Engineering/Architectural Graphics - Part 1
Orthographic Projection
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Lecture – 31
Orthographic Projections
Introduction to Sections of Solids

Good morning, welcome to the Week 7 of this ongoing online course on engineering or architectural graphics. And in this course, we are discussing about the orthographic projections. So, up till this week, we have already covered the orthographic projections of solids. So, we started with the orthographic projections of points and then we moved on to lines. From there we started talking about orthographic projections of planes. And then finally we moved on to solids.

So, we saw the different projections of solids in simple positions in inclined positions and in oblique positions where the solid or the plane was inclined to both the reference planes. Now, with this, we have fairly covered a large part of orthographic projections. Now, one thing which is left and which is very important also is what if the solid is cut?

So, so far we have been discussing about the regular solids, which is how which is what we learned to draw and then placing them in various positions. What if this solid is cut? What will we see? What will be the cut section looking like? Because most of the times many a times in architecture and engineering we use these shapes in multiple different ways. We have sometimes multiple number of solids intersecting. Sometimes they are kept on top of each other or they are adjacent to each other. Sometimes they are just chiseled, cut, to arrive at different beautiful forms. Now, in order to do that we have to understand what happens when a solid is cut or when what do we see as a section of the solid. This is what we are going to start learning in this entire week. And today the very first lecture we will just be understanding the introduction of section of solids.

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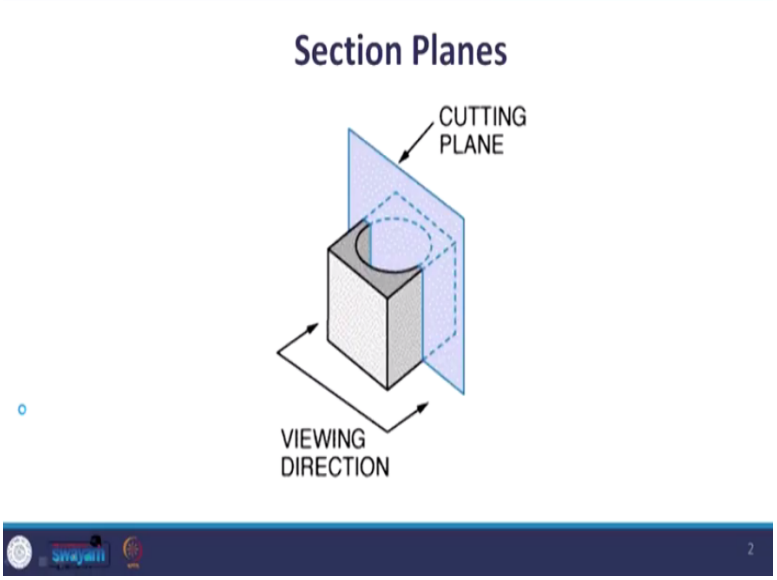

So, before I start, how do we look at the section of solids? We should first know what how will the section be cut? And, what will be the plane which will be cutting it? So, to explain that let me take an example of a solid here. **(Video Starts: 02:44)** For example, this is a cylinder a simple right angled cylinder. Now, what happens when this cylinder is cut by a plane which is perpendicular to this cylinder?

Now, the plane which will be cutting, for example, if this is the plane. If this plane is cutting the cylinder in such a manner that it stays perpendicular. So, this perpendicular plane will be cutting the cylinder like this. This plane which is cutting the solid is called a section plane. And, what do we see? What will we see? When the solid is cut by through this section plane depends upon where we are viewing this from.

For example, if I am holding the cylinder like this and we are assuming that it is cut by a section plane which was perpendicular to the cylinder. There are 2 halves of it. What do you see? If you are seeing it right from there the camera is right in front of this solid, what do you see? You just see a half of the circle. You will see a rectangle. However, if you were seeing it from this side, so, if I rotate it like this, you see another cylinder which is equal to the width of this is equal to the diameter of the circle.

What will I see if I am holding the cylinder like this and the section plane was cutting it like this? In that case, we will be seeing a semicircle and a section plane will be below it. Or, if I

do it like this and we are seeing it from the top then we see a complete rectangle. And from the side, we will see a semicircle. So, what do we see depends upon the viewing direction? So, there are 2 things important.

