Engineering/Architectural Graphics - Part 1
Orthographic Projection
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Lecture - 30
Projection of Spheres

Good morning, welcome to the last lecture of this Week 6 of the ongoing online course on architectural graphics or engineering graphics. And in this week, we have been discussing about how to draw orthographic projections of solids? So, we started from simple solids and then we finally moved on to more complicated solids that is the complicated position. So, the solid was inclined to both the reference planes.

Now, one solid which we have not discussed at all is a sphere. So, sphere how do we draw projections of a sphere? And, what would the projections of sphere in combination with other objects look like? So, though the projection of sphere is very simple because whenever you will look at the sphere it will always appear to be a simple circle wherever you look at it from. You look at it from top or front or side or auxiliary plane.

Wherever you look at it, it will appear as a circle. But the only problem is when it is in conjunction with couple of other solids. So, let us try to understand how the sphere will look? And, how will you draw the projections of these spheres? **(Video Starts: 01:42)** So, if we look at this sphere from top anywhere it appears as a circle. But what if we are placing this sphere along with this pyramid such that this sphere touches the pyramid, one of the surfaces of the pyramid? Now, where will the circle where will the center of the sphere be?

We will see it from the top but where will it touch? Where will it? It is not intersecting. So, where exactly is it going to touch? It is unlike a prism where the prism was going to be perpendicular. So, we knew that the tangent to this diameter of the sphere is where we will see. You know we can know where the center of the sphere will be. But the moment we have an inclined surface beneath it, we have a trouble. How to locate the center of the sphere?

Or, assume that there is another sphere if it is of the same uniform radius as that of the first sphere then there is not much of a problem. What happens if there is a bigger sphere? How do we draw? Where do we locate the center? Because drawing circles is not difficult at all but locating the center of the sphere is a tricky thing. That is what we have to learn. And that is what we are going to learn here.

And for understanding, where the center for this sphere is going to be located, our previous knowledge of orthographic projections will come handy. So, it will again be where what is the line which is parallel to one of the reference planes. And that is where the true length the distance between 2 centers, centers of 2 spheres will be seen in its true length. That is where we will start with. And that is how we will start to draw the projections of spheres.

So, let us quickly look at some of the examples and try to locate the centers of the spheres. **(Video Ends: 03:46) (Video Starts: 03:47)** So, let us start by drawing the projections of simple sphere. Here I am assuming that the sphere has a radius of 3 centimeters. So, let us assume the first condition that the sphere is kept on the HP and it has its center 5 centimeter in front of VP. So, very simple, what you will do? We will draw.

We will locate the center of the circle. So, it is 5 centimeters in front of VP. And it is resting on the HP. So, what we have? We have this sphere a simple circle which will be drawn. This is the top view. And since it is resting on the ground, the ground is tangential to the sphere. So, this is the front view very simple. Now, I have. I say I have another sphere of exactly the same size which is kept touching this first sphere such that the line between the 2 centers is parallel to both HP and VP.

Now, what would we draw? So, it is a line which is parallel to both HP and VP which is connecting the centers. So, a line which is both parallel to HP and VP is represented as this. And both these spheres they touch. So, the other sphere is tangential to the previous sphere. So, what we draw what we get is 2 spheres just touching each other. So, this is the line between these 2 spheres, centers of these 2 spheres.

And we will take the center to the top and in horizontal. So, what we are locating is actually the center of the sphere. All the time you will be attempting to locate the center of the sphere. So, these are 2 spheres which are kept in a linear fashion and they are kept on the ground. Now, assume that I have to add a third sphere. I have to add a third sphere in such a manner that it touches both these circles.

So, I have to place a circle here. Now, what happens? In this case, what will happen is that the center of another sphere, so assume that we have to move because if there is another sphere of the same size then it can move around this in such a manner that the point of these 2 circles they remain touching. So, what we have? We have a path along which another circle will be moving. And similarly, we will have assuming this circle moves and this stays.

So, we will again have this path for the center of another circle. So, this is the new center which we are getting. And what we have is this point as the center. So, it is actually not the tangent here. But what you will see is that we get the tangents to this circle to these 2 existing circles somewhere here. So, what we have is we actually have a triangle, an equilateral triangle formed between the 3 centers. That is what we are seeing in the top view.

That is these 3 circles. Now, where is the third circle? It is right in front of these 2 circles. Or, if it was at the back then this would have gone at the back. And we will and it is at the same height because these 3 spheres are of the same height. And what we have is we will just take it perpendicular. It is right in the center. And taking this one as the center, we will draw another circle. Since, I am drawing on the existing drawing I am not making a new drawing.

That is why our hidden lines are actually currently depicted as the solid lines. However, if you knew already that there are 3 spheres and that is how they are going to be placed, we would know that anything which is behind this front circle is going to be hidden. So, these 2 curves representing these this portion behind this is actually going to be hidden. So, that is how. So, it could be any arrangement of spheres which are of the same size.

