Engineering Graphics and Design
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Week 2: Graphical Representation
Types of Projections

Welcome back to this course of engineering graphics and design, we are on week 2 of graphical representations. Today we will be introducing a new concept called projections and especially in this lecture we will be looking at what are the different projection types which are possible.

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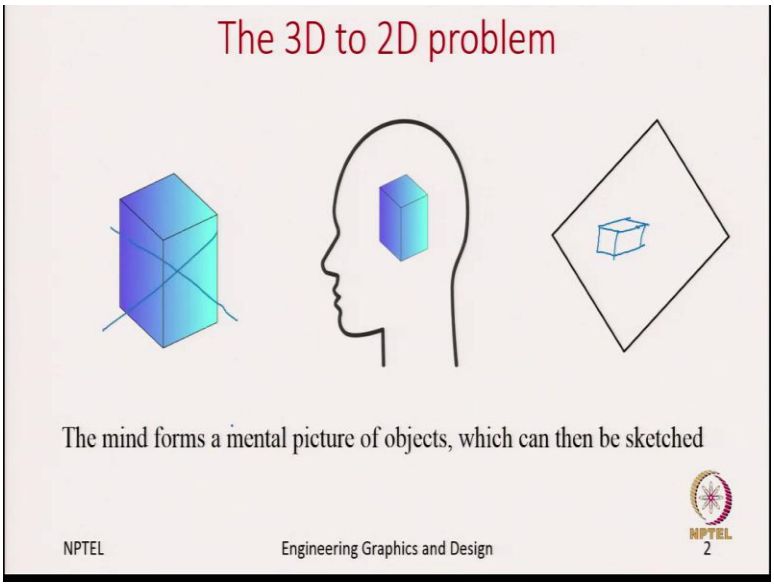

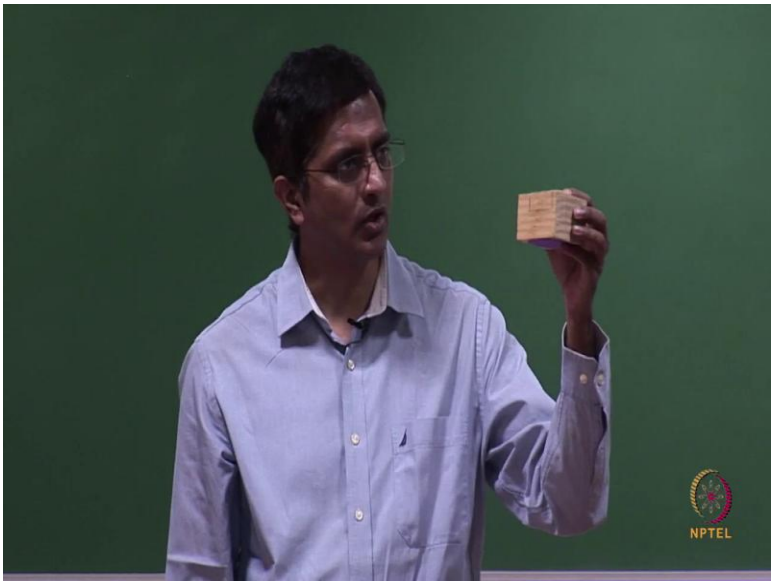

So, we start with solving a problem which is essential to draw make an engineering drawing, which is the 3D to 2D problem. Here, when we look at an object, we are looking this object in the 3D space, so, which means the object is a three-dimensional object. So, but we need to bring this object in three-dimensional space, and we want to draw it on a sheet of paper, which is a two-dimensional space, that is why we call that the object in 3D space, we need to move it into a 2D space, how do we do it?

So, when I look at the object, I make a mental picture of this object. And once I have this information, I need to process this information such that I represent this object on a paper where we can convey. So, for example, here maybe since this is a simple cube, one can depict the cube in this fashion, so what is interesting here is, the mind is so powerful that you really do not need to have an object. So, for example, if I do not even have this object, and the mind can picturize this object and then we should be able to draw it on a 2D sheet or the paper. So, let us see how to solve that 3D to 2D problems.