One, how the plane is how the solid is being cut through the section plane? So, the relative position of section plane and the solid. So, section plane is perpendicular. Section plane is inclined. Section plane is horizontal. How is the section plane being kept in relation with the solid? That is the first thing. The second thing is from where are we viewing the section which is cut?

So, if we viewing it from the side from top from front, where are we viewing it from? So, that will determine how will the object look like? And that is equally important. There is one more thing which is important is how is the solid kept? Now, in this case, where we are looking at the cylinder whether the solid is kept like this even if the section was perpendicular to its base?

So, if this section if the solid is kept like this, this, inclined, inclined to HP, inclined to VP, how is the solid kept will also determine what do we see as section of the solid or a solid which has been cut? **(Video Ends: 05:58)** Now, besides this, there is one more thing which is the shape of the solid. Different types of solids when cut will be viewed as different shapes. And each type of solid will have different arrangement.

For example, when we started drawing orthographic projections of pyramids versus orthographic projections of prisms, there was a very clear difference. That all the prisms we will see when we are drawing the projections we will see the triangles coming. So, every time we drew the pyramids we saw triangles coming except for the base shape. While when we were drawing the prisms we will always see the rectangles coming.

However, the solid may be placed we will be seeing rectangles which may be skewed and the base shape. So, that is what the difference was between prism and pyramid. Similar is the difference here. So, if we have a prism and it is cut by a section we will be seeing different

shapes. And similarly when we are seeing the pyramids and they are cut we will be seeing different shapes. That difference is fundamental.

And we have to understand that before we start to learn to draw orthographic projections of sections of solids. Another thing which is also important is sometimes, **(Video Starts: 07:25)** for example, if we have a pyramid like this. So, this is an octagonal pyramid. Now, here there is a section plane like this which is inclined to this pyramid. And it has cut the pyramid in an inclined manner.

So, if I remove this portion of this solid, what do I see? From the front probably you are just seeing the straight line because the section plane was perpendicular to the VP. However, if I look at it from the top or if I make it like this you can see that you can see an odd shape the it is essentially an octagon but an irregular octagon. But this is still when you see it from the front or top. This is still not the true shape.

But if we look at it right perpendicular to this shape to this face we will probably be seeing the true shape of the section. Now, why would a true shape of the section be needed? This may be needed in case of machines. So, if a block is being cut. So, if there is a section of a block and another part of the machinery has to fit into it, we have to know the true shape of the section. What will be the size of it? How will the other side of the machine fit into it?

So, we need to know the true shape of the section. **(Video Ends: 08:47)** And always the true shape of the section will be seen in a plane which is this plane which is parallel to this section plane.

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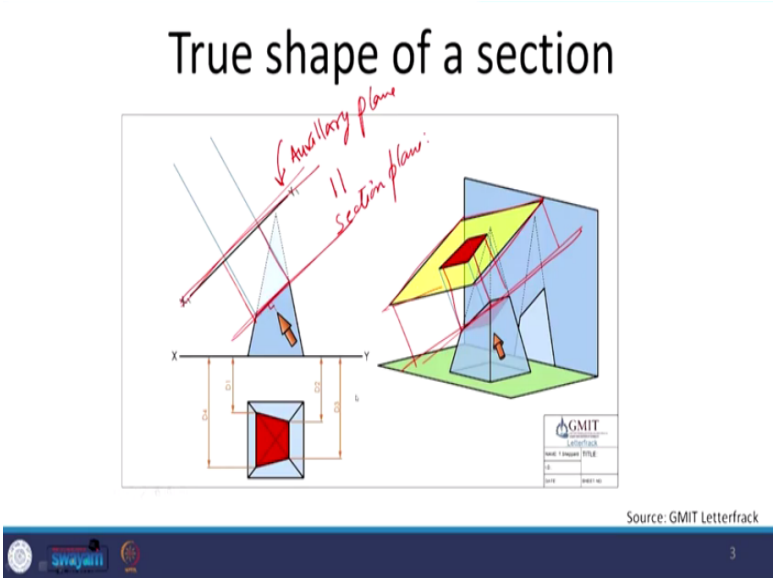

So, when we have a plane and the section is projected onto this plane which is parallel to this plane of section or section plane which is what is evident from here. We have a projection plane which is parallel to this section plane. We will see the true shape of the section. If you recall, this will be the auxiliary plane here.