Now, what if I keep another circle on top of this on top of these 3 circles? So, what happens actually if you look at it in the plan is we will have to locate the center. Now, the center for the fourth circle will actually be at the center of this equilateral triangle. But at what height because we know that this is going to be depressed in the center and the circle is going to rest.

So, if you look at this. suppose there was the center of the first circle was a, the center of the second circle was b and center of the third circle was c and there was this point d which is actually the center of the fourth circle which is going to be at some height. So, what we see? That this da, db and this dc. What is the true length of this line any of these 3 lines da, db and dc? It is actually twice the radius of this sphere.

Because if you look at this distance between a and b it is twice the radius, between b and c it is twice the radius, between a and c it is twice the radius. Or, it is actually the sum of radius 1 and radius 2. In this case, since it is equal sized sphere we will have it to twice the radius. So, this da is also twice the radius. But unfortunately, we will not be able to see this da in its true shape because it is making an angle with both HP as well as VP.

And similarly this db is also making an angle with HP and VP both. The only line which is this dc it is making an angle with both HP and VP. But we have the side plane to which it is going to be perpendicular. So, all we have to do is we have to take this line dc on the onto the side plane. So, just like we did earlier we will project it onto the side plane. So, what we have is that a, b and c are all lying at this.

So, this is the point where both the centers a and b will be. This is the point where this c will be. And we know the true distance between c and d which is twice the radius of these 2 circles. So, what we will now do is and we know that this d is lying on this vertical line. So, we need know the distance between c and d which is what this distance is because this line c and d is parallel to the side plane. So, we have now got this point d in height.

And, what we will do? We will not make spheres here. We will just take it to the VP. And from here we know that d is going to lie here. So, if you match the orthographic projections this is the point d. And now if I have to draw this sphere since I know the circle here the center here. So, what I will do? I will actually take the same radius and I will draw this another sphere.

However, a part of the sphere is going to be hidden between the other 3 spheres. So, we will only see this darkened portion outside. And this portion which has actually gone behind is the hidden portion. Here you might be getting confused because we did not make these lines as hidden. But I just wanted to explain to you how this point will be arrived. And again in the top view, we will keep the center.

And make a sphere which is assumed to be resting on top of these 3 spheres. So, this is how we will determine the location of the center. And with the help of the centers, we will be able to draw the spheres anywhere. Now, let us take an example where there are 2 unequal spheres. So, let us have the first sphere as the small sphere. So, this is the first sphere which is having a radius of 2 centimeters.

So, that is the smaller sphere assuming it to be the smaller sphere. Now, we have a bigger sphere. We have a bigger sphere which is kept in the same line as this. So, the line which is connecting these 2 spheres is actually parallel to VP. But it will not remain parallel to HP. Because the bigger sphere the center of it will lie slightly higher. So, what we will do? We will make again and we are assuming that both these spheres are resting on the ground.

So, if we draw this smaller sphere first we could start from any of the spheres. So, this is the smaller sphere. Now, if we have a bigger sphere which is kept right beside it. It will not be touching the smaller sphere. Both the spheres will not be touching at the point which divides the sphere into 2 hemispheres. So, we know that. Now, assuming that the bigger sphere actually has a radius of 3 centimeters, so what we will have?

We will have the center of the bigger sphere passing through a line which is at 3 centimeters above the ground. So, we know that the center of the bigger sphere is definitely lying somewhere here. Now, what is the distance between the centers of smaller sphere and bigger sphere? If this radius is 2 centimeter and that of bigger sphere is 3 centimeters then the total distance between the 2 is 5 centimeters.

We do not know where. We just know that it is somewhere on this line. So, all we have to do is we will measure a distance of 5 centimeters. And this center is fixed. We will have a line cutting. So, this is 2 and 3 So, this we have the smaller sphere. We have taken to be mistakenly as 3 centimeters. So, let us assume that the bigger sphere is 4 centimeters which is what we have taken here. So, the total is going to be 7 centimeters. 3 plus 4 is 7 centimeters.

Keeping this here and marking a 7 centimeter cut on this line. We know that the bigger sphere is here. And this line we assumed the given condition is that the line joining the 2 centers is parallel to the VP. So, this is going to remain straight while the line joining the 2 centers will not be straight anymore. So, this line is making certain angle with the HP. And now, we will have we will take the 4 centimeter in the compass with this as the center.

So, these 2 spheres there will be this bigger sphere which will be touching the smaller sphere. Connected like this. And if we see in the top view we know that the line connecting these 2 centers is parallel to VP. So, what we have is there is one bigger sphere and there is one smaller sphere. And we know how to locate their centers. This was a case where this line was parallel to one of the planes and inclined to another plane.

Automatically it will get inclined to the other plane. What if the line is say perpendicular? What if there is another sphere which is kept somewhere here? So, we have another sphere which is kept here somewhere. And in the front view, all that you would be seeing is that there is a circle. So, there is a circle which is right in front of the bigger sphere. So, there is a smaller sphere which is right in front of the bigger sphere.

