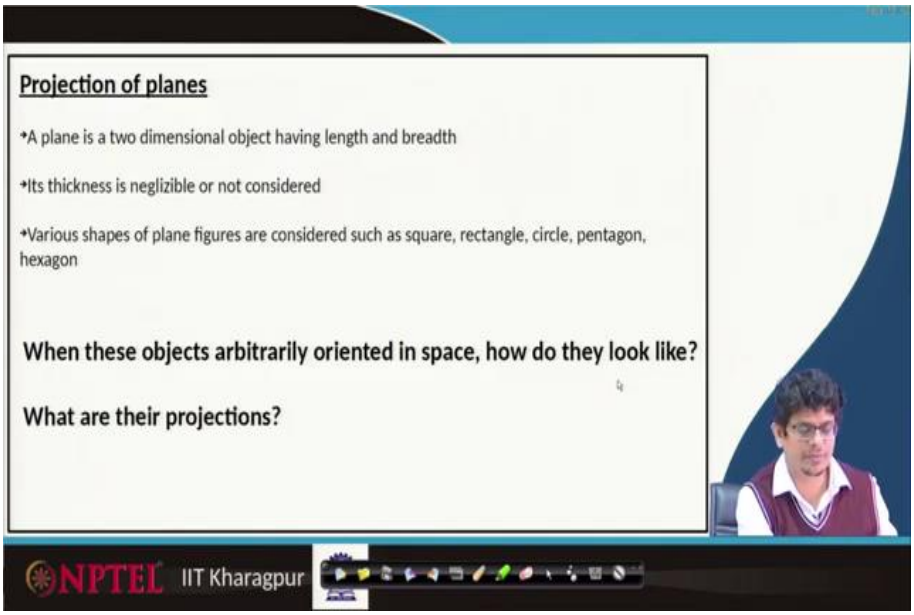
**Engineering Drawing and Computer Graphics**
**Prof. Rajaram Lakkaraju**
**Department of Mechanical Engineering**
**Indian Institute of Technology, Kharagpur**

**Module – 04**
**Lecture – 37**
**Orthographic Projections II (Part -7)**

Hello all, welcome to our NPTEL online certification courses on Engineering Drawing and Computer Graphics. We are in Module number 4 and Lecture number 37. Here, we are looking at Projections of planes. Earlier classes we try to look at the projection of points, prediction of lines and now we are going to look at the projection of planes.

(Refer Slide Time: 00:37)



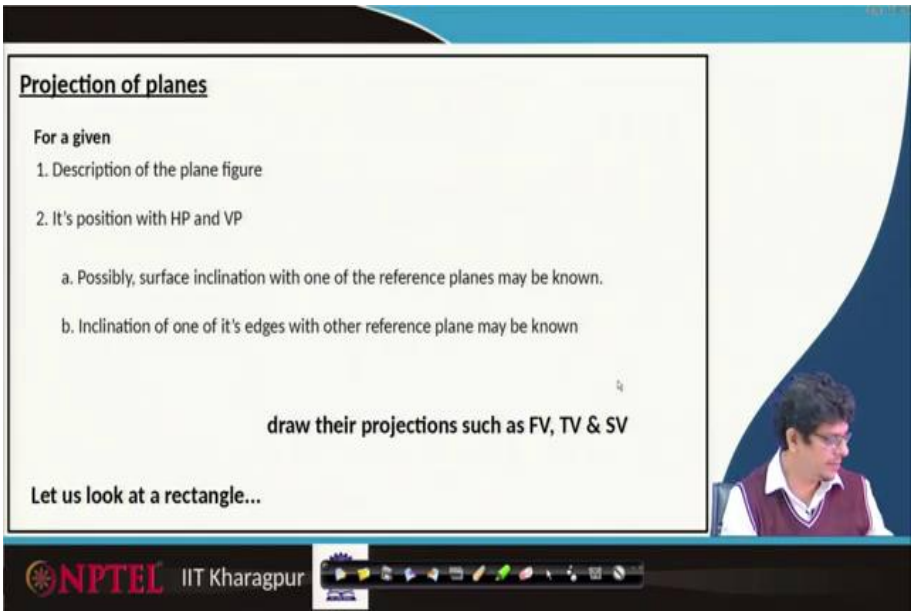

Let us look at what are these projections of planes. Plane by definition is a two-dimensional object. It has length, it has breadth.

For example, if we are taking this drawing sheet, it is a plane. The thickness is much smaller compared to either the length or breadth of that. So, such kind of objects for example, like rectangle, square, circle, trapezium and such kind of planes if they are making a different kind of angles on horizontal with respect to the horizontal planes and vertical planes how do their projections look like?

Sometimes what happens is these rectangles they might be inclined to both horizontal plane and also vertical plane at different kind of sections, different edges are making a different kind of angles and

if that is the case can we step by step construct that. Look at their projections like what is the front view, what is the top view, and how the side view looks like. Let us see that.