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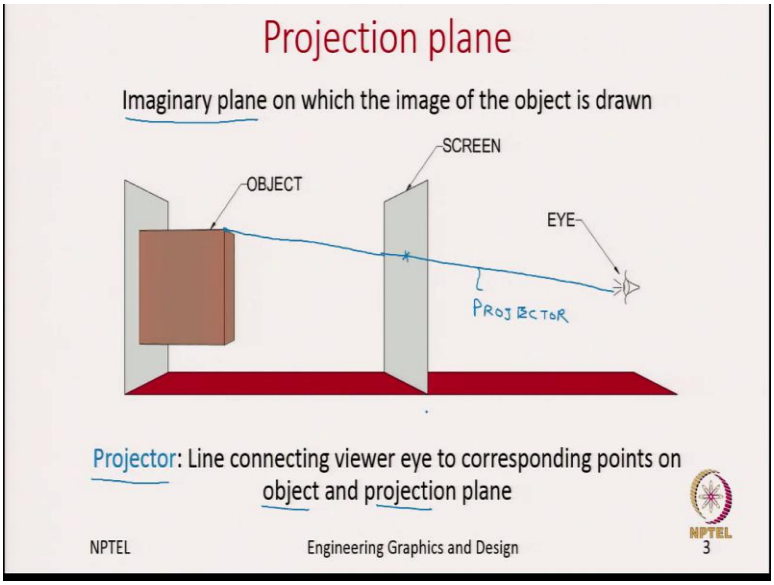

So, one way to solve that is to introduce a concept called as a projection plane, let us see what this is. So, now let us assume we have an object in 3D space and here is our observer, so let us say your eye are standing here in front of the object and looking at it. Now, what we do is we imagine a plane.

So, what we are doing? We are imagining a plane between the object and the observer. So, let us say this is the object and you are the observer, so between you and the object, we imagine a plane, let us say this is made up of glass such that when you look into the object you can still see the object. So, what we are defining is, this is the projection plane, which we call it as imaginary made up of glass, so when you see through this projection plane, you can see the object.

Now, the question is, let us say if you ask your friend to go and sketch on the imaginary plane just to make sure that you see the same thing with the object and without the object, so which means you are making a image of this object on this projection plane. So, this is a powerful concept, because as you will see to the rest of this lecture, we will use this concept to define or to make these projections of an object and there are many ways several ways of doing it, we look at what are the advantages and disadvantages of these methods.

And we will also look at the most common methods which professional engineering drawing experts use. So, here may not need to introduce a new terminology called a ‘projector’. So, what it is? It is a line connecting the viewer’s eye to the corresponding points on the object and projection plane. Let us, say we take a point on the object. And we draw a straight line

connecting this point to the observer. So, let us say this is a straight line I am drawing and connecting one point on the object to the eye or the observer.

So, this line will intersect this projection plane at a point let us say this is the point. So, essentially, what we are saying is this particular line which we are talking about is called the projector, so this terminology is important as we go along in this lecture. So, we have introduced this new terminology called the projector.

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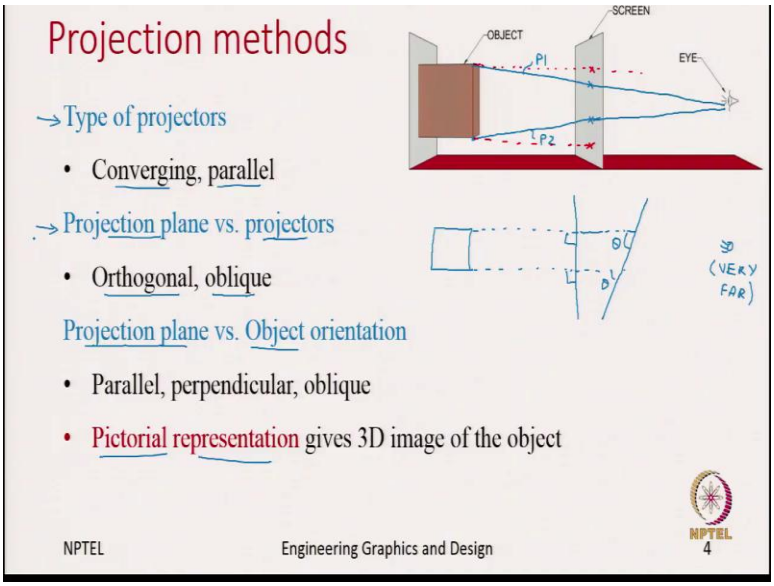