So, the true shape of the section will be projected on an auxiliary plane parallel to the section plane. Now, where do we draw auxiliary plane? Will depend upon the position of the section plane. To which plane it is perpendicular? To which plane it is inclined? We will gradually see in upcoming lectures, how to draw the true shape of the section along with the section of the solid? So, there are different solids. We have already learnt about different types of solids.

Here, I am going to take the most common types of solids. And we will understand how the sections of these solids will go? Now, before we do that, before we go on to understand the section of these solids **(Video Starts: 10:24)** different types of solids. We also have to understand there are multiple positions of section planes. So, we can assume that the section plane is perpendicular to both the planes both the reference planes.

So, it will be cutting. For example, we have this solid. So, if we have this solid kept assuming there is a reference plane perpendicular reference plane, a vertical plane here and a horizontal plane here. This section plane could be perpendicular to both the planes. In this case, we will

be seeing the true shape in the side view. It could be that the section plane is perpendicular to HP but parallel to VP. In that case, the true shape of the section will be seen in the VP.

We could also have that the section plane is parallel to HP and perpendicular to VP. In this case, we will be seeing it seeing the true shape of the section in HP because it is parallel to HP. There could also be a possibility that the section plane is inclined to HP but it is perpendicular to VP. So, we could be having a plane which is inclined to HP and perpendicular to VP.

In that case, we will not be able to see the true shape of the section in either of the reference planes even the side plane. What will we see? The true dimension of this entire length will be seen in VP because it is perpendicular. So, this length which is seen here is actually the true length of this section. However, the true shape of the section will actually be seen in a plane which is parallel to this section plane.

So, there will be an auxiliary plane parallel to this section plane where we will be seeing the true shape of the section. So, the section plane could be inclined to HP and perpendicular to VP or it could be inclined to VP and perpendicular to HP. In that case also a similar condition will be arrived. So, these are 4 different positions **(Video Ends: 12:44)** in which a section plane could cut a solid. And the solid could be assumed to be placed in any position.

It could be inclined to the reference planes. It could be kept straight in simple positions. It could be inclined to both, whatever could be the condition. So, let us start looking at the sections of prisms here.

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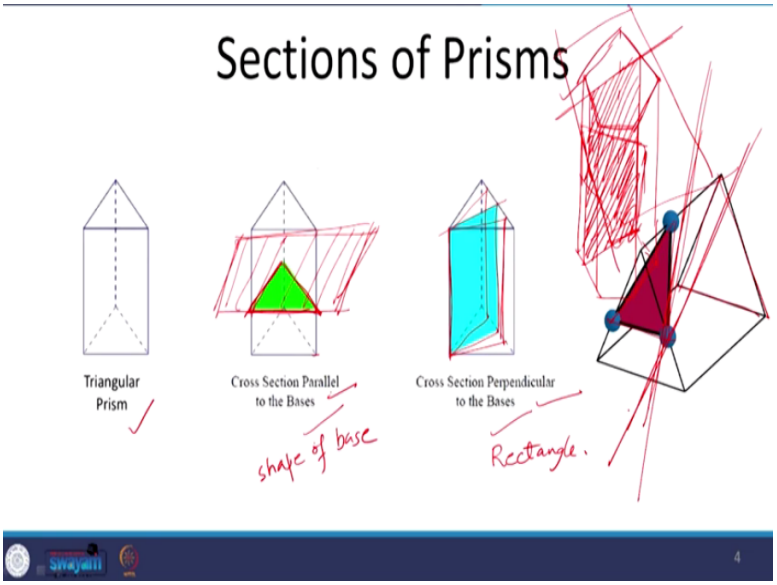

Now, what happens? In this example, we have taken the example of a triangular prism which is one of the most common prisms. So, this is the triangular prism which we are considering. Now, what happens if the section plane is parallel to one of the bases? In that case, the cross section will exactly be the same as the base. So, when the section is being cut through a plane which is parallel to the bases.

We will get the same shape of the section as that of the base. If the plane is perpendicular to the base then we will always get a rectangle wherever it cuts from. So, it could also be like this. In that case also we would have got a rectangle. It could be anything if it is perpendicular to the base. We will be getting rectangular sections. That is for prisms. Now, it could be triangular prism.

It could be hexagonal prism, pentagonal prism whatever it is. For example, we have suppose we have a pentagonal prism and it has been cut by a section plane which is perpendicular to the base like this. In this case also what we see as a section is a rectangle. So, in all the prisms, when a section plane cuts the solid in such a way that it is perpendicular to the base we will get a rectangle.

