Engineering Mechanics
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Lecture No: 1.1
Statics
Planar Rigid Body

Hi. In this particular clipping lets try and understand what a rigid body is, how do we determine the degrees of freedom of a rigid body. Before going in to details lets just look at how do we describe the motion of a particular body. I have this watch over here. It has a strap, just I am going to remove it for you to get an idea. If I look at this; this watch has a motion that I can describe. In addition it can also be very flexible or in another words each point of this body can move relative to each other. We call this as a flexible body.

On the other hand supposing I take a body like this and I want to describe the motion of this body. Let's say it is moving like this. If you look at it, whatever be the kind of force that we apply on this reasonable, you don't see that much of deflection that much of motion between the points of the body. For all practical purposes, I can define this body as a body whose lengths remain intact while in motion. In other words we call such a body as a rigid body. In this exercise we will just look at only the rigid body. Now the rigid body can move like this, move upwards. It can move towards me or away from me, it can rotate about an axis which is pointing towards you. It can rotate about the horizontal axis and it can rotate about the vertical axis. So there are 3 translations and 3 rotations possible in a general rigid body.

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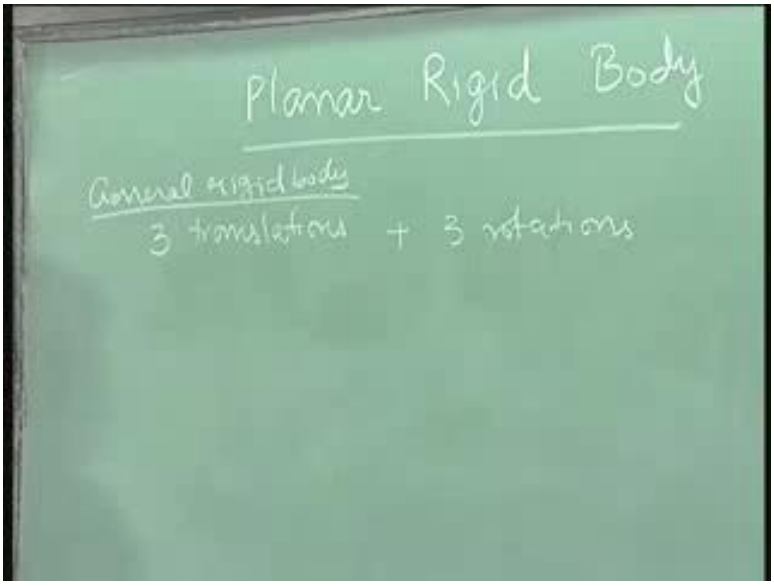

In order to make understanding clear, let's say reduce that to a body that has lesser number of ways of motion. For example if I take this board and a body on this board attached to this board and if I want to describe this body, let's say it's a rigid body. There are three ways in which it can move. It can move horizontally like this, it can move vertically like this or it can rotate about an axis. So in a planar rigid body, I can expect a two translations and a single rotation. One of the important points to note here is if I have to describe the vertical motion that is completely independent of what is happening in the horizontal motion. For example if it is going like a wave and if I have to describe only the vertical motion, it no way affects the horizontal motion or in other words two translations that I describe are independent of each other. I am going to add one more term over here, 2 independent translations and an independent rotation. This word independent is a very important addition to it.