Let us, see what are the different possibilities we have, though at the first look it looks that we have only three things the object, eye or the observer and the imaginary plane, but there are numerous combinations we can think of, so let us look at three different categories one at a time, starting with type of projectors. So, there are two kinds, the converging and parallel. So, in this case let us say we are drawing one projector from object to the eye and let us say we have another point and then we draw another projectors from the point to the eye, we have two projectors.

Let us, say call this a projector one and projector two, the reason why we use projectors is to see where it intersects the projection plane, so these are the two points on the projection plane. But

the point I am trying to make here is, how does these two projectors look like? Are they parallel or converging? So, at least in this case they look converging. So, which means these projector lines are converging all to a single point.

The reason why they are converging to a single point is because the observer is close to the object. Now, let us assume that the observer is watching the object from very far distance, let us say, so in mathematical terms let us say he is looking from infinity, but in real terms let us say that he is looking from a far off distance, then how do these projector lines look like? So, let me use a different colour and these projector lines usually they look parallel because the observer is at a very far off distance and they intersect at two different points.

So, now what we see is depending on the position of the observer, you can either have the converging projector lines or the parallel projector lines. Now, let us look at a different category. So, here we are looking at projection plane versus the projectors. So, in other words we are looking at what angle does this projector makes when it intersects with the projection plane.

So, in these blue lines, what angles do they make? Do they make 90 degrees to the projection plane? As you can imagine they do not make 90-degree intersection instead, they make other than 90 degrees projections which we call it as ‘oblique projections’. But in these red lines, you see that let us say if you look the same in the top view, let us say we are looking things from the top, now what we see as the cube is a square and this is your projection plane, which will see it as a line.

And let us say we have an eye here, but from let me write it as very far, meaning that the observer is at infinity and the projection lines or the projectors are parallel. So, how do they look like? They look something like this. If the observer is looking straight ahead into the object, then these projector lines will make an angle of 90 degrees. So, when these are making 90 degrees, we call them orthogonal.

So again, depending on whether you are looking from close or far or how your projection plane is oriented, so there is no rule saying that you should always have the projection plane in this fashion maybe you can have a projection plane which is inclined and then what happens is if you extend these projectors, you will see they make an angle theta which is not 90 degrees.

So, there are multiple ways you need to define whether your projection plane is perpendicular to the projectors or at an angle to the projectors, depending on that again we have different kinds of projections. Another category is how you orient the projection plane and the object. Let us, say this is the object, you are looking from the front, so then what is happening, we said that we have a projection plane in between and if we are only focusing on the this face of the cube, then the projection plane and this face are parallel.

Let us, say now I rotate the cube, the same face which was initially parallel is now perpendicular, so which means what I have done, I have changed the orientation of the object and I am free to orient this object in any other fashion. For example, instead of either having it parallel to the projection plane or perpendicular to the projection plane I can have it at a arbitrary angle.

So, let us say hold it in this fashion, such that when you are looking at it, you will be able to look at three phases of this cube, one this face which has this yellow circle, and second and the third phase. So, actually this leads to something called as pictorial representations, pictorial representation means, if I orient this cube in this fashion, you can see the three-dimensional view of this object.

So, since you are able to look at three different faces, you can quickly understand how this object looks like, instead if I was like previously, if I was holding it in this fashion, you know how this front face looks like, but you have no clue about how the other features of this object looks like. But, the moment I oriented the object such that you can look at three different faces, now you get a better understanding of the object, this we call it as the ‘pictorial representation’.

So, what we are learned in this slide is to say that there are several ways we can do these projections, depending on how the projectors are, are they converging or parallel, that we call as depending on the type of the projector. Second, we said that, depending on the plane whether it is orthogonal or oblique to the projector rays.