And when it is parallel to the base, we will get the same shape of the base. So, these are the 2 conditions, parallel to the base and perpendicular to the base. Parallel to the base, shape of base will be seen. And perpendicular to the base, we will see a rectangle in the section. There

is another condition where if the plane is inclined to the prism. In that case, it will depend that where the plane is cutting it from.

So, if the plane in most likely cases in most of the cases we will get a distorted shape of the base. So, in this case, since it is inclined and it is a triangular prism, we will get a distorted triangle. So, it will be a triangle but different from that of the shape of the base. In case, it was a pentagon and if this was being cut like this. In that case, we would have seen the shape of a pentagon.

So, it will be the shape of a pentagon which will be coming here. And we will see a distorted pentagon coming as a section of the solid. So, in case, it is inclined we will actually be seeing the distorted shape of the base unless the section plane actually intersects through both the bases. If we are totally chiseling it off, in that case, we will see a different shape. If it is cutting only one of the bases and through the height of the prism then we will be seeing the shape of the base in a distorted manner.

But if it cuts through both the bases, in that case, we will be seeing a very different shape, altogether. So, for example, **(Video Starts: 17:21)** this is a prism we have. So, this one is an octagonal. This is an octagonal prism. What happens if a plane which is inclined to the base in inclined to this solid is cut? What do we see here is an octagon again. But this is a distorted octagon. However, I do not have an example a solid example.

However, if this section plane was cutting the solid in such a manner one of the bases was also cut. In that case, it is not necessary that we will get an octagon. We might be getting some different shape depending upon how the plane is going to cut this. This will essentially be because 2 sides may be added or reduced depending upon where it is it getting cut in the base. **(Video Ends: 18:23)** So, that is about the section of prisms.

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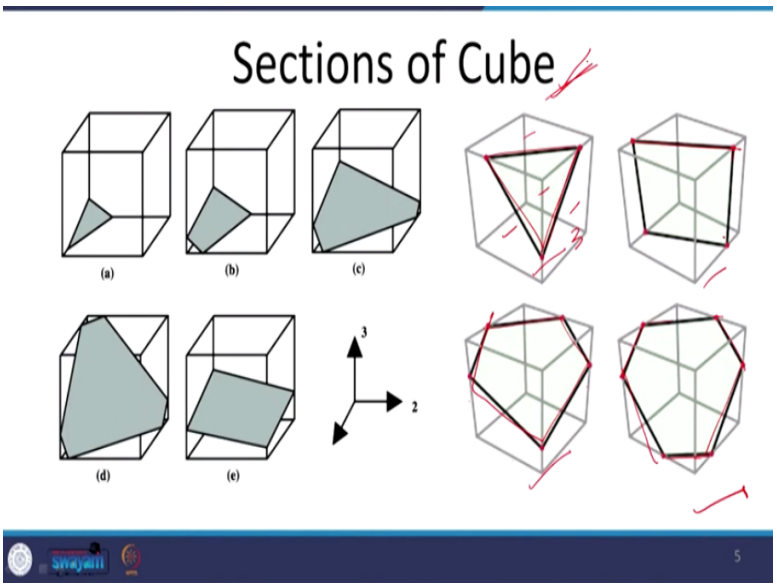

Next, we have section of a cube. Now, section of cube sometimes can be very tricky simply because it could be very simple as well as very tricky. Before we look at section of cube.

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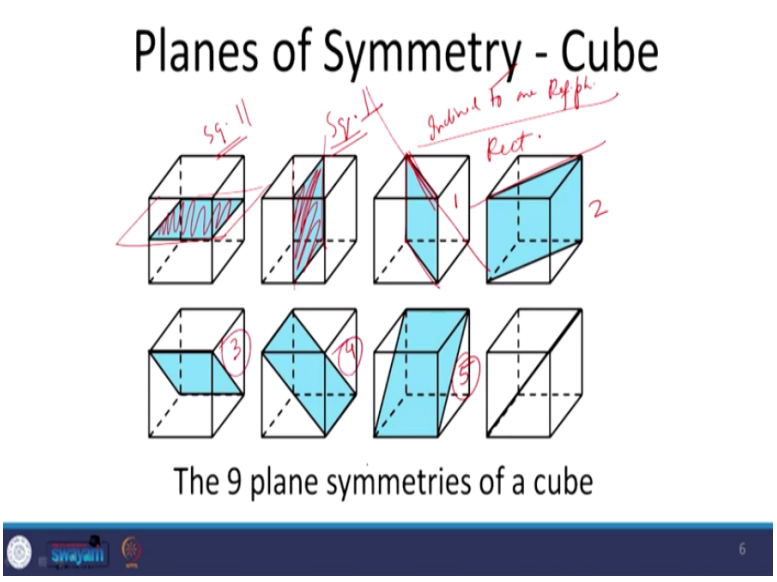