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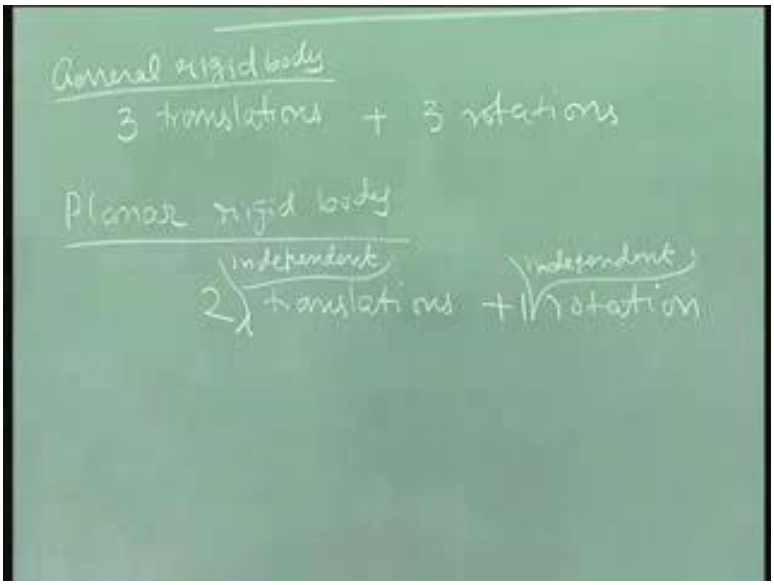

In all it is possible to have three quantities which are independent that can describe the motion of rigid body like this. We call this as three degrees of freedom. Are you with me? In general what we say is for a planar rigid body, there are three degrees of freedom possible. If I have to draw body here, as I describe there is a possibility of motion in this direction. Let me just use horizontal and vertical directions as two independent quantities. Let me call this as x and this as y. The displacement in the x direction, let me call as u and the displacement in the y direction as v and there is a rotation possible let's say theta. I am going to just say rotation theta. There are degrees of freedom that I can use. One is a translation u, one is translation v under rotation theta.

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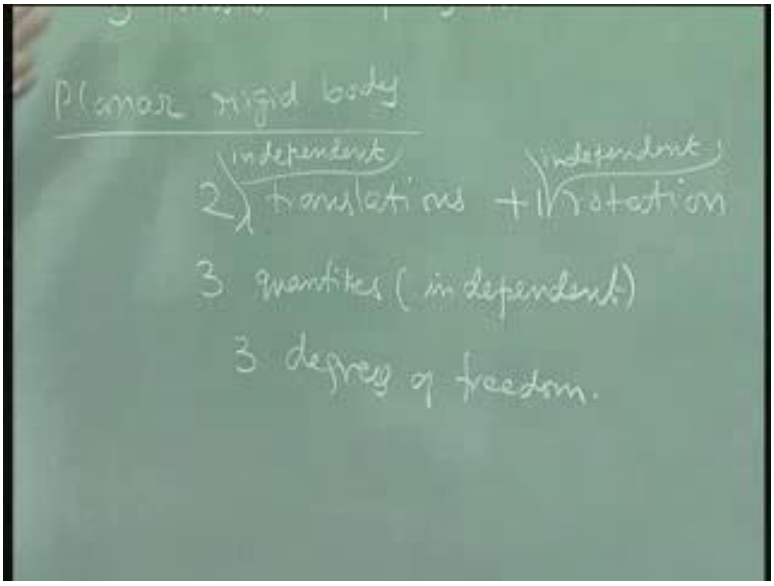

Given these three values I can tell you the position of this particular body that I have. What are the other important things? I have to have particular frame that I define for what is zero displacement in x direction, what is zero displacement in y direction, what is zero rotation that we have defined here. Say we have an origin which specifies zero displacement in x and y direction and the horizontal axis can be taken as a reference axis. If I have the body here and if I draw this axis on it and let's say it gets attached to this. So let me call this as o. I take this and I attach it over here and then start to define the displacement in horizontal direction and vertical direction and its rotation.

