Engineering/Architectural Graphics - Part 1
Orthographic Projection
Prof. Avlokita Agrawal
Department of Architecture and Planning
Indian Institute of Technology – Roorkee

Lecture - 28
Projection of Solids with Axis Inclined to One and Parallel to Another Reference Plane

Good morning, welcome to the third lecture of this Week 6 of ongoing online course on architectural graphics or engineering graphics where we are focusing on orthographic projections. So, in this week, we are discussing about how to draw orthographic projections of simple solids. So, if you remember in the very first lecture of this week. We understood what are the different types of solids which regular solids which we can use?

And in the second lecture, we learned to draw orthographic projections of solids in simple positions which is when the axis was parallel to one of the reference planes and perpendicular to the other or the axis of the solid was parallel to both the reference planes. And we had seen all the 3 examples of each one of the possibility by taking one of the representative solid. So, today we are going to learn about how to draw orthographic projections of solids which have their axis inclined to one of the reference planes and parallel to the other plane.

So, this is what we are going to learn today. **(Video Starts: 01:51)** So, before I proceed to describe to tell you how to draw the projections orthographic projections of these solids which are inclined to one of the reference planes let us first understand what this means. So, in the previous position in the previous lecture in simple positions what we had? This is the horizontal plane. This is the vertical plane. What we had?

Either we had a solid like this which was kept on the HP or where the base is being parallel to HP and the axis is perpendicular but staying parallel to VP or we had this kind of a position where the axis was parallel to V parallel to HP and perpendicular to VP. In this case, the base was parallel to VP. We also had a case where we drew it like this where the axis was parallel to both HP and VP. And the base was eventually parallel to the side reference plane.

And the axis was being perpendicular to it. So, in each of the cases, the base was being parallel to either one of the planes. Now, today we have another set of condition where we say that this solid which was originally like this. Suppose like this is now inclined to one of the reference planes and its axis is still parallel to one of the reference planes. So, in this case, the axis is parallel to VP perpendicular to HP.

Now, imagine if I incline it like this, what happens? We do not have the base parallel to any of the reference planes. But the axis remains parallel to VP. So, what we will have? We will still see the true dimension of the axis the true height of the solid in VP. Because we have the axis parallel to VP and everything else is skewed when we see it in HP in plan. Or, the other condition could be that this was the original condition where the base was like this.

Axes is parallel to HP. And it is inclined to VP. So, we could also have it this way where the axis is parallel to HP but inclined to VP. In that case, again what we see? We will still see the true height of this solid in HP. But we will see a skewed figure being drawn in the VP. That is what we are going to see. How do we get those skewed projections and in orthographic projections just as we have been learning? It is a very scientific process.

It is methodical step by step as we proceed progress ahead we will be getting the orthographic projections. So, to start with again whenever we are given a condition where the axis is inclined to one of the reference planes. But it remains parallel to the other. In that case, where we will start with is when assuming that the axis is perpendicular to the other reference plane and it still stays parallel to the plane to which it is currently parallel.

So, what I mean by this is assuming that we have a pentagonal pyramid. And in this case, what we are assuming is that this pentagonal pyramid has its axis parallel to HP. And this axis makes an angle of 30 degree with the VP. So, it is going to make an angle of 30 degree with the VP. And it will remain parallel to HP. So, to begin with we will assume that this axis is parallel to HP but perpendicular to VP. Let us start by drawing this pentagon.

So, I have done some drawing of the pentagon here, if you remember the original basic construction drawing. So, I have this I have arrived at this center for this pentagon. And now,

we will draw the pentagon. Now, we do not have to make it very dark because this is not the final figure because the base in this given condition is not parallel to VP. So, we will not be seeing it. So, with what we have here is a step prior to arriving at the final figure.

So, make it little light. I am not drawing it very light because otherwise you will not be able to see it. But it is still lighter than the darkest. This is the point through which the axis passes. So, what we have is this. So, assuming that the height of the cone is say 10 centimeters. So, what do we see? In this original position, what do we see? We see the projections of all the triangular faces.