(Refer Slide Time: 02:04)

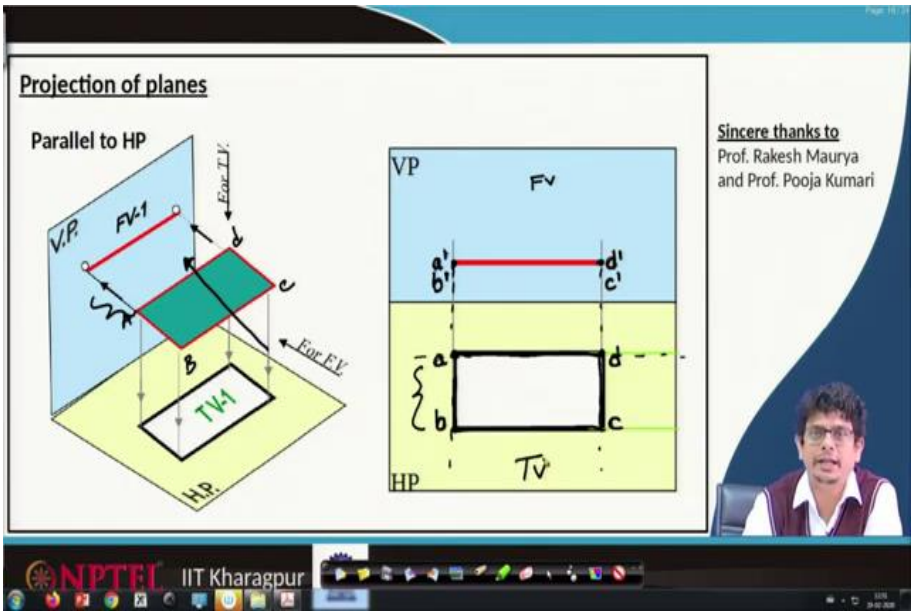



So, usually what is given is description over the plane figure is something like a square of so and so side or perhaps a rectangle of length this and breadth that.

And its position with respect to the horizontal plane and the vertical plane is given usually. Possibly, we may have a surface inclination with one of the reference planes and inclination of its edges with reference planes also available in certain cases. If that is the case can we be in a position to draw a front view, a top view, and a side view?

Let us look at a rectangle.

(Refer Slide Time: 02:57)




So, a rectangle parallel to the horizontal plane. How it looks like in three-dimensional? So, we have a rectangle here and this is parallel to the horizontal plane.

This is the horizontal plane. In three-dimensions, we can easily see that if we are looking from this view, this entire line coincides and we will see a vertical line, ah we see a horizontal line in the front view. If we are projecting this rectangle down it gives us one more rectangle.

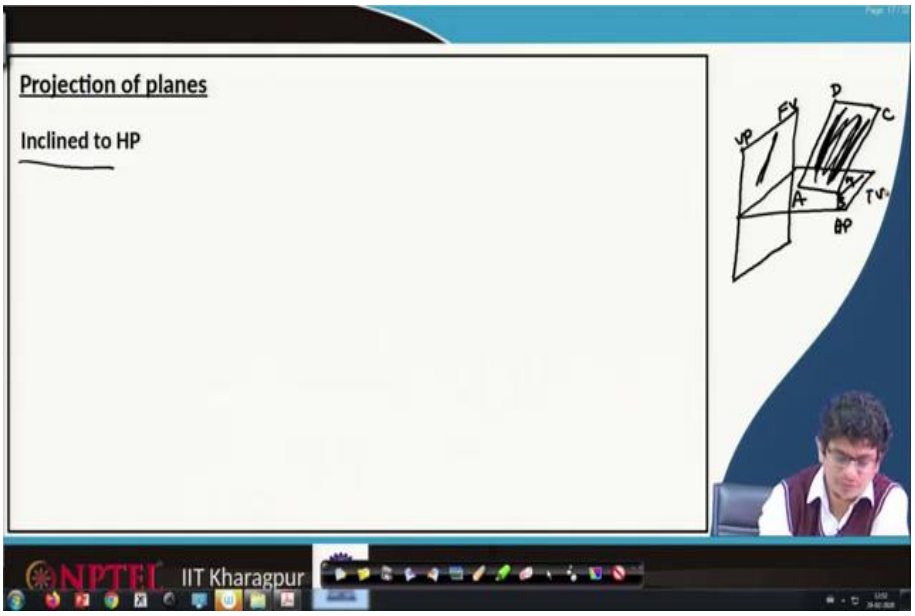
When this rectangle is parallel to the horizontal plane, the complete length of this rectangle one can visualize it in the front view. The complete area one can see it in the top view, where we have that length and also breadth. So, if we are rotating this horizontal plane by 90 degrees would like to show the projections what we do is, first we locate a', b', a'. So, let us call this is point A and this is point B and this is point C and this is point D.

So, when we are projecting in that way the front view both A B points coincides. So, in the frontal view what we are going to see, a' b' at the same position, similarly c' d' at the same location.

