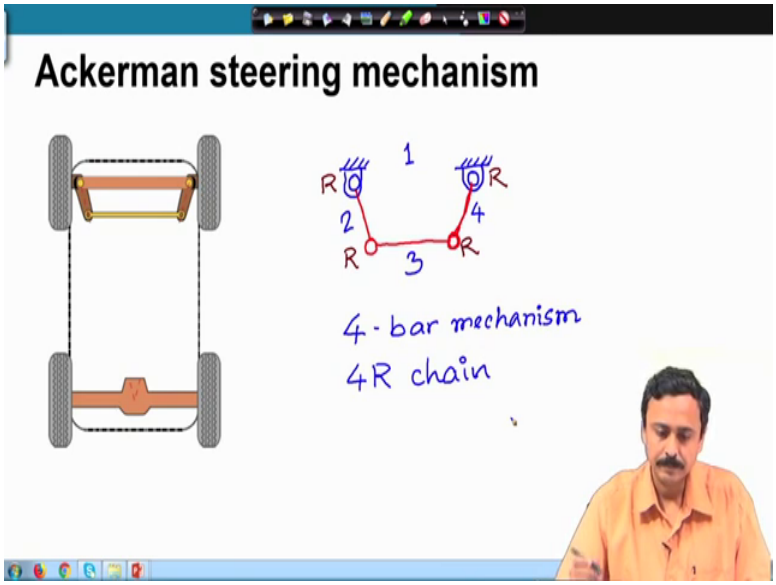

The first example, we have is of a steering wheel mechanism. You know all cars they have a steering wheel and one of the very common steering mechanisms is the Ackerman steering mechanism. If you look at this mechanism, this link is part of the car body. This is part of the car body.

So, therefore, these two hinges are what are known as the Ground hinges. So, I will start by drawing the ground hinges. So, these were the ground hinges and here, we have the first link connected to this coupling link connected to the other wheel. Now, in this kinematic chain you have the ground link as the first link. This is the second, third and fourth. Therefore, there are 4 links or 4 rigid bodies in this chain and these are connected by revolute pairs, simple hinges. So, there are 4 revolute pairs connecting these 4 links.

This is a closed kinematic chain as you can realize, there is no singular link and we say that this is a 4 - bar mechanism. This is a 4 - bar mechanism. There are four links. So, we call this mechanism as a 4 - bar mechanism or 4 - bar chain. We sometimes also referred to this chain as a 4 R kinematic chain. This is a 4 R kinematic chain because there are 4 revolute pairs. The next example is a Crimping tool.

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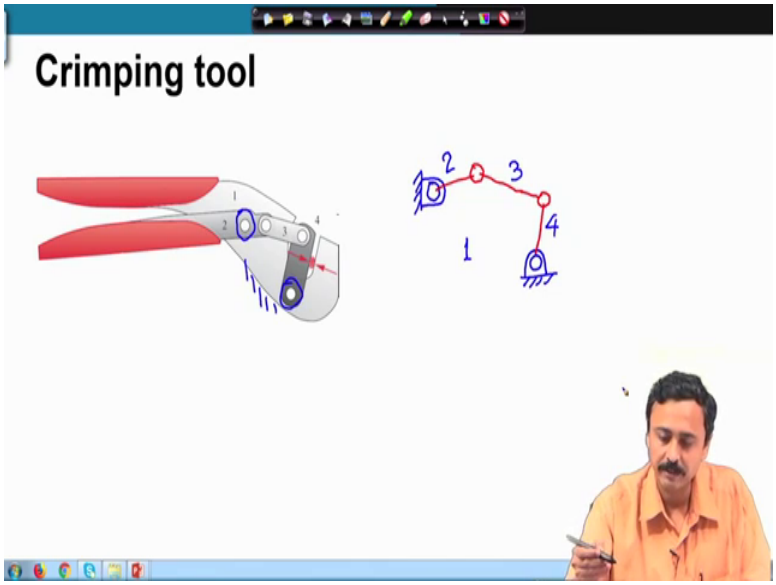

Now, here this typically forces are applied to these handles and get crimps ah piece which is held in the jaw. In order to draw the Kinematic Diagram, we consider this body which is numbered as 1 to be fixed. Let us consider that the link 1, the body 1 is fixed. These are the 2 ground hinges; so, which I am drawing. So, these are the 2 ground hinges, 2 revolute pairs.