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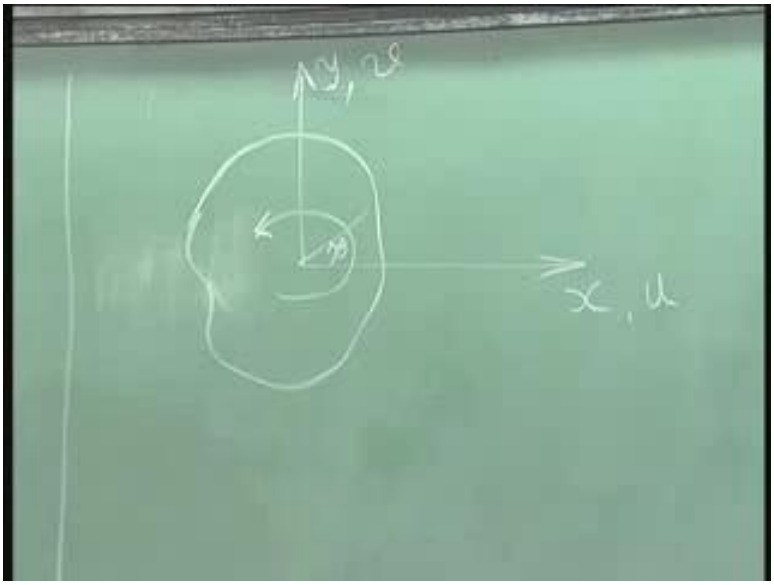

It is possible to describe the motion of this planar body on this board completely. This basically tells us that if I have a planar rigid body, I should expect a maximum of three degrees of freedom. Let me explain a little bit more. This is the rigid body that I am looking at. This is the planar rigid body and it can move anywhere like this. It can also rotate as we have already talked about it earlier. Let me just take a point here. Mark it as say a. Now if I fixed this with the pin, how many degrees of freedom will it have? If you look at it, the only way I can move this body is by rotating it. Forget about the planar motion, it's only the horizontal motion that to a rotation that is possible.

One way of describing any point on this rigid body is with respect to this particular point a, I can define motion of any other point on the body by simply knowing the amount of rotation it has undergone with respect to an axis. If this is an axis, how much rotation it has undergone. Every point will have undergone the same rotation which is an important idea to remember. The other distance that you have to take care of in order to know how much motion is occurred is a fixed point. The distance between that point and let's say another point that I choose over here does not change during this particular motion. Or in another words if I fix a point on the rigid body, the only way it can move is by rotating which means it reduces to one single degree of freedom that I have to define in order to understand the motion of this rigid body and mind you this is all with respect to a point that I have fixed.

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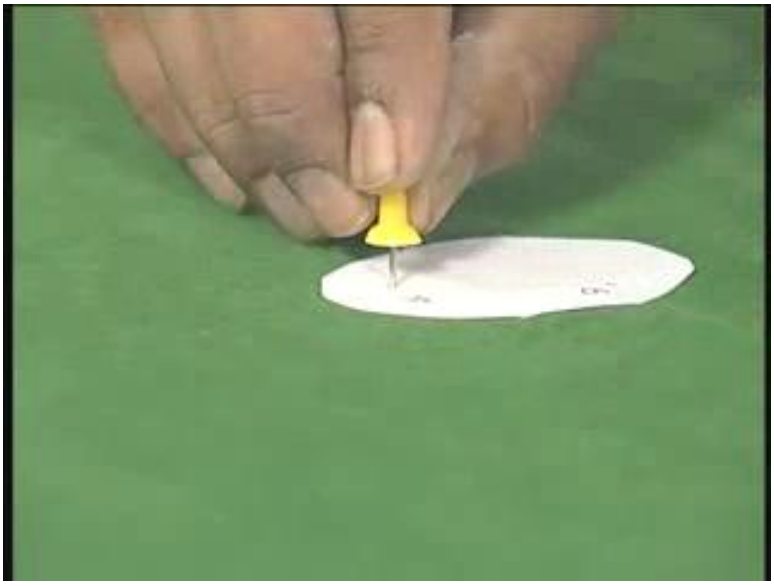

Now supposing I let this particular point to move around. I am just going to do like this.
If I let this particular point move around and then also rotate about this. Since I have already defined the rotation of this particular body with respect to a. The additional degrees of freedom come about by looking at the motion of this point a. How many degrees of freedom are possible? Two degrees of freedom are possible for this particular point a to move around. This we already know because a particle has two degree of freedom, one in x axis, the other along the y axis.

Once we have this concept, we will move on to the system of rigid bodies. So that we get an understanding of how to define the degrees of freedom. This is very essential before we go on to understanding how to write the equations of motion to solve the problem.
Thank you.