This is the way we observe. Then, their projections if we are extending it down; down. If we know in front of the vertical plane where exactly a point begins, we will be in a position to locate a. So, draw another horizontal line to locate a' point.

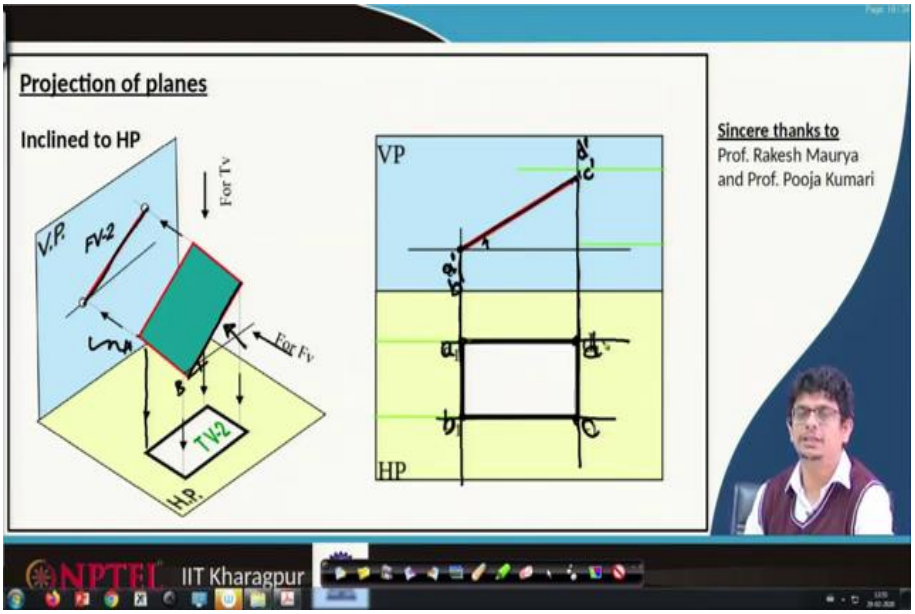
And rectangle breadth is known, so we will be in a position to locate b point. Once b is known we know this locus, so c point we can easily note it down. Already we know this a point, already we know a point, so the on that locus because of this breadth we can locate d point also. So, join a b, bc, c d, and a d. This is the way we construct top view of that rectangle.

(Refer Slide Time: 06:26)




Let us look at if the same rectangle is inclined to the horizontal plane. So, for that let us visualize that we have something like a vertical plane, there is a horizontal plane and our rectangle is inclined to the horizontal plane. Possibly, it might be such kind of rectangle, this is the rectangle. So, your A point, B point, C and D points. So, it gives us an inclination angle which we may be in a position to sense on this front view which is on the vertical plane. This is a horizontal plane, and this gives us top view information.

(Refer Slide Time: 07:17)




So, if we are seeing here, this line maps to an inclined one, so that inclination angle with respect to the horizontal plane we will be in a position to see in the front view. When we are projecting this

rectangle down onto horizontal plane these points about that if we have an inclination and rotation happens about this A point and B point then AB points will be mapped to their this is a this is b, but C point maps at a much closer distance here and here, because it is a projection, projection of that always decreases. So, bc, lower case letter bc is smaller than upper case letter BC length.

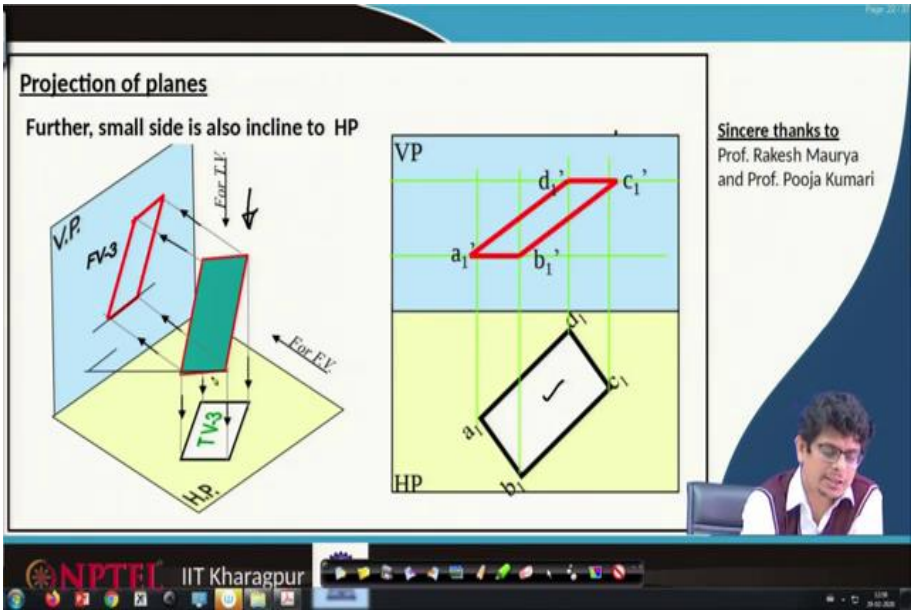
So, if we are drawing this picture again let us look at it because this length is not changing even if we are projecting this line onto this vertical plane. So, first of all, we locate where exactly A point, B point is located in the above horizontal plane. Once we know from the horizontal plane this much length, immediately we will locate a' and b' point there.