Let us look at these planes of symmetry of cube and which is how we will also get to understand the various sections in a cube. So, if the plane is parallel to the base, how the cube is going to be placed? In that case, we will see a square. If it is perpendicular then also we will see a square. If the plane is inclined but perpendicular to the base, if it is perpendicular to the base, we will be seeing the rectangles because this will be the length of a diagonal and the height of the cube.

So, we will get square here if it is parallel or perpendicular. In case of parallel and perpendicular, we will get squares. In case, it is inclined to one reference plane, we will get rectangles. So, all these, 1, 2, 3 and 4 are the variations of the same case where it is inclined to one of the reference planes and perpendicular to the other. In all these cases, and even 5, in 5, it is inclined to both the planes.

But essentially since cube is like it has perpendicular surfaces. All the surfaces are perpendicular to the adjacent surfaces. We will get rectangles in all these cases. So, it is simple. In case, the section plane is parallel to either of the planes of symmetry. But what happens if the plane is inclined to both the reference planes and that of the cube as well? In that case, we will get starting from where is it cut from.

So, if it is cut in such a manner that 3 surfaces of the cube are cut, we will get a triangle. In case, the 4 surfaces are being cut, we will actually get a rectangle. In case, the 5 surfaces are being cut we will actually get a pentagon and like that. So, here again, there are 6 surfaces which are cut. So, we are getting a hexagon but a distorted hexagon. That is how the square the section of a cube is going to be seen.

So, depending upon where the plane is passing if it is passing to through 3 surfaces, we see a triangle; 4 surfaces, we see a rectangle or a square depending upon how the plane is passing; 5, we see, 5 surfaces, we see a pentagon; 6 surfaces, we see a hexagon. This is what we are going to see when the cube is being cut. The section of cube is fairly simple it simply because it is equidistant and it is quite symmetrical as a solid itself.

So, the drawing of orthographic projections for sections of cube often becomes very simple unlike those of pyramids. So, pyramids which is the next solid that we are going to take.

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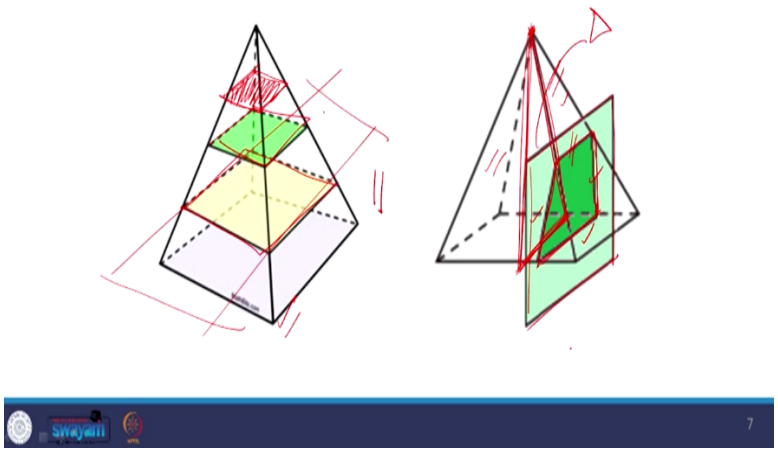

If I am going to explain to you the theory it appears very simple. But when we start drawing them then it becomes slightly trickier because we have to ascertain where that point exactly is going to be. So, if we have a pyramid and we are cutting this pyramid with a section plane which is parallel to the base. In that case, we will be seeing exactly similar shape as that of the base.

I am saying similar but depending upon where the section plane is passing through. It is cutting the solid the pyramid. The size of the section will be determined. As we go upwards towards the apex the size of the section of this solid it will get it will go on reducing. That is when it is parallel to the base. Now, if it is perpendicular to the base, what happens in that case? In case of a square pyramid, this is a square pyramid.