Therefore, I have the ground link as 1, 2, 3, 4. So, I numbered the links and once again, this is a 4 bar mechanism or a 4 R kinematic chain. You will notice that in a Kinematic Diagram. First of all, we do not care about dimensions. The other thing is we do not draw the extra things, like I have not drawn the handle. It is not necessary to draw the handle because what we want to visualize is the mechanism, the kinematic chain that is involved in the mechanism.

Therefore, these extra things we omit from the Kinematic Diagram.

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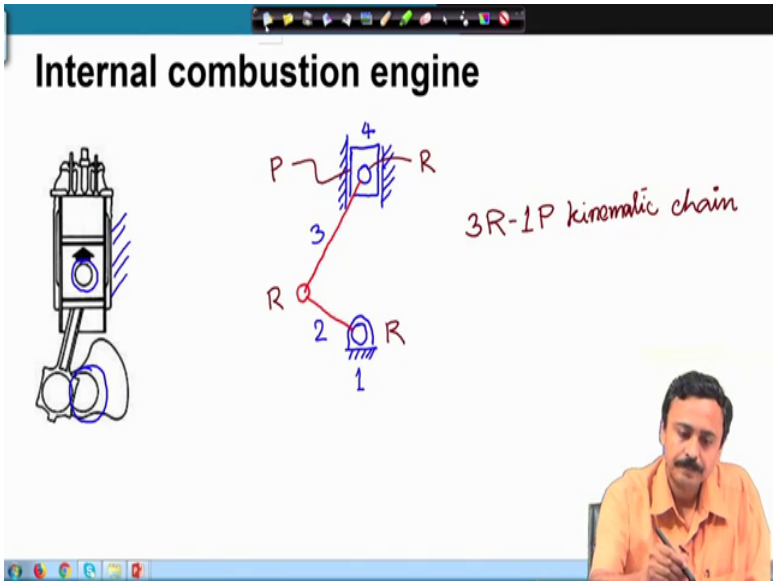

This is an Internal combustion engine. Here, is a ground hinge and you will realize that the cylinder is also grounded. Therefore, I have a ground hinge and I have the cylinder against which a piston is sliding.

Now, the piston has this pin is marked here and this is connected to the crank by a coupler a coupling link. So, this is the coupler and here is the crank. Let me number the links. The ground is to be numbered always as 1. This is 2. This is 3 and the slider being another link, in fact, a binary link as we have discussed is the fourth link in this mechanism.

This mechanism has revolute, revolute, revolute here and a prismatic kinematic pair between the slider and the cylinder. Therefore, this mechanism is called 3 R - 1 P kinematic chain. This is a 3 R - 1 P kinematic chain, but there are 4 links. So, this is a special case of a 4 - bar linkage.

Next, we have a Surgical instrument.

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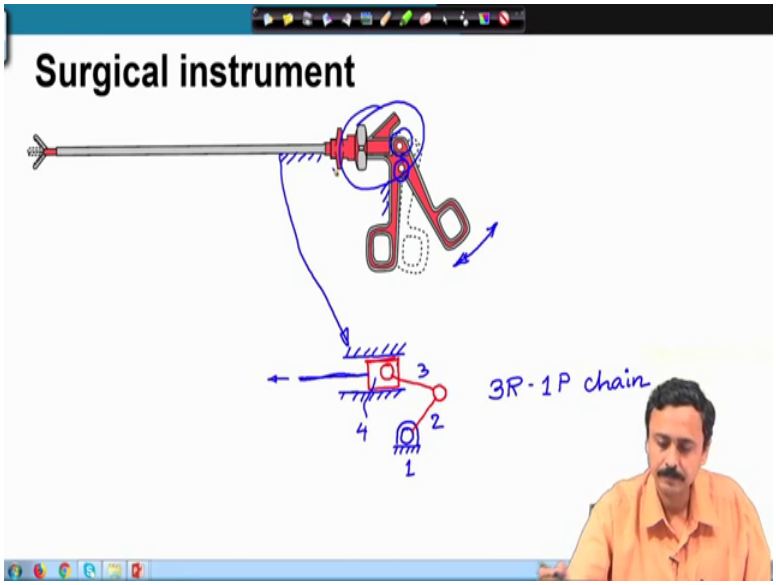