And this rectangle is making an angle with the horizontal plane. So, we can visualize that in the vertical plane, draw that c' and d' lines. Because this length we will be in a position to get it from the front view.

So, we locate that. Once these lines are done, we project it down all the way, project it down and from the top view, we know how far this A point is or perhaps in front of the vertical plane where exactly this a point located we locate a point, similarly, we locate that b point.

Now, draw locus lines which are intersecting this projector line to locate that a, b, c and d points. Once we know that we have this reduced rectangle as a projection.

(Refer Slide Time: 09:56)




Now, further, we can locate if the small side also inclined to the horizontal plane. So, let us look at that pictorially. We already have a rectangle, for example, this is the rectangle what we are referring

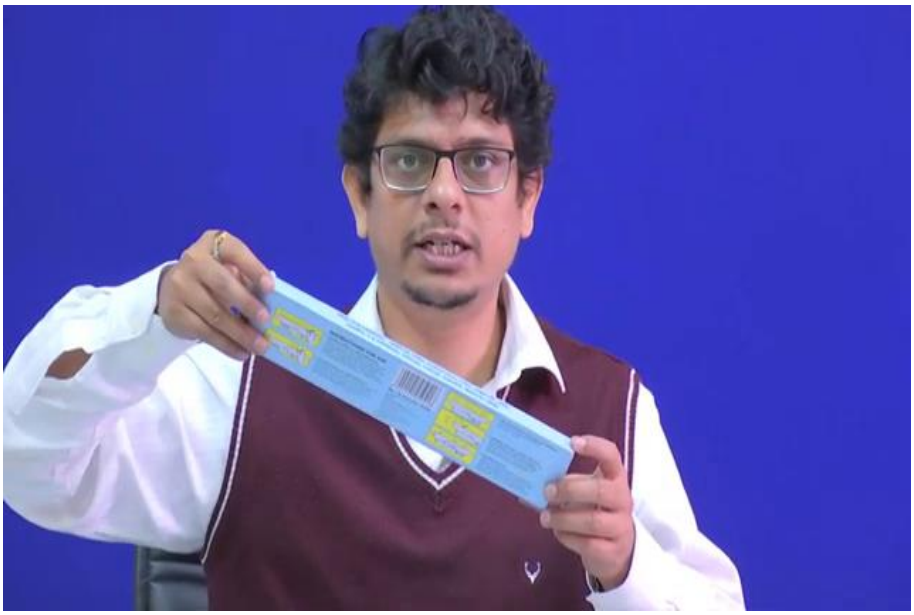
to, initially, we have parallel to horizontal plane, after that we have this tilt, after that, we want to tilt it in that direction. So, it is more like 3 directions.

So, if this is the horizontal plane, first we have tilted it in that direction then we want to tilt it in that direction. If that is the case, what is the projection you are seeing? Are you in a position to see the complete rectangle?

For example, this is the area what you are seeing, but what I am trying to do is rotate it. Now, at projection level, if you are seeing that it looks like the area of that rectangle is drastically reduced. You see that. Based on my inclination angle when you have these projections you see it differently.

The same thing happens for even for this. Let us pick this box. We have this box. See, the way what you perceive and the way how it looks like these are different. Now, this one if we are going to make an inclination and that you can see it in that way.

(Refer Slide Time: 11:29)



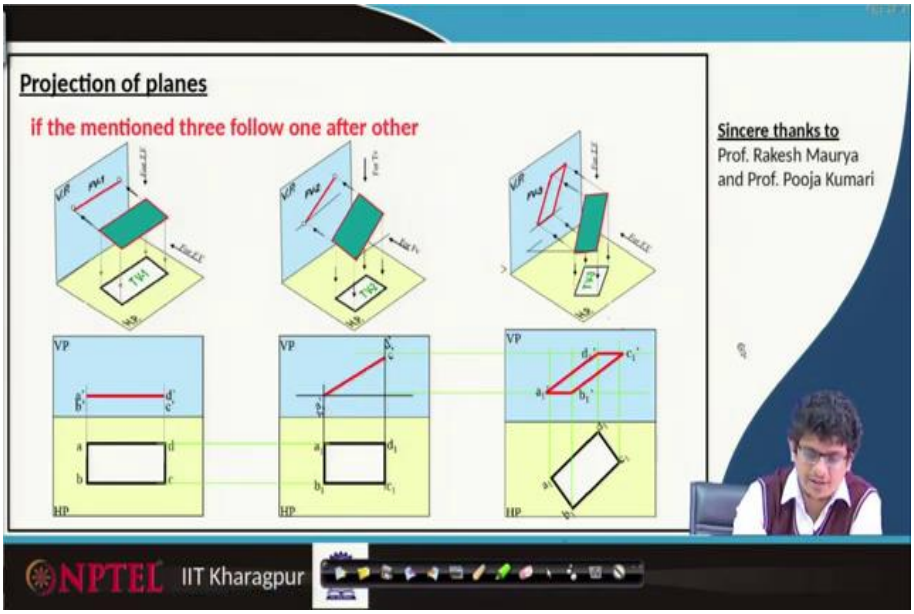
So, this is the rectangle let us assume that you are seeing this, even if I rotate it in that direction same rectangle at the front view you see. Now, if I tilt that you see something else, like this line you will see this one and also that backside line here you see this one. This is the way you see.