Just assume that if this was perpendicular like this. If it was perpendicular, what do you get? You get a triangle if it is passing through the apex. So, any pyramid it could be a square based pyramid, a pentagonal pyramid, hexagonal pyramid, any pyramid if the section plane is perpendicular to the base and passing through the apex, we will get a triangle for sure. However, if the section plane perpendicular to the base, and it is passing through any point other than the apex. In that case, we will get polygonal surfaces depending upon the number of triangular surfaces the prism is passing through. So, here we will have 1, 2, 3 and 4. 4 surfaces through which the section plane is passing, one is the base surface; one is this

triangular surface; other one is the surface back and here. So, 4 surfaces which means that we will get a quadrilateral. In case, we had a pentagonal prism.

And the section plane is passing through 4 surfaces we will get a quadrilateral. In case, it is passing through 5 surfaces, we will get a pentagon, a distorted pentagon and like that. So, this is how we will get the surfaces. In case, it is inclined.

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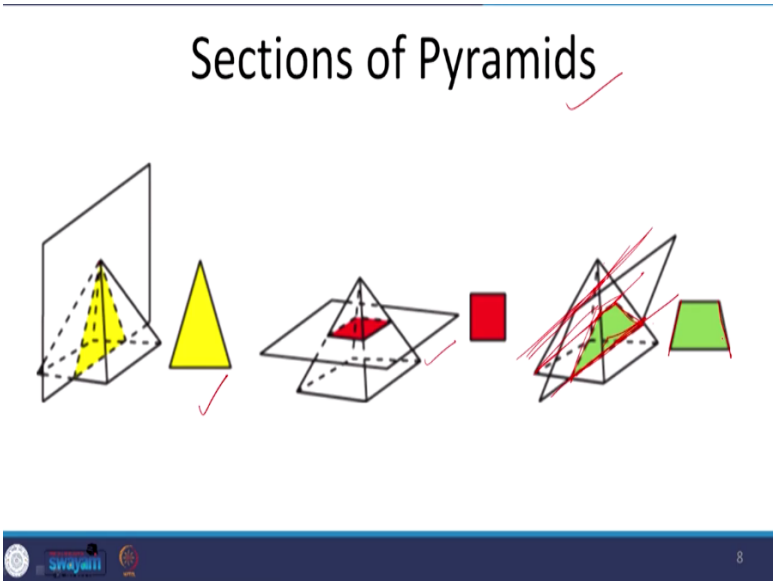

So, this is when it is parallel. This is when it is passing through the apex. In case, it is inclined. Again, how many surfaces are being cut will determine the shape of the final solid? In case, we are passing it through the top portion only, we will probably be, in this case, we are getting all the 4 surfaces cut again. So, we will get a quadrilateral, 4 sides. In case, it is passing through this corner. So, in that case, how many surfaces?

1, 2, 3 and 4, a quadrilateral again. We make it pass through this 1, 2, 3 and 4. So, we get a quadrilateral again. So, depending upon where this plane is passing through and how many surfaces are being cut in a pyramid, we will get this. However, the shape of it will be distorted. How do you determine that what is this angle? Where will you see it from? How will you draw the true shape of the section is something that we have to learn.

And that is what we will learn in subsequent lectures. How to draw the orthographic projections?

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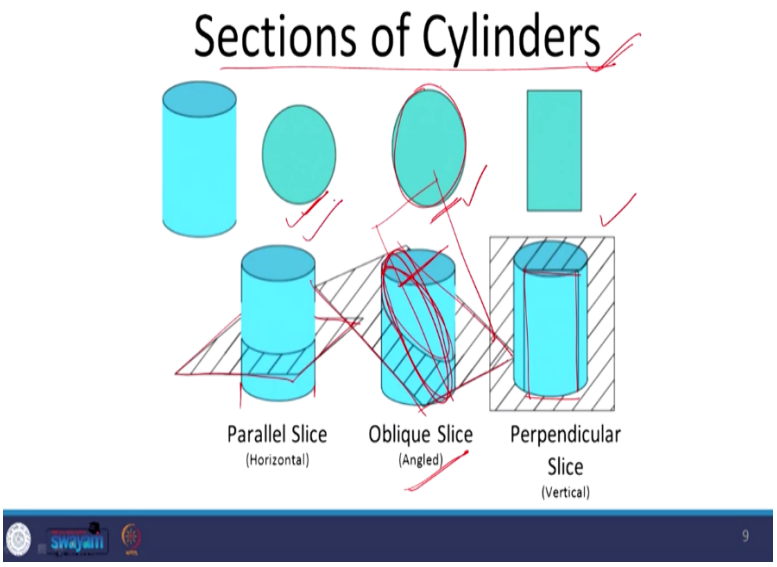

