Engineering/Architectural Graphics – Part 1
Orthographic Projection

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Lecture – 39
Intersection of Surfaces - I

Good morning, welcome to the second last lecture of this course, which is on engineering graphics or architectural graphics and we are in the last week of this course. So, by this time, we have covered almost the entire series of problems for orthographic projections. We have learned how to draw orthographic projections of points, lines, planes, solids and then we also went on to discuss about sections of solids.

Then we have also seen how to develop the surfaces of these solids which are either regular in shape or may also be cut. So, this we have already covered and prior to that, we had the introductory part for this course, where we looked at what are the tools to be used, what is the basic geometrical construction technique. So, all that we have already finished. Now, one topic which is left and which is of common use in engineering and architectural practice is intersection of surfaces.

So, so far, what we have done is; they have understood what if a cylinder is cut by a slant plane, which well might be a case if you are designing a machine or some part of you know a piece of furniture around you or anything like that, but, we know for all practical reasons, this part will never be alone. There will be another part which will be intersecting it, which will be welded with it, which will be glued with it and how do we draw them together.

So, we have to develop the drawings for both of them and we also have to develop the surfaces. So, right now, what we are going to look at in these last 2 lectures is intersection of these 2 surfaces. And the most relatable, the closest of the problems that you will encounter in the practical world is how the ducts will be designed and how they will be joined together, how the sheets will be unfolded, how will you design the junction.

So, one of such problems, we have already looked at when we looked at the development of surfaces. So, we were trying to join a square section pipe with a circular section pipe and how the intersection, how the joining piece would be designed. There could be a variety of such problems and few of them, we will look here. How the intersection of these surfaces will happen? So, to begin with, let us start with very simple solids.

So, let us assume that there is a rectangular prism which is intersected by a circular cylinder or right angled cylinder which is cutting its axis perpendicular. So, in such a manner that the axis of these 2 solids, they are intersecting. **(Video Starts: 03:23)** So, assuming that we have a rectangular prism with us, which is kept like this on the ground and it is intercepted by a cylinder or circular cylinder, perpendicular to its axis.

And that is how, so, it will pass through it and it will actually be (()) (03:42) penetrating this prism. So, if we have to draw this **(Video Ends: 03:46)**, this is a very simple position. So, we are going to start with that and then further we will see how do we arrive at the more complicated ones.

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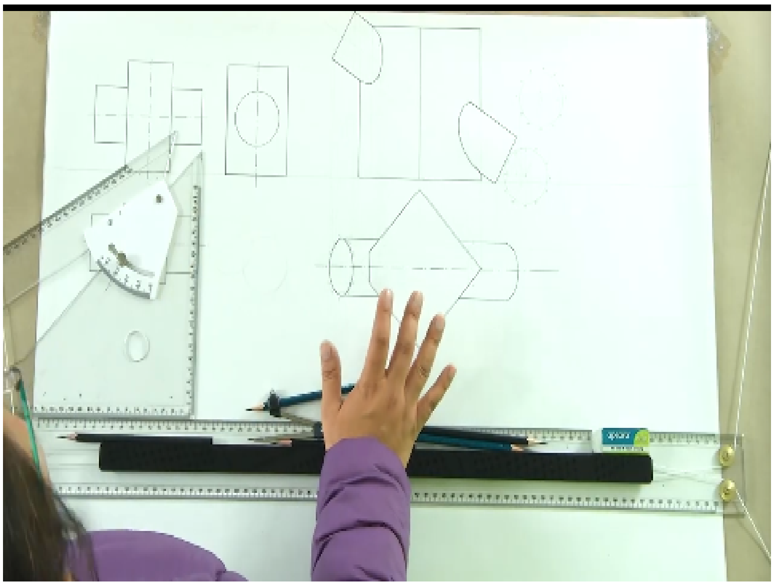

So, it says that it is a rectangular prism which is kept on ground. So, if we look at this prism in isolation and we forget about the cylinder, what do we see? We actually see the base, the size of the base. So, here I am assuming that this base is 7 by 5, 7 centimetres by 5 centimetres of a rectangle. So, we just draw this rectangular base and the axis for this rectangle is going to pass vertically through this point. So, that is what where we will see the axis.