So, in the same way on our slide when we are observing these rectangles, the views when you are projecting, as a third person if you are looking at that front view projected ones this rectangle drastically changes to parallelogram sometimes trapezium and many other kinds of shapes.

So, for production, for manufacturing these views are very important to construct these objects, because you have a tapered object you want to observe it from the top view. Without knowing what are the views you are getting is difficult to manufacture such kind of products. And it has to be conveyed in a clear way to this production team. So, let us learn how to construct such kind of rotated inclined kind of objects even for the simple rectangular objects.

If we rotate it this rectangle the way how it is visible from the top view is rotated, squeezed up, similarly in the front view that completely changes to a parallelogram.

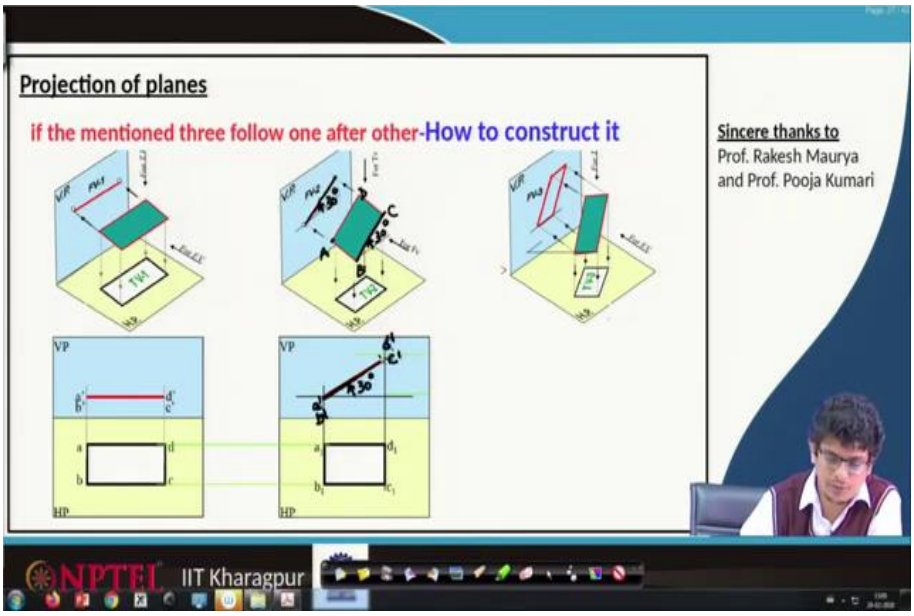
(Refer Slide Time: 13:17)




So, let us ask a question, systematically, if we are going to take a rectangle first lift it from the horizontal plane so that it makes an angle with the horizontal plane, then rotate around this small edge. So, move this small edge in that way. If that is the case if we are projecting these points, what kind of object we are going to get? Similarly, project these points. How to do that? We would like to learn.

So, the first thing we have already seen, something like a rectangle and a line. Then, whatever the projections we get like rotate that, so we will have that line projection and so on we will construct it.

(Refer Slide Time: 14:19)




Let us see how to do that first the object is parallel to our horizontal plane. This is the one, at 3D this rectangle is parallel. When it is done in the vertical plane the front view, we can draw that length locate a', b', c', d'. Similarly, in the top view draw this rectangle.