Now, the next solid is cylinders. And section of cylinders is fairly easy very easy rather. If we have the section plane parallel to the base of the cylinder, we get a circle of the same size as that of the cylinder. In case, it is inclined to one of the planes, we will get an ellipse. This is what we always get. And if it is perpendicular which is what we have seen, we will always get a rectangle. Cylinder is essentially a prism.

So, what we are getting is the same thing except when the inclined plane is passing through the base. If it is passing through the base, for example, in this case, this section plane **(Video Starts: 27:15)** if you can see this section plane is passing through the base. It is inclined and it is passing through both the bases. In that case, just see, what we get? This is part of the ellipse and here it is abruptly cut. So, we do not get a complete ellipse.

In this case, we get a distorted ellipse. It is not even an ellipse. It is suddenly truncated ellipse from the sides. This was dependent upon how the section plane passed. So, if you look at this, the section plane was passing through the top base and the bottom base both. So, we have both the top bases and the bottom bases being cut. And that is why this peculiar shape. In this case, this was perpendicular to the base. So, what we got was a simple rectangle.

That is how the section of cylinders are going to be. **(Video Ends: 28:18)** So, section of cylinders is fairly simple. But, how do we determine the shape of this ellipse? This ellipse

could range minimum from close to a circle to an ellipse which is as big as this. How do you determine what is the shape of the ellipse is the trick when we are drawing the sections of cylinders. And it is fairly simple once we start doing it. Then you will realize.

But you just have to remember that the oblique slice of a cylinder will always be an ellipse. And the perpendicular slice of a cylinder will always be a rectangle. And a parallel slice of a cylinder will always be a circle. If you have these concepts in your mind formed then it will be very easy for you to draw sections. And you will very rarely be going wrong. And side by side, you will also have to keep the fundamentals of orthographic projections in place.

That all the time, vertical and horizontal projections should meet and result in the final point of the projection. Then section of cones.

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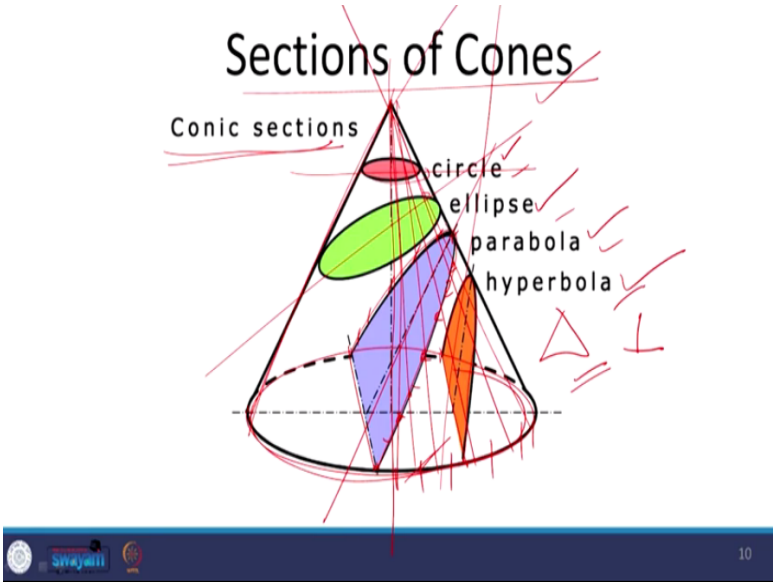

So, conic sections we have already covered as part of the basic geometrical construction. So, if the cone is cut by a section plane which is parallel to its base, we get a circle. If it is inclined in such a manner that it is not cutting its base, we will always get an ellipse. If it cuts in such a manner that the plane is parallel to its generator, we will get a parabola. So, this is the parabola.

