Engineering/Architectural Graphics – Part 1 Orthographic Projection

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Lecture – 19
Projection of Lines Inclined to Both the Planes

Good morning. Welcome to the 4th lecture of this week where we are discussing about orthographic projections as part of the ongoing online course on architectural graphics or engineering graphics and in today's lecture we are going to learn about the projections of lines inclined to both the planes. So, before we go on to understand how to draw the projections of these lines which are inclined to both the planes.

Let us understand the fundamental behind that and understand how the line will be inclined to both the planes. Now, just imagine that the line is inclined to any one plane say for example HP in this case and it is parallel to VP. What happens in that case is that this line makes a certain angle with HP and is parallel to VP which was the case which we dealt in the previous lecture.

So, what happens in that case is we get the true length of the line here and we get a diminished trace. Now just imagine that this line which is kept like this at say an angle of 45 degree to HP now will also make an angle of 30 degree or whatever with VP. What happens if we start moving it like this? So, what happens is that the condition remains that the top point will maintain the distance it has from the HP because the angle from HP is not changing.

So, imagine this position where it is making a certain angle with HP and now it has to make an angle with VP as well. So, what happens that as it moves such that the horizontal line the locus of this point which is on top remains the same as the lower one remains pivoted in front elevation we will see that the top point is moving in a straight line. The top point will continue to move in a straight line in such a manner that the line now makes an angle of whatever say 30 degrees from VP.

We can understand it in the reverse manner as well. Imagine that this line is parallel to HP and it is making an angle of say 30 degree with VP which is the final angle. Now, we have to move this line in such a way that it now makes an angle additionally 45 degree to HP as well and how do we do that? In that case we will move it in not like this, but we will move it in such a manner that the distance this point has from the XY continuous to remain the same.

So, we move it to like this. So, if you essentially see we are moving if it is inclined to one plane and we want to incline it to the other plane we are moving it in a cone like manner. So, what happens with the cone? So, let us understand this with the help of a cone. It is actually the angle the movement is like that of a cone. So, suppose there was a line which was making an angle of say 45 degrees and now it has to make an angle of 45 degree with VP as well.

We will only raise it in such a manner that it starts to make an angle which is like a cone. So, we were moving it. So, what happens with the cone? There is this cone the point is fixed at its apex of this line which is the generator and now if we were to move this in such a manner that the distance remains the same from this. So, we will move it in a conical manner and in a line which is inclined to both the planes it is essentially that we have two cones.

One which has its axis parallel to VP and in the other case it will have its axis parallel to HP and in that case when we make these two cones the lines where both these cones intersect is the actual line which is being depicted in this question say it is inclined to VP at 45 degrees and 30 degrees to HP. We assume that there are two cones one with 45 degree angle solid cones and the other one with a 30 degree angle and then these cones intersects.

So, just imagine that there is a cone kept like this and the other one is kept like this and wherever these cones intersect is the line which is in question that is what the concept of doubly inclined line is. Now, as I had explained earlier also if the line is inclined to a particular plane we will not be seeing its true length or the true angle in that plane. The true angle and true length can only be seen if the line is parallel to a certain plane which means when the line is inclined to both the planes we will not be seeing the true angle.

And the true length of the line in either of the planes the final projections. So, we will have to start from a hypothetical situation just as I explained that it will be considered to be inclined to one plane and parallel to the other and then move on to incorporate the conditions that are given. So, it is a multistep problem when we try to solve it and we have to do it step by step only in order to arrive at the final one. Let us see how do we do that, but before we do that let us assume a problem again.

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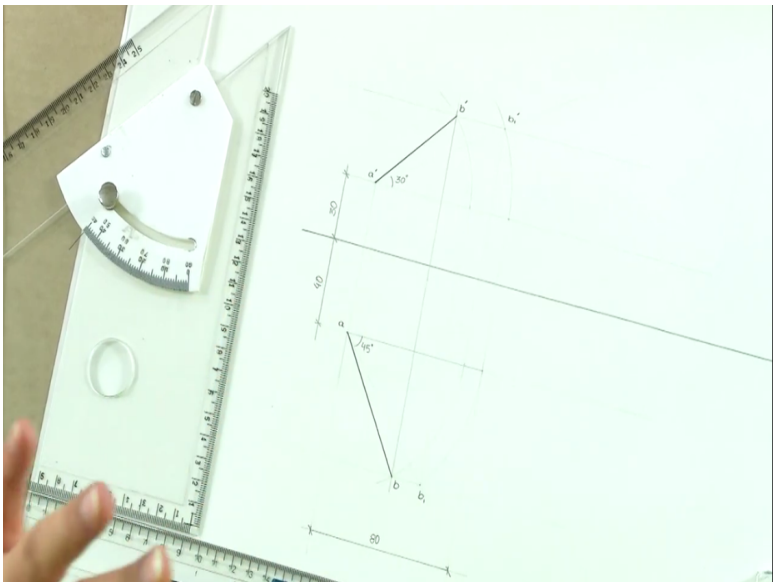