This is the apex. And we join the apex to each of the points. Right now I am drawing it very light because if you look at it, we will actually not be seeing this side because it is below. From the top, we will not be seeing the 2 sides joining these 2 points to the apex. But, to facilitate an easy drawing, we will have to draw it. And hence we draw them very light. So, you have to be careful about what you draw light and what you do draw dark.

Now, this is the projection of this pyramid if we see it in the simple position. Now, what it says? That this axis is inclined at 30 degrees to VP. This axis is inclined at 30 degrees. So, what I will draw is I will draw an axis inclined at 30 degrees to the VP. This is where the axis is going to be. And when I draw it like this my base is going to come on to this axis. So, what I will have? I will have exactly since the axis remains parallel to HP.

This entire figure will move in such a manner that the axis becomes at 30 degree to the VP. So, all that we have to do is we have to just take the same projections from this and mark it over here. This is for the top 2 points. This is for the bottom 2 points. And this is for the apex. So, what we have done now here is we have reproduced the cone in such a manner that the axis remains parallel to the HP. And it makes an angle of 30 degrees with the VP.

So, this is what we get. Now, that we have the plan of this cone which is now inclined at 30 degree. We need to take it back up the horizontal the vertical heights from the base. They will remain the same because there is no movement. So, what we will draw is we will get the

projections from the elevation which we had got. And now, we will start projecting these. So, we also have to get the projection for this axis because this was just the base drawing.

This is the line where the axis would have come and apex would be. So, we will take the projections further up. Let us quickly mark them. So, suppose this was I am writing it very lightly here A, B, C, D and E. And if this was A, B, C, D and E here and this is the apex O. And this is the point O of the apex which we will see from the front. So, this O is now this point O. B will be here. A will be here.

Then you have E which will come here, D which comes here and C which comes here. So, the projections orthographic projections coming from each point would match. And what we will have? If we move it like this, we will have each of these points joined to the apex. So, what we will have? Some of these may not be visible. So, we will start by joining the topmost points. So, this is O.

And now, what we will when you seeing it from the front you will see this E and D first. So, we will draw that. So, we draw the E and D. And now, we have the C. So, we have we will also be able to see the OC this side. But this side OB will actually be hidden behind the cone the pyramid itself. So, we will have a line but it will be a hidden line. And now, when we join the outermost points of this base what we get?

We get a pentagon and it will be a slightly skewed one as we can see here. And all of its points will not be visible. So, what we get here is again some 2 of the sides will be hidden. I am drawing them light. But when I darken them it should be evident that these 2 are hidden and that is what we have to draw when we are doing the final darkening of this picture of this figure. So, let us start darkening it here.

So, what we have in the HP is the same picture same figure which we would have got if it was parallel to HP and perpendicular to VP. So, we will just darken it, OB. Now, if you see at this from the top we will not be seeing the OC and OD. This is a hidden line. So, how do we draw the hidden line? If you remember, we draw hidden lines by equal sized dashes. So, it is a dashed line which is used to represent hidden line which is what we are drawing here.

OA is visible. This is what we seeing as solid. Again OD will remain hidden when seeing from the top. So, we will draw a hidden line here again and a solid line. And in the base we have a firm solid line. So, this is the top view of the cone. And now, we will start to draw the front view. Now, this cone is inclined like this. So, the base is not visible only the outline of the base will be visible which is what we have to keep in our minds. And let us draw.

So, only the solid lines or the edges which are visible will be made solid. And this line which is OB is actually a hidden line which goes behind the cone itself. So, we draw a hidden line here. This is a solid line which is AE because we will be seeing AE clearly. So, this is a solid line. Now, the D will again be visible. So, we draw a solid line for D. And there is a solid line for C OC. Now, the outer surfaces will also be the firm lines.

And the lines which are inside are also hidden lines. So, we make them dashed again. Now, if I label it we will be able to see the shape clearly. So, if I start from here taking the same numbers here this was my A this is B, C, D and E. And this is the apex O. In plan, this is the apex O. The projections are matching. The projections must match all the time, A, B, C, D and E.