In this, if you consider that this is grounded. This handle is also grounded. This handle is an integral part of the whole instrument. This cannot move with respect to this barrel. The other link which can move is this finger grip. Now here you will realize that this therefore, is a ground hinge this hinge is a ground hinge. There is another connection to the ground that will come to. So, therefore, let me first draw the ground hinge. So, this is the ground hinge; from here I have a connection to the other hand grip.

So, this is the other hand grip which is connected to this hinge. So, that is the other hinge I have drawn. Now, from that hinge you must have another hinge which is connected to a slider. So, this ground is the barrel. So, this represents the barrel. Now here, this slider connects to the surgical instrument that is at the end of this instrument.

Once again, you will see that I have not drawn these paraphernalia; I have not drawn the hand grip for example. If we number once again ground is 1 2 3 and this slider is 4. So, again we have a 4 - bar mechanism which is a 3 R - 1 P kinematic chain.

Now, this slider which is inside this portion is not observable.

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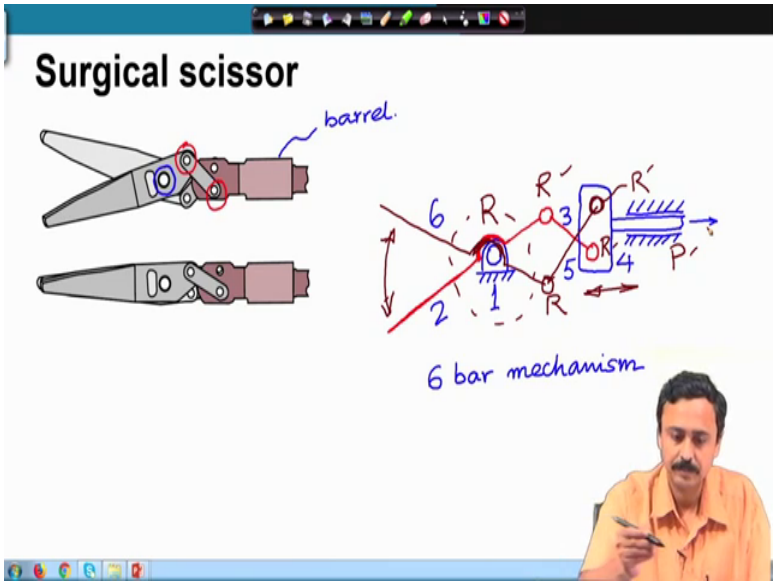

Let us now look at the scissor which is at the end of this instrument, the laparoscopic surgical instrument. Now here, when you look at this it is quite complicated as you can realize. Therefore, we have to proceed step by step as to how this scissor works. This is the part of the barrel. This is the part of the barrel that I showed you in the previous slide.

This hinge is connected to the barrel. This hinge cannot move. So, that the scissors when they when they are being used, this hinge is stationary its only the blades that will move that will rotate about this hinge. Therefore, I will first draw this ground hinge. One of the blades looks like this. So, this is the lower blade in the diagram. This hinge that I have drawn corresponds to this hinge in the diagram and here, this symbol means that this link is hinged to this ground hinge.

Now, from here you have another link connected to another hinge which is this revolute pair and that is connected to a slider. This slider goes into the barrel and this goes right up to the mechanism that I drew for the handgrip. Now, this is the lower blade. The upper blade goes this way and again, connected to the same slider. Thus, when the slider moves back and forth because of the motion of the surgeons fingers, that is being transmitted by the motion of this slider, the blades they exhibit rotational motion about the ground hinge.