Now, it says that the axis of the other circular cylinder is being intersected by the axis of this rectangular prism. So, these 2 axes are passing through and through and let us assume that the cylinder which is intersecting it, the prism is of radius a 2.5 centimetres. So, just making a reference image here, which is the base of the cylinder which is intersecting. When we see it from the top, what do we see?

We will see that this cylinder is passing through it. So, given the total length of the cylinder, so, let us assume that the total length of the cylinder is say, 12 centimetres. So, this is the total length of the cylinder and if you see it from the top, we will only be seeing a rectangle, because, now, the fundamentals of our orthographic projections for solids will remain the same.

So, what we are assuming right now is that there is a rectangular prism which is kept on the ground in such a way that its axis is perpendicular to HP and its faces are parallel to its faces are parallel to the VP. So, this is what we going to see. While this other cylinder, a circular cylinder which is intersecting it, it has his axis parallel to both HP and VP. So, they will not be able to see the base of this cylinder.

Now, we see it in the front, what do we see? We will be seeing the cylinder where the axis is parallel, so, we will still be seeing a rectangular shape for the cylinder and for the prism, we will be seeing the front face of the prism which is parallel to VP. So, assuming that the height of this prism is 10 centimetres. So, this is the height of the prism which is what it is and this is where your access is coming. So, this is the place where access is coming.

Now, this access, we are assuming that it is cut in the centre. So, this is the place where the access is going to be cut. Now, the same because it is a circular cylinder. So, we will be seeing exactly the same profile here or what we could do, we could also take it to the side plane, which we also know as profile plane now. So, we may also take it up. So, this is what we are going to be seeing here and you could also be taking the circle.

So, we could be drawing the circle again using the centre or we could just directly be drawing the circle using its dimensions the same dimension, but ideally we should be projecting it all the time. And then we just have to draw these lines which are passing now. If I back on it, so, what would we see? We will see the prism with smaller face of here. We will assume that the smaller face is being parallel to VP. So, this is what we see here. This is the prism.

This is the circular cylinder which is passing through this prism. So, here we draw this circular cylinder. In top, so I will also make the axes as we see. So, this axis, we are seeing being perpendicular to HP and parallel to VP that is for the prism. I would advice that you should make the axis all the time because making the axes, drawing the axis helps you understand how the solids are being placed.

Then in the top view, we will be seeing the base of the prism and we will again be seeing the cylinder exactly the same as we saw in the front view. So, this is what we see in the top view. Now, here we are not seeing the axis of prism, but we will be seeing the axis of the cylinder because it is parallel to both HP and VP. So, this is what we see and if we have to make the side elevation, then we will just take these forward and project them onto our side view.

So, the side view of this same would be where the base of the cylinder would be seen. So, that is how our side view will look for this simple intersection. Now, this is the simplest case, because the circular cylinder is actually being cut by a plane, which is the surface of this prism. So, this circle circular cylinder is cut and hence, we will actually be seeing the circle here.

There is no change in the original shape of this the cylinder, the base remains the same. So, it is a simple case. The only thing we have to remember is where the axes are intersecting and how they are intersecting. So, this was a simple case, which we started with. This is the axis of prism. And that is what we get when these (()) (12:28) 2 will intersect that is how the drawings would be orthographic projection drawings would be.

Now, imagine that if this instead of this rectangular prism, we had a square prism Okay. A square prism which is kept which is intercepted by this circular cylinder in such a manner that it is passing through one of its corners. It is entering the square prism from one of its corners and exiting through the other and in an inclined axis. Now, let us see what happens that what I mean to say is.

(Video Starts: 13:10) If we have this square prism here, so, we have the square prism. So, assume that it has a longer height and it is kept in the base and now, we have a cylinder. So, earlier, we just had a flat face and the base being parallel to each other. Now, we have it entering like this and not just this; it is inclined. So, this cylinder is inclined it enters and it exits. So, how would we get the projections? **(Video Starts: 13:44)**

So, we have to draw the projections of such a case. Now, assuming only one solid at a time, so, what we will do? We will start with say the square prism. Square prism is assumed to be kept diagonally to the VP. So, the axis is perpendicular to HP, parallel to VP and the base is put diagonally. So, we will make that first drawing first. So, let us assume that it is a 10 centimetre square pyramid which is kept diagonally.