So, say we again have a line which has a length of 8 centimeters. Now it is making an angle of 30 degree with HP and an angle of 45 degree with VP and nearer point to reference line is 3 centimeter above HP and 4 centimeter in front of VP. This is what the given condition is. Let us see how do we draw the final projections of this line which is inclined to both the planes.

So, we start drawing the projections of this line which is doubly inclined or inclined to both the planes and just as we do we will draw a reference line. Now this is 3 centimeters above HP. So, we will make a line 3 centimeter above HP and 4 centimeters in front of VP so 4 centimeters in front of VP and we draw imaginary lines. Now, assuming that we had a line which was parallel to both the planes and it was 3 centimeters above HP and 4 centimeters in front of VP.

What would we get? We would get this line which is 8 centimeters long and is parallel to both the planes. So, these are the two lines which are going to be considered when the line is to start with parallel to both the planes. Now, let us incline this line at an angle of 30 degree with HP. So, when the line makes an angle of 30 degree with HP it will be seen in the elevation or in VP.

So, we make this line at 30 degree to HP and we make another line which is at 45 degree to VP. So, we make this line which is at 45 degree to VP. So, this is how the line will be moved assuming that when it is inclined to one of the planes it is remaining parallel to the other plane. In that case this is how the lines would look like. We are drawing it simultaneously, but this is not how it is going to be seen because if you take the projections up like this.

You will see that it does not match with the projection of this line here. So, it is absolutely not possible. These lines always have to have the same projections. Now, if you remember when I was explaining to you the movement of the line we said that if it is inclined to one line and it is inclined to the other plane as well. This is how in a conical manner this is how the line will move.

And similarly if it was inclined to say HP at an angle of 30 degrees to make it at an angle of say 45 degree with VP. We will have to incline it in a conical manner such that the top point maintains its distance from the horizontal plane and the vertical plane. So, what it means is as we move it the locus of this point will be along this path which is actually circular, but it will be seen as a straight line because it is a cone it is a base of the cone.

And similarly here it will be making a cone here which is represented by this straight line. Now, what do we do? We take the projection of this top view the inclined line on to the front elevation and we can also do the reverse, we can take the projection of the front elevation on to the top view and see where it intersects. So, I am doing simultaneous drawing, but if you see this is the point.

And this is the point here which ideally should match in a straight line because now here what we have done we have taken the projection of this line which was inclined at HP to a

locus to a line apart which is obtained by inclining that same line at 45 degree to VP or we could do it in the reverse manner. And what we would get if we have drawn it correctly we would get the projections in the same line.

And so the final line that we get here as a result this line this is the top view and this line here is the front view. So, this is the top view, this is the front view and if you can see clearly I will slightly darken the projections for you. This projection that we are getting here we got it both ways. We could have done it like this or we could have done it the reverse way. In both the cases the projections for both these lines should have matched and they are matching.

So, that is the beauty of this graphics and these are the projections of doubly inclined lines. Now, we have to see how do we label it? So, we start with the labeling here. We have this point a and we have this point a dash because it does not change. The final one in the plan is the point b and the final one in the elevation is b dash. Prior to that, what we got was this line b 1 dash which we drew before we arrived at b dash.

And we had a line b 1 which we arrived before we arrived at the final projection. Now, we had certain condition which is what we have to represent here. So, what did we have? We had a line of length 8 centimeters. Now where are we seeing this line of length 8 centimeters? We are seeing it parallel to both the planes which was our first condition. So, this line which we are seeing here is a line which is parallel to both the planes.