But in plan exactly where would it be? So, it will actually go in slightly, but how much? Will again be seen in the side view. Because, if you look at this, the other center of this sphere will be somewhere here. We may be seeing it in the side view. Or, what we can also do is since we already had a sphere now since there was not much difference between the radii of these 2 spheres the bigger one and the smaller one.

We saw that it did not actually overlap that much. However, if we had a much smaller sphere we could have. So, now what we do? We have the same a smaller sphere here because it is exactly the same size of sphere. And we will make another sphere in the front of this bigger sphere which is what we are seeing in the elevation. Now, what if we have another very small sphere say of the radius is just 1 centimeters? So, what we will have?

And it is again on the same line. So, what we will do? We will have this line passing through at a height of 1 centimeter from the ground. But, since we know that all these 3 spheres are falling in the same line which is parallel to VP, so, we know that this will be somewhere here. Now, the center the radius of this bigger sphere is 4 centimeters plus 1 5 centimeters. So, we will have and this will be the distance of the line joining the 2 centers.

So, we will take a distance of say 5 centimeters. Take this as the center. And we will mark here. Now, this is the point where the center of the smaller sphere is going to be. And taking a radius of 1 centimeter and this as the center, we will now draw the smaller sphere. So, this is the smallest view a very small sphere which we will be seeing in the elevation as this. So, what we actually have is these straight lines which are joining the centers.

Now, this line again is parallel to VP. So, what we have? We will bring it back onto the same line. And what you actually see is that this is the center of this very small sphere. And keeping this as the center, if I draw the small sphere we will hardly be seeing this sphere here. It has actually gone inside or beneath the bigger sphere. So, that is how we're going to make the spheres.

So, we have we can actually have any combination of spheres of different sizes of same sizes. The only thing that we have to do is we have to locate the center of the sphere both in elevation and in plan and then accordingly make. Sometimes, the spheres will overlap. Sometimes, they will just touch and they will be visible throughout. For example, in this case, they are almost visible. However, in this case, it is almost gone inside.

Other interesting way, other interesting condition would be where we have say, a cone. So, if we have a regular cone or a pyramid. In that case, we will have to assume or we will have to first make the circle such that the face of the pyramid is tangential. So, for example, if I have to make a cone, so, if to this circle we had a cone which was tangential to this sphere. However, if the condition given was reverse.

So, we if we first had to draw the cone and then take then draw the sphere. So, suppose this was the cone a very sharp angled cone. And for this, we had to make a sphere. So, what we would do in that case is we will actually be taking a line at the same height as that of radius in the cone. And then we will actually be drawing a circle at this given distance from this. So, we will be making a perpendicular from this.

And take a sphere which is just touching. So, if you look at it from the top, this is a cone. What do we see here is the cone again may be having its center here and the radius of the cone the base of the cone. So, we will actually be seeing the cone partially. So, this is a cone a circular cone. And it has been taken over by the sphere partially because this sphere is overlapping this surface of the cone. So, what we see?

That the part of cone has gone beneath the sphere. So, though it is all it also appears as a circle part of it has overlapped. We could draw. If I want to draw another circle another sphere which is on this side then what we have to do? We have to take a perpendicular. And we know that this circle is going to lie somewhere here on this line this sphere which is this. So, what we have is that from this cone this surface we will have a sphere lying somewhere here.

So, we will make a perpendicular to this tangent. So, we have this. So, then we will draw a tangent which will be perpendicular in such a manner that we still have the same radius of sphere available to us. So, we will draw. We will mark the center of this sphere. And we will draw the sphere which will be touching the surface of the cone which will be touching the ground. And this is what the another sphere would be.

We will again locate the center of this and draw it in the plan. So, what you see in the plan is that this sphere again overlaps the cone. So, we will actually not see this part of the cone again. And similarly, you could be making the combination of spheres with any solid for that matter. The only thing, always remember the only thing that we have to keep in mind is where is the center of this sphere.

And always remember that the sphere will be using one of the surfaces, surface of the cone or whatever solid as a tangential surface. So, whenever we make, we will have to take the perpendicular bisectors. So, this was one tangent. So, we could take perpendicular bisector of this. And we could take perpendicular of this. And wherever they would meet is the sphere which we are going to get.

So, this is how you will be able to locate the centers and draw any combination of spheres. So, this is with this we complete the orthographic projections of spheres in this week. **(Video Ends: 31:58)** In the next week, we will be moving on to sections of solids. So, not necessary that the solids will always be used in their full form. Most often they are truncated. They are cut by certain planes. And that is how machines are designed.

So, what happens? How do we see? What do we see? What will be the actual shape of the section? What happens if a pyramid is cut? What happens if a prism is cut? And, how do we locate these various points on the sections of solids? So, this is what we are going to be seeing in the next week which will be the seventh week of this course. So, I am hoping that you are following the orthographic projection properly.

And in case, you have queries, you can always write to us. We will be continuously reverting responding back to your queries. And continue to stay with us. So, thank you for watching this lecture with me. See you again in the next week, bye, bye.