So, this is what the square base is going to be and is kept vertically. So, we see it like this. Now, it says that the cylinder enters one of the corners. So, it enters diagonally; it exists diagonally. How long we are not sure as of now? The only thing that we know is that the axis of the square prism passes through this point and the axis of the cylinder which is intersecting will appear. So, it is actually parallel to the VP, but it is inclined to HP.

So, what we will see? Since, it is parallel to VP, we will be seeing a straight line for axis here, which is what it is and assuming that we have the same size of circular cylinder passing through the square prism. We will just draw a reference here since it is parallel to VP. We will be seeing a rectangular shape passing through this. So, what we have is we have this circular cylinder passing through this.

Now, right now, it is assumed to be parallel to both HP and VP. So, it is appearing as a straight rectangle that I am not drawing the ends as of now, because it is actually not parallel and we will draw it once we draw the VP, so, the front view. So, now, we taking it up, taking the height say 14 centimetres here. So, what we are taking is that this axis of the cylinder is parallel to VP and it is inclined to HP.

Assuming that it is inclined say at 45 degrees to HP or maybe. We taking here it is inclined at 30 degrees to HP. So, what we have here is that the axis would something be like this. It will be passing through the prism like this. So, this is the axis which is what we see. And if we see it from the front, we will actually see the same size of the circle. So, if I just draw a reference circle somewhere just this is just for reference.

So, this is just a reference circle that we are not drawing it for the final. Now, if I draw this, this is the rectangular. This is the circular cylinder which is passing through this rectangular prism. So, what we have actually is and if I just assume that this is cut, I am just taking. So, if it is cut like this here and here. So, what we can see that there is this prism, which is cut by a circular cylinder in this manner.

So, what we will see? We will again get back. So, we can have the same 12 divisions for the same circle. We can use those divisions to get it back onto the HP. So, we will draw these divisions here first. So, this is one of the most trusted ways of projecting your circles. So, now what we have is we have the circular base and we will develop its generators just as we do.

So, these are the projectors for all those 12 different points. So, this is how the 12 points on the surface of the cylinder are going to look like and now, we have to project them back on to the top view. So, what we know is where each of these points is getting cut. So, this is the circle. And if I were to make it initially parallel originally here and then rotate it, so, we will also get the same 12 points in the bottom.

So, what we were having originally was a line like this and these 12 points coming and the same were being projected back. So, originally it was like this. So, let us make another circle for a better reference here. So, what we have is that this point remains the same and all other points are rotating about the centre, which is where the axis has rotated itself. So, this is where if we were just having it originally parallel to this, this is the point where the centre would be and then we can have the original 12 points for the circle.

This is where the circle originally was, which has now rotated like this. So, we have inclined this entire cylinder like this. So, have you 12 points in place? Now, why are we required to draw these 12 points is to get their horizontal projections in the plane. So, if we bring it back here, so we will be seeing where, so this is the horizontal projection and if we have to take it to the from the top here, we will be seeing it horizontal projections.

So, what we have is, if we see it from the top, we have another circle here and the 12 projection points, which are seen here. So, this is actually the side view. And if we get it again here, this is where all these points are going to come. So, these are the 12 points. And if I just take it back on to, set this as 45 degrees and this is where each of this point is going to come. So, we know that this point is where our so, I will just draw these lines here.

So, that is how each of these points is going to come when we see it from the top that is in original position and this. Now, let us match up the points. I lightly numbered them here. So, what we had was 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12. And now, when we rotated, we had the same points here 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12. So, let us get back the projectors. So, what we have?

For 1, we have it here and it comes here which is the centre line. Again, for 2 so, it is here and the one is actually coming to be here too and then let us bring it back from the top for all the points. So, this is the point which is 4 and if you look at this 4 here, this is where we will get 4, 3, 2, 1 and 5. So, this is the point where you get your 5, 6, 7, 8, 9 that is 9, 10, 11 and 12. So, this is exactly the ellipse that we should have seen from the top, because the surface is inclined this entire cylinder is inclined.