Now, let us look at this kinematic chain and let us count the number of links we have. So, I have here 1; this lower blade as 2; this coupling as 3 and the slider as 4; the other coupling as 5 and the other blade has 6 though here. So, we have a 6 link mechanism. We have a 6 - bar mechanism or 6 link mechanism.

We also ah can count the or first let us look at the kinematic pairs that we have. Here, as you can see in this portion we have 2 blades being connected or hinged to the ground. When we say kinematic pair, it means it is a connection between 2 links, 2 rigid bodies that is why it is called a Kinematic Pair.

Now, at this hinge, there are 3 rigid bodies; one is the ground, the other is the lower blade which is 2 and the upper blade which is 6. So, we will count here 2 revolute pairs; 2 revolute pairs, so there are 2 revolute pairs at this hinge, at this ground hinge. These are revolute, revolute, revolute and here we have a prismatic pair. So, when we count the number of kinematic pairs, we must count here 2 revaluates; at this ground hinge we must count 2 revaluates, the 2, this is 3, 4, 5, 6, 7.

So, we have 7 kinematic pairs in this kinematic chain.

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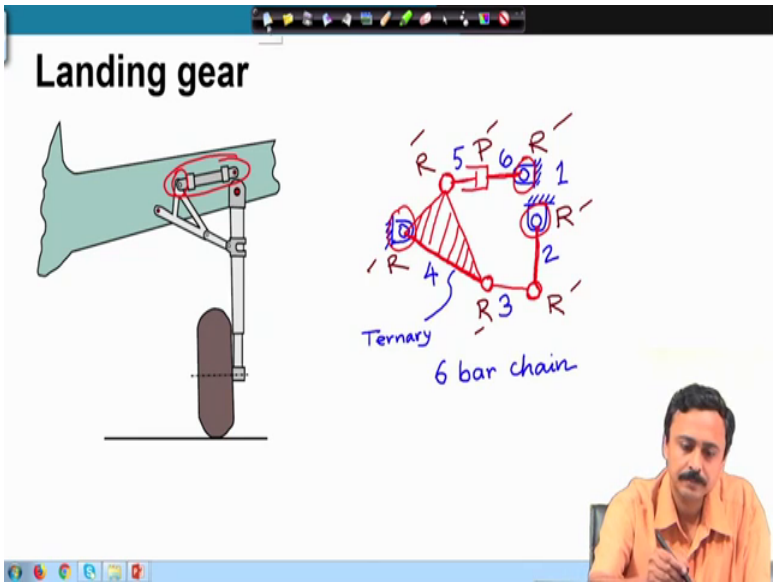

This is the Landing gear mechanism of an aircraft. Here, the red filled hinges or revolute pairs are grounded. Grounded means it is connected to the aircraft body. The aircraft body is considered to be the ground in this case. So, let me draw these ground hinges.

Let me start drawing the links now. This link carries the wheel which is having a hinge. At this point is connected to this coupling link to another link connecting the ground. Now, this link which connects to the ground has another hinge, as you can see here. So, this is one rigid body and it has a hinge at this point.

This hinge is connected to an actuator. So, this is an actuator. Now, this hydraulic actuator will have one prismatic pair. As you know in a hydraulic actuator we have one prismatic pair. Therefore, there must be 2 links connected by a prismatic pair and that is connected to this ground hinge. Now, let us number the links ground link is numbered 1 2 3 4 this is 5 and this is 6.

Thus, this is also a 6 - bar chain or a 6 link mechanism. Here, we have a ternary link as we have discussed this is a ternary link. There is another ternary link which is the ground. The ground is also a ternary link because you have these 3 hinges, which connect to the ground. If you count the kinematic pairs, this is a revolute, revolute, revolute, prismatic and revolute.

So, we have 1 2 3 4 5 6 7. So, 7 kinematic pairs once again. Let us look at this Excavator.