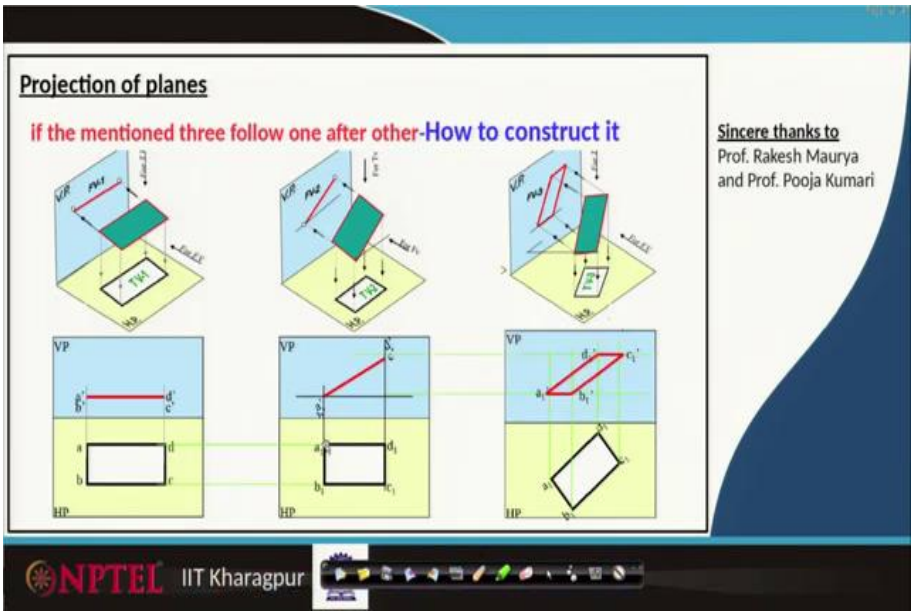
Now, we would like to rotate this rectangle by a certain angle, maybe let us say 30 degrees we would like to rotate it, this one 30 degrees. Where do we observe this 30 degrees rotation? If we are rotating about A B line, lifting this C and D bit up.

If that is the case, we see BC line, AD line coincides making an angle 30 degrees in the front view. So, draw the same length BC or AD line with an angle 30 degrees in the vertical plane. Let us call this is a', b', c', and d'. Once that is done, project line, project line from c down, and project from a' also down.

When we are looking from top view this length hardly changed, this AB remains the same. So, locate first point a based on how much in front how much above that, locate a', locate b'. Once we know we can construct locus points to construct complete a, b, c, and d. Usually, when we are constructing these kinds of projection of planes we will have multiple figures to distinguish that at the first figure level we write a, in the next figure level we write it a 1. And this is the projection of lines.

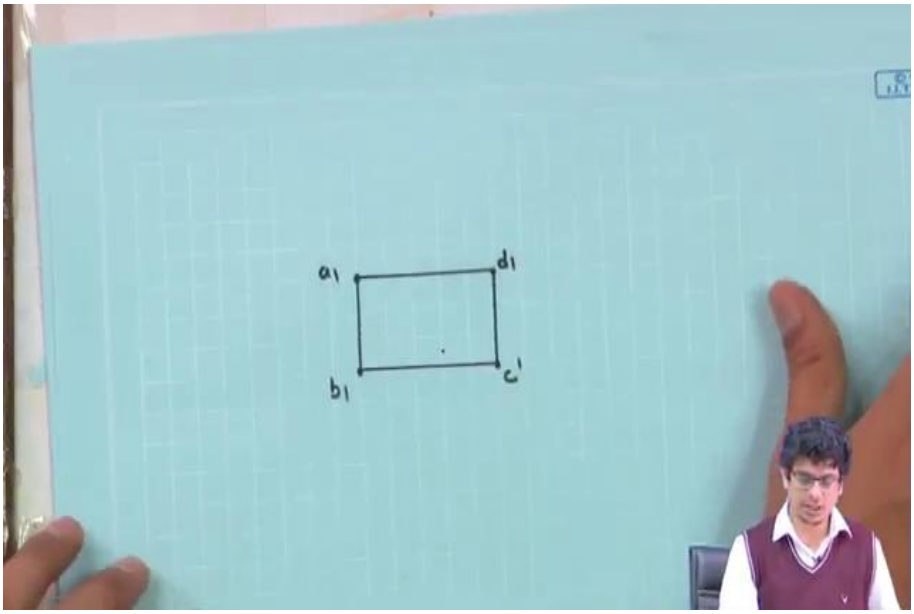
If the second picture comes, naturally it becomes a 2, b 2 and so on that that is the standard convention we follow it.

(Refer Slide Time: 17:36)




So, projecting this rectangle, we will be in a position to locate a 1, b 1, c 1, d 1 line. Once that is done we will be in a position to rotate this entire rectangle with respect to a particular line. Let us consider this a projection one a 1, b 1, c 1, d 1. We want to rotate about d 1 point for this c 1, so this point has to go there. If that is the case where exactly it will be located. So, a 1 also moves. If we are rotating around d 1 point, is more like let us locate on the drawing sheet..

(Refer Slide Time: 18:26)



If I am locating this point as a 1, this point as d 1, this point as b 1, and this point as c 1, let us join these lines. Maybe this is the rectangle what we have. What we want is rotate this around d 1. So, one should not move out of d 1, about this d 1 point we have to rotate it. So, this is the projection what we have already.