So, this is the elliptical shape. We were to get which is what we have seen here. In the bottom, we will not be seeing because this is where it will come. So, only half of the ellipse will be seen, but not the full ellipse. So, what we see here is again? So, these are the 2 points and then the remaining points, only half the ellipse will be visible on the other end. So, we know that this is how it is going to look like.

And from the top since it is a perpendicular surface, we will be seeing that this cylinder which is here it is getting cut by a perpendicular surface. So, not just one perpendicular surface, but it is actually getting cut by 4 perpendicular surfaces. So, the prism remains the same and the cylinder is actually getting cut, but what we do not know is how will it look here so, which is what we have to again take back.

So, let us get back these numbers, the same numbers and I will just mark these points. So, what we actually have is, if you look at this, this is the line where no one is going to come and in horizontal again, this is the point where one is coming so, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12. And now, we will again take it back. So, this is where 7 is getting intercepted. So, If I take it back up, this is where 7 is getting intercepted.

At this point which is 6 and so, this is where the next one comes. And this is the point where the fourth point along these lines will come. 7, 8, 9 and 10 is how we are going to get 7, 8, 9 and 10. So, this is how we will see it from the front. This is how it is going to get cut and then we will move back to get the other points. So, that is going to be at the back however, the same points will then repeat on the. So, we will get these points.

So, this is how the circle will actually get cut by the square pyramidal face sorry square prismatic face that is how the circle is, cylinder is getting inside because it has a slant face it is not a perpendicular parallel to VP face, it is a slant face. So, this is what we would see emerging out of the prism. So, what we see in this case is a part of the cylinder which is coming out of this prism. The rest of the prism remains the same.

Now, we have to visualise it and we know that this surface is inclined which is cutting the cylinder. The other half of the cylinder is not visible, but this is how we will be seeing it which is what we have derived. Now, ideally yes, we should have a good imagination, but even if we do not have it, if you follow the procedure as I repeatedly say, we would be able to get the same result.

So, now, we will take the same thing here. We will again see how these points are getting cut. So, what we have is 1, 2, 3, so, here, the cylinder was actually directly getting cut. So, this is where we were getting the last point which is the line. Now, if I draw this and if you see it from the top, this is the line where the cylinder since it is a horizontal surface. It will be seen cutting into the square prism.

So, we will have one corner of the prism cutting and cylinder entering and you join these points. You get this curvilinear surface here. This is ellipse at the end of the cylinder which we will get and this side, we will only see half of the curvilinear surface of the cylinder. So, if I see this, this is where the prism is going to come, so, in this manner. So, if you look at this, now, there was an abrupt end to these 2 points which was on the top.

So, which is what we got here, otherwise, we should have actually got the point somewhere here. So, now since it was cutting it, it was abrupt and that is why we got a straight line and from the rest of the elliptical the curvilinear surface would start. So, that is how the cylinder would look when we see it from the top and when we see it from the front that is how the orthographic projection of this intersection is going to come.

So, what we are going to actually do when we are drawing this intersection of surfaces is assume if the solid was kept in simple positions, so, parallel to both the reference planes or parallel to one and perpendicular to the other. So, which is what we had done just assuming it that it was parallel since it was simple, we just had to incline it, we just needed these horizontal projections and then this vertical projections back. This is what we are doing and getting the projections in place for any solid for that matter if it was a circular solid.

So, instead of a square prism, if we had a circular cylinder, in that case, what we would also have is instead of these 4 edges, which are here, we would have again these 12 points and wherever the generators of both will intersect would have determine how these cylinders are going to intersect that is how we would have done in case this was a cylinder. Either ways, what we have to keep in mind that the projectors?

So, if the projector of 4 is here, it has to match with the projector of 4 horizontally. We cannot have the projector row of 4 will have to meet up in the projector of 4 in the top view. The projectors, whether they are coming from vertical plane or horizontal plane, will result in a point only when they intersect. So, keeping this fundamental in mind, this is how we will draw intersection of surfaces.

Today, we have taken for prisms. Tomorrow, in tomorrow's lecture, we would look at conical surfaces and intersection of 2 cylinders together so, that you have a fair idea of how to draw intersection of surfaces. So, thank you very much for being with me here today. See you again tomorrow. Till then, bye, bye.