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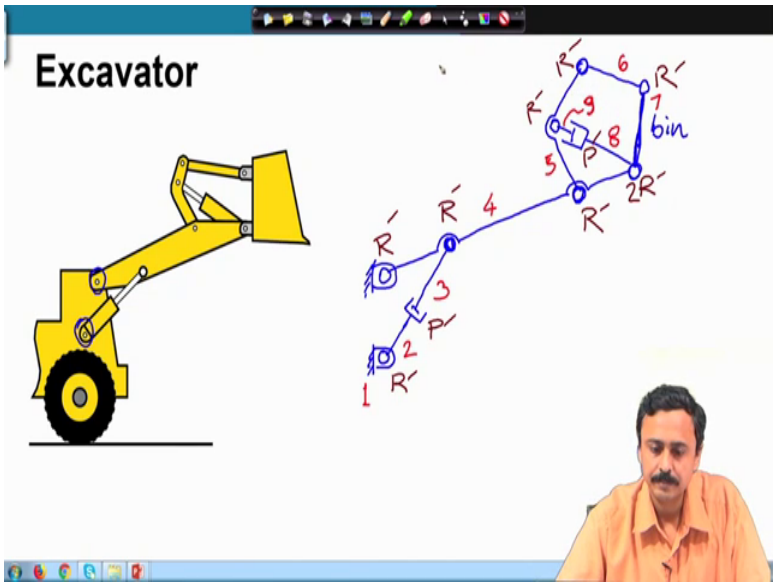

We will consider these 2 as the ground hinges. This is one big link. Here, we have an actuator connected to this link, this link as you can see has 4 kinematic pairs, it carries 4

kinematic pairs. So, this is a quaternary link. This is connected to a ternary link to a binary link and finally, to the bin.

So, this is the bin. Now here, we have an actuator. So, let me count the number of links. Ground is 1 2 3 4 5 6 7 8 and this is 9. Now, this has 9 links. This kinematic chain has 9 links and if you count the kinematic pairs revolute, revolute, prismatic, revolute, revolute.

Now, here as you can see there are 3 links being connected at this kinematic pair this just link number 4; link number 8 and link number 7. So, there are 2 revolute pairs here. Here there is a prismatic pair, revolute, revolute and revolute. Therefore, we have 1 2 3 4 5 6 7 8 9 10 and 11. So, we have 11 kinematic pairs.

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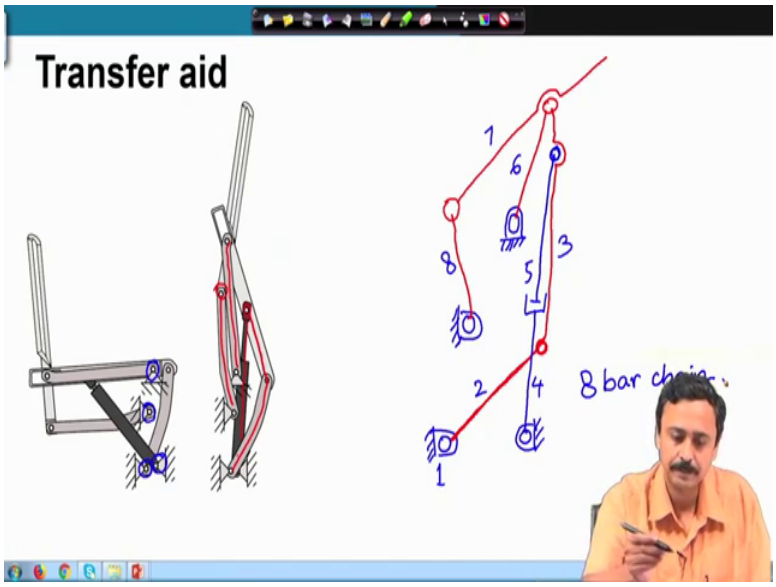

Now, here is a Transfer aid. Let me look at the ground hinges, identify the ground hinges first. So, this is a ground hinge; this is the ground hinge; this is a ground hinge; this is a ground hinge. There are 4 ground hinges. So, these are the 4 ground ranges. Now, this connects. So, this is one link. Now, that gets connected to the seat which is connected by this prismatic pair.