This is the final projection the vertical projection which is front view and the horizontal projection which is the plan of this given cone. Now, we had the axis. So, we also have the axis which is here. So, we have the axis which I will draw in thin line which represents axis which is a big dash and a dot. This is the line representing axis which clearly shows that this axis is parallel to HP. And we have this axis here which is inclined at 30 degrees to VP.

This is the final projection. Now, we have to take the dimensions. So, what are the dimensions that are known to us and where are we seeing them? So, we have the axis parallel to HP. So, we can see the true length of the axis in HP which is the most simple. So, what we have? We have a total length of 10 centimeters which is 100 which is the height of the cone which we have to show.

Now, we do not have the true shape of the pentagon if we are looking at this the final version. In this case, what we can also do is we can draw an auxiliary plane. And we can take the projections onto the auxiliary plane to get the true shape of the pentagon. So, in that case, if you remember how we draw auxiliary planes we can draw an auxiliary plane here. This is the new reference line for the auxiliary plane.

And all we have to do is to take the projections perpendicular to this. So, this auxiliary plane we are assuming as parallel to the base. So, we get the projections of these points here. And the vertical heights are going to come from the elevation. So, if we look at the height of A from the axis is what we will mark from the axis. Then we take the vertical height of the other 2 points.

And we will mark all these distances from the axis because that is what we are taking. And C and D remain the same. Let us now darken these to get the true shape of the base in auxiliary plane. So, if you check the shape, this is the true pentagon. Because what we have drawn is we have drawn the base on a plane which is parallel to the base. And hence we will get the true pentagon here.

So, what we have here is A, B, C, D and E. So, we have the true pentagon here on auxiliary plane and what we get is the true size of the side here. So, we can also be drawing it mentioning the dimension of this here which was to begin with we had taken a 4 centimeter. So, this is 40. With this the projection of a solid a pentagonal pyramid inclined to VP but parallel to HP is drawn.

And this is where we will see the true shape of the base the front elevation and the top view the plan of this pyramid. Now, there could be another possibility where the solid is inclined to HP but it remains parallel to VP. So, let us first understand how it is going to be. So, what we have is that we have this HP. In this case, it was inclined to VP. Now, we are assuming that this solid is going to remain parallel to HP sorry parallel to VP and it will incline to HP.

So, what we will get? We will get a solid like this. To begin with where the axis is perpendicular to HP parallel to VP and it remains parallel to VP and the solid is inclined to

HP. In this case, the solid was initially assumed to be this and then we inclined it like this or this. In this case, we will keep the solid initially like this and we will incline it like this. So, that it makes a certain angle with HP.

Let us see this by taking example of a simple solid another simple solid. So, let us assume that we have a cube to start with and this cube is inclined at 45 degrees to HP. And it is parallel to VP the axis of the cube so and size of the cube you can assume to be a 7 centimeter cube. So, to begin with, let us make and the cube is stationed. It is placed in HP. And it rests in HP on one of its edges finally.

So, let us draw the 7 centimeter cube in its original position. So, what we have here is the simple cube if it is placed. And then in the HP also we will only be seeing another square. So, in pyramids, we will be seeing triangles. In prisms, we will be seeing rectangles. And in cubes, we will be seeing squares and then skewed forms of squares. Now, this cube is placed simply. Now, what we see? Let us draw the axis of it.

The axis of this cube is perpendicular to HP and parallel to VP. So, let us draw the axis of this cube because that is how we going to understand it. So, we should be always drawing the axis. So, this is where the axis of this cube is passing. So, what we are assuming that the axis of this cube is perpendicular to HP and parallel to VP. Now, when we have to incline it, what happens? The axis of the cube, the cube was placed like this.

And the axis of the cube is now inclined at 45 degrees to HP. So, we have this cube and this is the axis. So, in simple position, the cube is placed on HP like this. And it has an axis perpendicular. And now, we are saying that this axis is making an angle of 45 degrees with HP. So, if this was the VP assuming it is parallel to the face of this and the square is kept in the simplest position.