And in case, we cut it in such a manner that it is the invert of the cone is also being cut by the same plane. In that case, the shape that we are going to get is a hyperbola. So, this is

something that we have already discussed. The only thing, what if it is cut in such a manner that it is absolutely perpendicular and passing through the apex? In that case, we will get a triangle. So, that is the only condition which we have not seen here.

So, in that case, we will get a triangle. In all other cases, either we will get a circle, an ellipse, a parabola or a hyperbola which is what the conic sections or sections of cones are. So, we have also discussed how to draw ellipse, circle, parabola and hyperbola? But, we did not see how to draw it in relation to the cone? If we know the cone as it is and then we draw. We cut it and then we are supposed to draw the sections.

In that case, it will become important for us to trace these points. How all these points are going to come? And every time I talk about cylinders or cones or as we had talked about circles. Just be sure that we are going to divide the circle or the cone along its periphery of the base in certain number of certain equal number of parts. And every time we draw this it will be the projection of these points.

So, if it is ellipse and then we have inclined, what happens? We have these 12 points, whatever number of points and these varying heights which will give us the shape of the ellipse and similarly in cone. So, if we have 12 equal parts or whatever number of equal parts and we make the generators like this. So, we will be getting varying heights along these generators. And that is what we will be getting.

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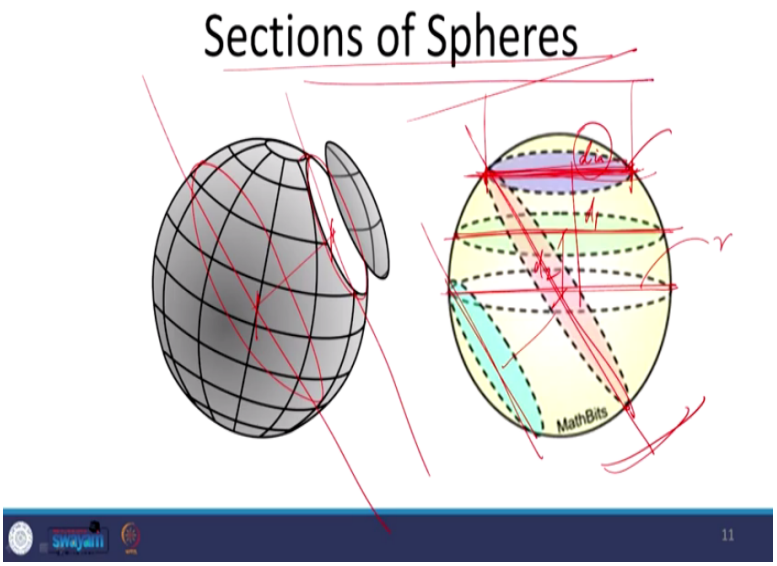

The last one is the section of spheres. Now, section of spheres wherever you cut it from it will actually be a circle. So, just as the projection orthographic projection of a sphere from wherever you look at it will always be a circle. Similarly, wherever you cut the sphere from it will be a circle. Now, why will it be a circle? Because anywhere wherever you cut, for example, if we are cutting it by a plane which is passing through this then it is parallel to a plane which is passing through its center.

And at the center, it is a perfect circle. So, this is also going to be the same shape similar shape but diminished in size depending upon what is the distance between these two planes. So, here if we are cutting it from the center, it is the circle of the same size radius r. If we cut it slightly above depending upon what this height is, we will get a reduced circle. Further up, we get further reduced circle inclined.

It is still parallel to this center the circle passing through the center. It is again a circle. So, wherever you cut the sphere from, wherever you pass the section plane from, it will still be a circle. So, that is the essence. Place it anyway place it anywhere it will be your circle. And it is very easy to draw also. Because if you have a plane. So, if you look at this plane, it is perpendicular in this current view assuming this is perpendicular to the VP.

So, what we see as this length is actually the diameter of the circle. So, what we see from the top is actually a circle with this diameter. Similarly, this is the diameter. This is the diameter.

This is the diameter. This is the diameter. So, this is how we will actually be drawing the sections of this sphere. With this I have already covered the introduction to the sections of solids.

And in the subsequent lectures, we will be learning to draw orthographic projections of the sections of solids. So, thank you very much for being with me here today. We will see you in the next lecture tomorrow where we will start to learn to draw orthographic projections of these sections of solids different types of solids one by one. So, thank you and bye, bye.