And hence it would be of length 8 centimeters or 80 mm. So, we will represent this dimension 80 mm here. This is 80 mm for this parallel line which we assumed in the beginning. The next thing is it is making an angle of 30 degree with HP. Now, we clearly know that this angle of 30 degree has to be shown in VP assuming that this was parallel to VP.

So, this is the angle 30 degree which it made with HP and the angle that it makes with VP will be seen in the top view which is 45 degree here. And also we have this 3 centimeter above HP and 4 centimeters in front of VP so we will make this. So, this is what we have, we

have 3 centimeters above HP which is seen here in VP and we have 4 centimeters in front of VP so which is seen here.

This is the final projection for doubly inclined line. Now you can see very clearly that the actual angle of 30 degree is not the same angle that we see in the final projection this angle has changed and similarly this angle has changed from 45 to something else. We cannot determine that angle before we draw it we cannot do that. However, once we have drawn it we can determine it or we can measure it, but there is no way to calculate it unless we do a detailed mathematical calculation.

So, this is how we would be drawing the doubly inclined lines. Now, what happens suppose we are given the trace of these lines assuming. So, the true length of the line is given may be and then the traces are given. We might be required to determine the actual angles, what are the actual angles at which the line is inclined that is another problem. So, it could be the reverse calculation of it.

In that case what we would given is what is the trace? So, we might be given the horizontal trace and the vertical trace of the line which is inclined at certain angle and in addition to that we might be given the angles that the projections make. In that case the same process will be done, but in a reverse manner. So, what we would do here is we will draw the traces at the given angles say alpha and beta and then draw the locus of it.

And then we will draw the true length of the line if the true length of the line is given to us we will draw the true length of the line in both the places and then we will calculate the true angle of the line that it makes with VP and HP. So, that is what we can do in order to calculate in reverse the angles that the lines make. So, where would this be necessary? Sometimes you would find that these lines are not necessary, but the direct use of this one is when you calculate the shadow angles when you are studying climatology.

In that case, this light source the angles which we are seeing here and inclined to both the planes is the angle that the light rays, the sun rays are making with the horizontal as well as vertical. And in that case how do you design your shading devices and how the shadows will

be calculated will be determined based upon how you arrive at the projections of doubly inclined lines here. It is exactly the similar principle.

Now one very interesting case in doubly inclined lines could be when the line is inclined to both the planes, but it is perpendicular it is contained in a plane which is perpendicular to both the planes. To explain this, just imagine that we have a line which is contained in a plane which is perpendicular to both these planes. So, what we have here is something like this. So, we have a plane we have a horizontal plane and we have a vertical plane.

And the line which is inclined to both the planes is contained in a plane which is perpendicular. So, this plane say the set square is perpendicular to both HP and it is perpendicular to both VP. So, this is the plane. Now, if I have a line which is inclined to both HP as well as VP. So, whatever that line is if it makes an angle with HP and VP both the sum total of the angle that it makes with HP and VP will remain 90 degree.

Now how do we draw that? How do we draw this kind of projection? We could start by doing this as well. However, that would not be the right way or it might be difficult to draw. The easier way to draw is since this plane is perpendicular we can assume that the line is contained in this and we can start by drawing the true projections of this line in this inclined plane and then comeback to draw or we could also start also from here.

So, assuming that we have a line which is inclined to both HP and VP at 45 degree. Let us see what happens? So, in this case 2 instead of these two conditions let us assume that this line is inclined to both the planes at 45 degrees and it is contained in a plane which is perpendicular to both HP and VP. Ideally, we know that the final projections that we would achieve is going to be a straight line in VP as well as in HP.

Let us start to draw this given condition where the line is inclined at both 45 degrees to both the planes.