And now, when it makes an angle of 45 degrees, the cube is resting on one of its edges and not faces. It is resting on one of its edges. And it makes an angle of 45 degrees with the HP. So, what we have? The axis is still parallel to VP. So, we will draw this cube. We will rotate

in such a manner that it now makes an angle of 45 degrees. So, we will rotate this entire drawing of elevation by 45 degrees. So, what we have?

We will just make this entire thing inclined by 45 degrees here. And we will also draw the axes parallelly which is here. So, this is the new I have not darkened it but if you can see this was the original position of the cube. And now, this is inclined at 45 degrees such that the axis this axis now makes an angle of 45 degrees with the HP. And let us now take back. Now, when it is inclined like this, the distance of all the points from VP will remain the same.

So, essentially the horizontal projections continue to remain the same. So, what we have? We will take down the projections from the top. So, what we have here is this point 2 3 and 4 and this is the point where the axis passes. And in the bottom, let us take the points again. So, this is where the axis passes. For this point, we have the 2 points coming here. And for this one, we have the 2 points coming here. If I darken it, the picture will become clearer to you.

So, I am seeing it from the top and when I see it from the top, I see this edge here. I see both these edges right on top of each other. So, I see one single edge here representing both. But I am darkening it because I am seeing this edge first. So, it is a solid line. And the hidden line will actually be hidden behind the solid line. And then I see the solid edge which is this. This is the these are the visible edges. And we have an axis which is passing through this.

So, it is not visible here. But then it clearly shows that this axis remains parallel to the VP. Let us now darken the elevation which is inclined. This is the front elevation of this cube. And what we get as axis here is this which is inclined at 45 degrees. Now, let us label it to understand it in a more clear manner. To begin with, if we see from the top, this was assuming A, B, C, D and beneath it, it was P, Q, R, S.

So, if this was A, B, C, D, so what we have here is to begin with A, B, C, D and P, Q, R, S beneath it. And on the top, what we see is DA and CB which is what is going to get rotated and P, Q and R and S. So, S,P and R,Q here let us rotate it. So, it rotates about the same point which is R,Q. And this point S,P comes here. The point D,A not the same point but the 2 points are rotated and be seen there and C,B.

This is all elevation and hence we will have dash here. So, that is the final front elevation of it. And when we seeing it from the top, so what we see here is the new point. This is A, D. And what we see here is B and C. And beneath this A what we actually have is here we have P. So, beneath A we have a Q which is here. And beneath D we have an R. And this is S. And this is the axis. So, what we have here is VP, HP.

And this axis remains parallel to VP and at 45 degrees to HP which is seen clearly here. And since it is singly inclined we will still be seeing the true shapes. And what where will we see the true shape of this 2 side dimensions? In front elevation because the axis remains parallel to VP. So, what we have here is the true sides of the cube. So, we said that the cube is 70 mm side each.

Now, try at home assuming that this cube in its original position was placed in such a manner that the axis was perpendicular to HP parallel to VP. But the side of the base was making an angle of 45 degrees with the VP. So, while this solid essentially remains parallel and perpendicular to the reference planes. Its base is actually making an angle of 45 degrees one of the sides.

And now when you incline it when the axis makes an angle of 45 degrees actually the solid is being the cube is being inclined by 45 degrees about a point. So, this solid will be resting not on one of its edges but just one of the points. So, when you see it from the top tell me what do you get? So, you have to draw it at home and then you have to figure out what do you see? How many faces from the top do you see? And what is the shape of each of these faces?

Do you get rectangles like this at right angles? Or, do you get some different shape? So, I hope with these 2 examples **(Video Ends: 36:31)** you have fairly understood how to draw the orthographic projections of solids which are inclined to one of the reference planes and the axis remains parallel to the other reference plane. I would love to see your feedback on what do you get as this the question which I have told you here.

And from the next lecture in the next lecture we will be moving on to projections of solids which are inclined to both of the planes. So, if you have been able to grasp what we have done till now how to incline solids with one of the reference planes we will be able to graduate to the next level where the solid will be inclined to both the reference planes. So, thank you very much for joining this lecture with me today, bye, bye.