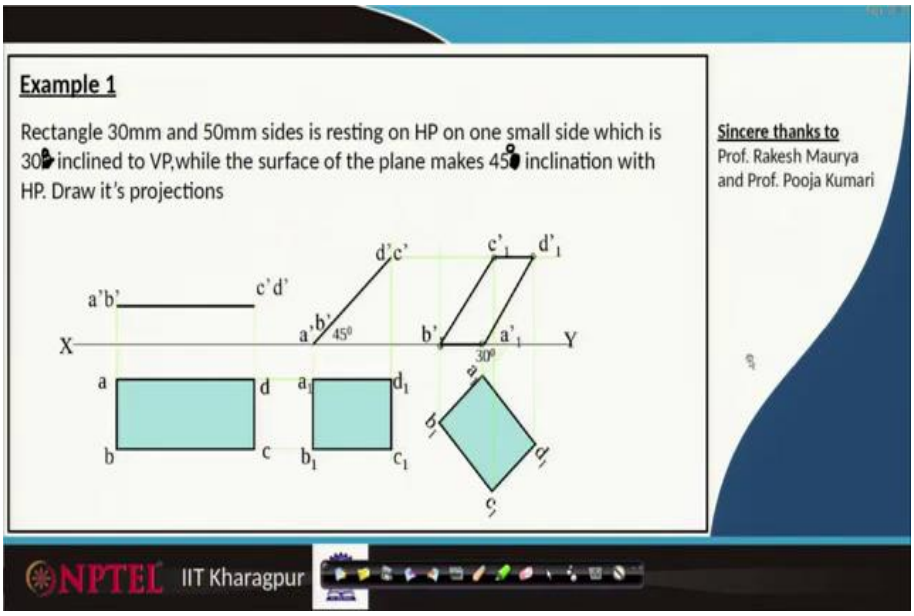
And the next projection what we are going to make is around the d 1 point, we want to rotate it. If that is the case, d 1 remains the same there, but a to d is going to make an inclination angle with respect to our horizontal axis. Let us consider this is our horizontal axis with respect to that we have rotated. So, in the next projection, we have to draw what is that rotation we are looking for. So, let us go on to our slide.

So, we have already after constructing this a 1, b 1, c 1, d 1 we rotate around d 1 point a 1, d 1. So, like that we rotate; when we are rotating it is just transfer of lengths. . We are going to make it there we are just rotating not changing any projections. Similarly, a 1 b 1 perpendicular to a 1 d 1; so, perpendicular to do that we have to draw that; again, perpendicular to that perpendicular. So, in that way, we can construct this rectangle.

Once this rectangle is constructed, we want views of that. So, what we do is on the sheet here a 1 point we project it up, b 1 also rotated one we project it up, c 1 projection, d 1 projection goes through that. But already this inclination angle we know, from there we rotate it so that d 1' c 1' we can easily locate it. Similarly, transfer this one where it is intersecting, so let us do it in this way.

Project a 1 point, project a 1 point where it is intersecting locate that. Similarly, project b 1 onto that line, locate it. Project c 1 from c, locate that. Similarly, project d 1 onto that line, locate it. Once the projection is done, we can always join these points to have the final figure what we are about to see..

(Refer Slide Time: 22:02)

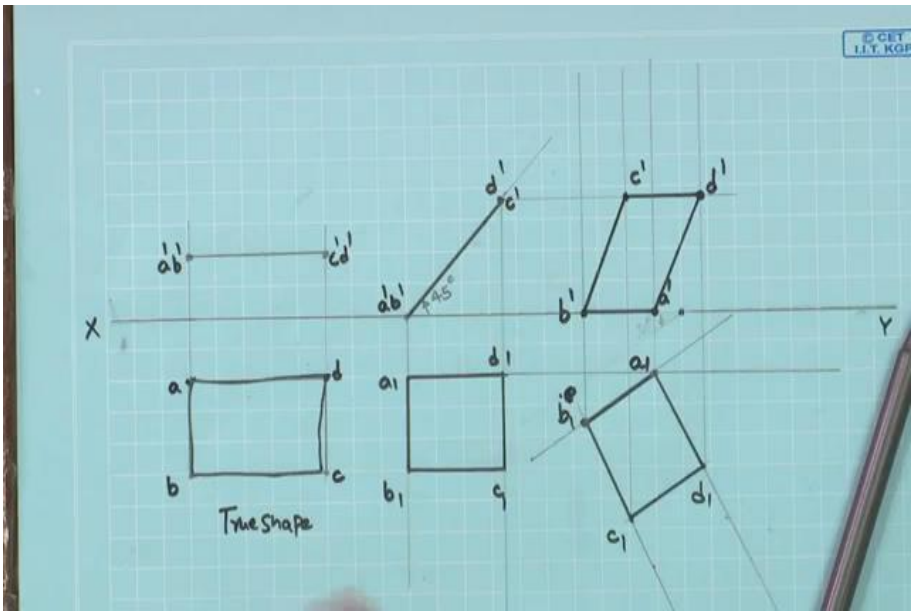



Let us look at example 1 on this slide. We have a rectangle 30 mm and 50 mm these are the sides, resting on the horizontal plane. On one small side which is 30 degrees, I am sorry this is 30 degrees inclined to the vertical plane, while the surface of the plane makes 45 degrees, with an inclination to the horizontal plane. If that is the case draw its projections.