So, till now what I have drawn is this part of the mechanism. This link, this link and the prismatic pair. Now, this has an extension which is connected to this ground hinge which is this link and from here starts another link connected to this ground hinge which is this

link and from here starts another link to a hinge this is this hinge. So, I have drawn now this link which goes to the backrest of this chair.

So, this is the kinematic diagram for this Transfer aid. Let us quickly calculate or number the the links 1 2 3 4 5 6 7 8. So, this is an 8 bar kinematic chain and you can count the the number of kinematic pairs.

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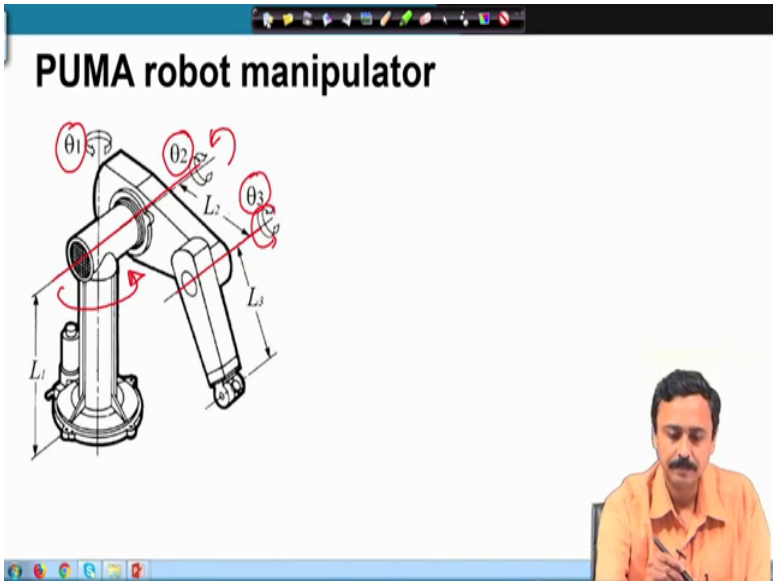

Now, this is Robot manipulator. Let me show you first what are the possible motions. So, one is rotation about this base revolute pair which is indicated by theta 1. Then, rotation about this axis indicated by theta 2 and finally, rotation about this axis indicated by theta 3.

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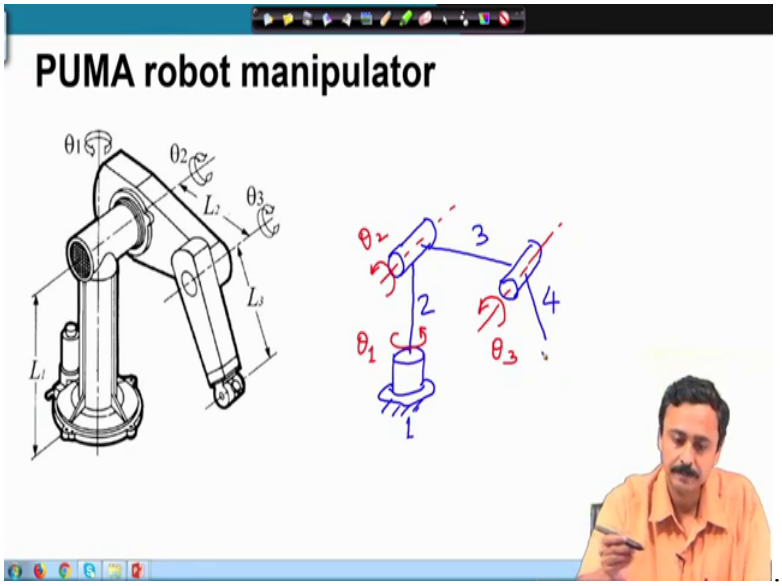

So, if I draw the ground. So, this is the theta 2 axis. This is the theta 1 axis. This is the theta 2 axis. This is the theta 3 axis and finally, we have the end effectors at the end. Let me count the number of links ground is 1 2 3 4. So, there are 4 links and the fourth one is a singular link; as well as the ground which is also a singular link and we have all revolute pairs in this kinematic chain.