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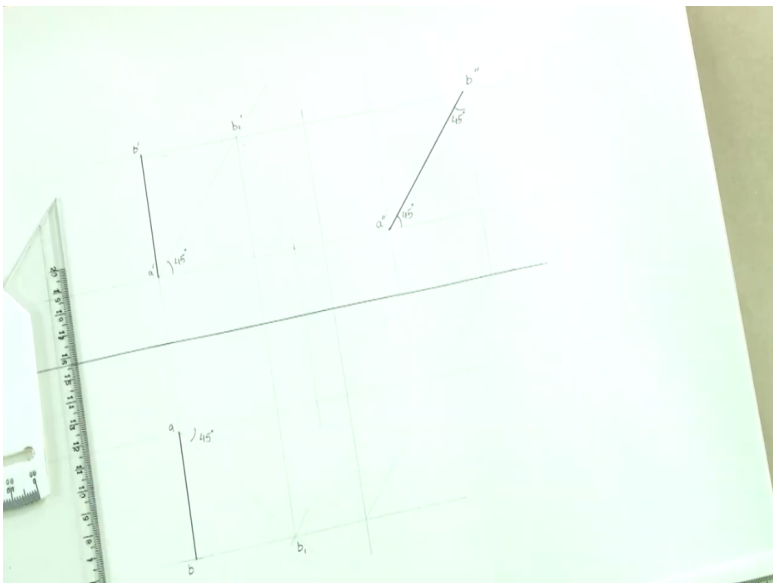

So, we will start with the same thing and everything else remains the same. So, let us quickly draw and start from how we did how we proceeded previously? So, we will draw this line of 8 centimeters assuming that initially it is parallel to both the planes. So, this is the line. Now, we have to incline it to both the planes at 45 assuming that it is parallel to one plane and at 45 degrees to the other we will draw these lines at 45 degrees.

Then we mark the length of 8 centimeters along this inclined line at 45 degrees and then we will draw the locus of this point in each of the planes. That is how this is going to be and then we will take the projections. Now, what is happening in this case is since it is inclined at 45 degree the projection of this would remain the same, but this is actually not the projection. So, we will take the projection of this one.

And then take it to the line of locus. now it touches it does not intersect, it just touches. So, what we are getting if you see clearly what we are getting is that the projection of this line when it goes and meets the locus it actually becomes a straight line. This is where we are getting the plane intersecting. So, this is the line that we get and this is the line that we get which is exactly how it should have been because this line is contained in the plane which is perpendicular to both HP as well as VP.

So, ideally we should have had these lines and that is what we have got. So, if you have the correct drawing, if your geometrical construction is flawless and we do not make mistakes

you should ideally be getting that solution. So, that is what we have got here. This is again we will start giving the nomenclature here and we will do rest of the writing, the labeling just as we did for the previous case.

So, we have done exactly the same thing here and now let us see what we get in the side view if we project it without anything. Now we have these projections and let us take these projections on to the side plane. Now, let us match the projections for both the points. So, this is a and this is the point which we get for a this is b and this is the projection for the point b. So, what we get actually is if I place my 45-45 set square here.

So, if you can very clearly see that I get a line which is inclined at both 45 degrees to HP and 45 degrees to VP and it is perpendicular to both the planes and parallel it is contained in a plane which is parallel to the side plane which is what exactly we have got. So, we got this 45 degree, but actually 45 degree this angle is the true angle and which will be seen in the side view.

So, we have here is a double dash b double dash and this is the point where we can mention that this is 45 degrees and this is also 45 degrees. So, one is the angle that it makes with HP and the other one is the angle that it makes with VP because it is the same. So, this is where it makes this angle with VP that is how that is the beauty of this geometric construction and it does not go wrong because we have just followed the process.

You saw that I could have started with this where we saw that this is the side view and then it comes back and this is what we are going to get. We could have done it the other way which might have been easier. This one requires a meticulous geometric construction to arrive at this where there is no flaw and if there is no flaw you will ultimately get this whether you start from here and come back here or you start from here and come back there.

Here we can again mention 45 degrees here because we started with this. If we are starting with that we could have mentioned it there either ways it is right it is going to be right. So, I hope with this you have clearly understand how to draw doubly inclined lines the special case of doubly inclined lines. Now it could be try for yourself instead of taking 45-45 you may try

to take something else say try taking 30-60 in the same case where it is contained in this plane and it is making an angle of 30 with HP and 60 with VP and then see what happens.

So, try doing the special cases and also these cases where you have the line inclined to both the lines and see whether you get at that whether you get the same projection line for both the projections. If you have understood it clearly, you will always get these projection lines matching. Always keep this in mind that the projection lines for a point should remain or they should match throughout the drawing.

There should not be any ambiguity if it is a the projection of a will all match in either of the planes not just in HP and VP, but also in the side planes and then you can appropriately label it, it is as simple as that. So, I hope you have understood the projection of doubly inclined lines up till here. So, thank you very much for being with me. We will see you in the next lecture tomorrow. Thank you.