So, what we have is a 30 mm by 50 mm rectangle with the sides resting on the horizontal plane, and one small side it makes 30 degrees to the vertical plane. That means, if we are taking this one as the rectangle, let us consider it has maybe 50 mm on one side, 30 mm on one side.

And this is resting on the horizontal plane. And small side, whatever the small side we have that is making 30 degrees inclined to the vertical plane, so which way we will see 30 degrees inclination to the vertical plane. If we have it in this rotation view, we will have that inclination angle.

(Refer Slide Time: 23:50)




So, let us look at our drawing sheet for this construction. How to do that? So, first of all, draw an X Y plane in the projection of planes, we require a longer X Y line because there always be 2-3 views. Let us call this one X-axis, somewhere Y-axis. It is a 30 mm by 50 mm rectangle. Where it is present, we do not know because of that reason what we do is first of all draw a rectangle 30 and 50.

So, initially, we begin with a plane which is parallel, then make an angle with vertical plane with the horizontal plane. So, this is the rectangle what we might be having something like this and then make such kind of thing, then align the views. This is the way we begin with.

So, first of all, construct 30 by 50 rectangle. Name a, b, c, and d points, and its projection always be goes to perhaps this location let us call because we do not know in front and away. So, we begin at one location. And this one a', b', both are coinciding, c' and d'.

Now, this one has to rest, so this entire rectangle has to rest on the horizontal plane, so that means, I have to bring it in that way. The small side is always making 30 degrees with the vertical plane. So, draw that resting one line which is making 45 degrees on the plane. So, let us begin it here. It makes 45 degrees from this point, 45. So, let us join the rectangle which is resting in this location.

And the length, what we are going to see is the true length we are going to see, so that entire longer one 50 mm we have to locate it. So, here if we are going 50 mm, locate it, let us call a' b' still we just rotated it. So, that is the reason we are not changing any other suffixes and this angle is 45 degrees. That means if we are looking from the front view the rectangle is making an angle 45 degrees inclination.

Now, project these lines down. So, use our roller scale to transfer projection in that way. Now, the rectangle is this one, having a projection that and the other projection is this.

So, if we are darkening it, the rectangle is taking 30 mm, 50 mm resting it smaller length, breadth on the horizontal plane and rotating it by 45 degrees. If we are looking from top view it looks like a smaller kind of rectangle. So, let us call these points in the top view a 1, b 1, c 1, and d 1

Now, what we have to do is rotate this entire thing either about a 1 or about this b 1, c 1, this is the thing what we would like to make. While the surfaces of the plane make 45 degrees inclination with the HP, it is going to make 30 degrees for the small side. So, the small side is this one. This one we have to make it 30 degrees in that direction. So, let us transfer that length.

So, here on the drawing sheet first of all if our rectangle supposed to make 30 degrees, first locate the point this one, smaller one making 30 degrees somewhere there. Join these lines. This is the 30 degrees angle and we have to locate this point.

So, if about a 1 we are rotating it, if that is the case then naturally the projection remains same somewhere about that this a 1, b 1 is rotated. So, let us transfer that a 1, b 1 length.

So, if we are not having that enough length, what we can do is increase this length to locate it. So, on the projection let us have this locus, maybe our a 1 is here because about that we are going to rotate it by 30 degrees.

If that is the case, locate 30 degrees around that join this line a 1. So, that is intersecting here on that transfer our a 1, b 1. About a 1 we are rotating it, keeping a 1 remains same. So, our b point nu 1 b 1', b 1 will be here. Let us join a 1 and b 1.

Perpendicular to that I have to draw these other points like c' and d'. So, let us extend that, similarly extend this line. The same length we are going to see. And this b 1, c 1 also we are going to see the same thing. So, transfer this b 1, c 1 length here. Similarly, transfer that length. Now, join these lines onto that plane.

Now, we have to draw projectors to this b passing through b 1, a 1, let us call c 1 is not' b 1, a 1, c 1, and d 1. Let us draw projectors to a 1, similarly, to c 1 and d 1.

And when we are doing that these are the intersection points b with b we have to locate, b with b is here. Let us call that is b'. a with a, we have to locate that, so this is the original line what we have, a with a line a' d with d line, so, let us draw again the locus line somewhere here. d with d line called d', c with c'.

Let us join these lines. If we are joining, so though it is a rectangle when we rotate it by 30 degrees and change that angle from the top view and front view when we are looking at it, it looks like something named parallelogram kind of shape we will get. So, the views are in some sense misleading.

They might not give us complete true shape of the object. When an object is rotated, lifted and so on so things, when you are looking either normal to it or side view kind of thing these angles and also the true lengths are slightly distorted. So, this is one of the reasons. The projections and the drawing course help us to visualize, to find out these object true shapes.

In that sense, reverse engineering goes in this way. You have that object this is the thing what you are getting, based on rotations one will be in a position to get, this true shape this is the true shape and true lengths. And, these are the views what we are perceiving. That object by rotating properly bringing it back to the original thing we will see this rectangle, ok.

In the next class, we will learn more about these planes.

Thanks a lot. Bye.