So, this is a 3 R robotic chain.

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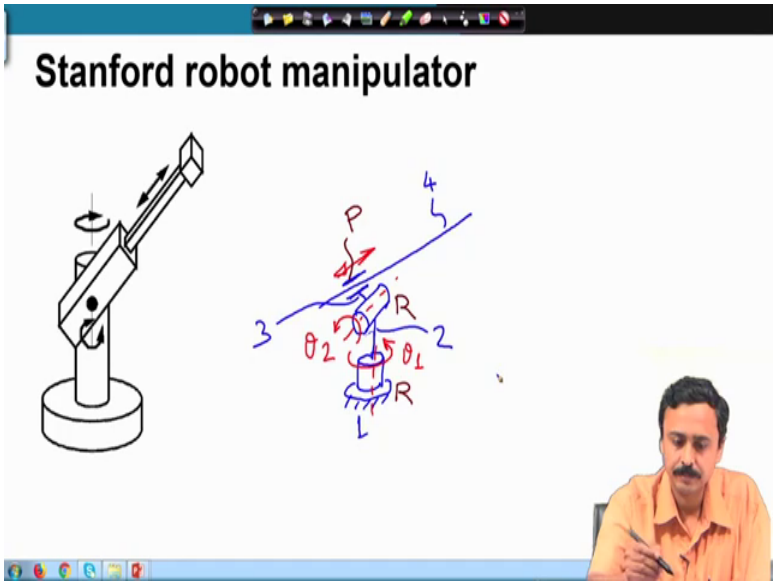

This is what is known as the Stanford robot manipulator which has a ground revolute pair. On this, you have another revolute pair. This is the ground revolute which is theta 1. This is the second revolute which is theta 2 and the third one is a prismatic; the third kinematic pair is a prismatic pair.

So, this is a revolute; this is a revolute and here we have a prismatic pair. Again, this is a 4 link let us look at, let us count the number of links. So, ground is 1; this is 2; this is 3 and this is 4. So, there are 4 rigid bodies, 4 links and we have 3 kinematic pairs.

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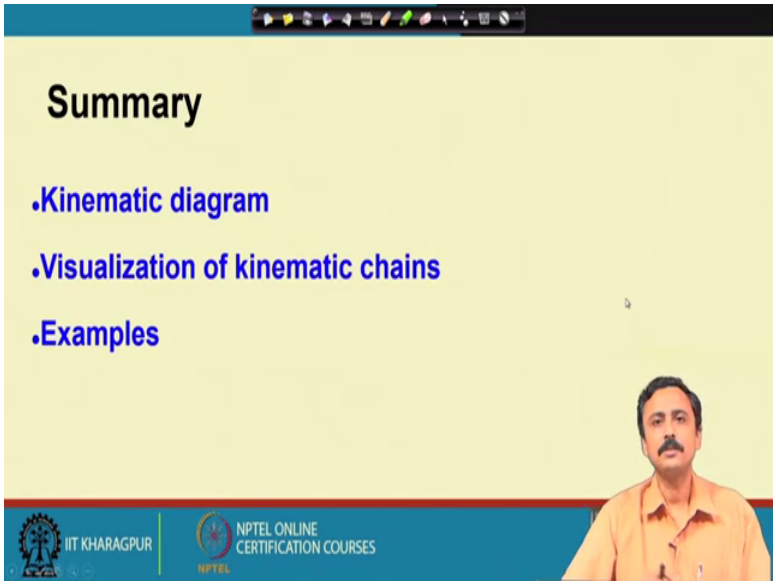

To summarize we looked at the concept of Kinematic Diagram which helps us visualize kinematic chains and we looked at examples, where I have shown you how to draw Kinematic Diagram and number the links, identify the kinematic pairs and count them. So, with that I will close this lecture.