And finally, we said the orientation of the object also defines what kind of projections we are doing. So, let us get started. As you can see, there are several possibilities, but we will be looking at four important projections which are commonly used in engineering drawings, we will start with the ‘perspective projections’.

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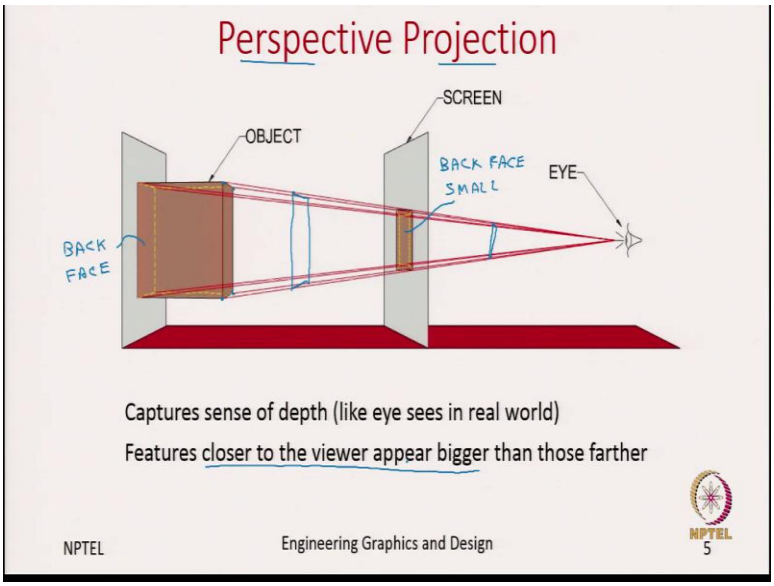

So, let us again have the same example where we have an object to the left, we have the observer at the other extreme and in between we have the projection plane. So, here we are thinking of the observer looking closer to the object, so the observer is in the proximity of the object and he is looking at it. So, the object is something like this.

So, you are looking into the object, so if you look something like this what would you see from the fronts face, since I say it is a cube, what you will see is a square. So, how do we construct that, so we take the four corners of the square and then draw the projectors, so once you draw the projectors, they will intersect with the projection plane.

So, these are the four projectors from the four corners of the front face of this cube. And depending on these, four projectors will make four intersection points on the projection plane and once you join them, this is the view you get off the front face of this cube. Now, let us try to understand a little more. Now, let us say if I move this projection plain closer to the observer, what happens to the size of this square? Will it be big or small?

As you will notice, the size of the square will be a little smaller. And now let us see the other extreme, when you move the projection plane closer to the object, if you are moving it closer to the object, you notice that the size of the square increases. So, which means you need to define where you are placing this projection plane, you cannot randomly pick the location of the projection plane, one needs to specify how far it is from the observer or how far it is from the object.

And now let us look at a different scenario where you are moving the object, let us say if you are moving the object far, so if you are moving the object farther from the observer or the projection plane, what happens to the size of this cube? Will it decrease or increase? Let us, look at it to answer that, let us focus on the back surface of this cube, back face let us say.

So, if you are looking at the back face of the cube and then draw the projection lines, so these yellow lines are dotted, because actually you cannot see these back face if I am holding the object like this, but let us say instead of wood it is made up of glass such that the object is transparent to light. And then you are able to look at the back face, now, let us say now I have painted the back face then even if it is transparent, you should be able to look at the back face.

So, these yellow lines are the dotted lines represent the hidden lines saying that there is a back face which you cannot see normally, but since you know that there is a back face you can show that through yellow lines. And if you look closely especially on the projection plane, we see that the new square is smaller. So, the back face is small.

So, what does this mean? Which means that objects which are closer to the observer appear big and the object which are farther from the observer, they appear small. In other words, for this example in hand, the front face looks big and the back face looks small on the projection plane. So, an interesting feature of this perspective projection is this is close to how you see in the real world, which can capture the sense of depth.

So, for example, if you are looking at me or when I am holding this object you know that this object is closer to you compared to the distance you have from me, because this you are able to know because your eyes looks at a perspective projection, it knows the sense of depth, which means which is closer to you and which is farther from you.

So, as I already mentioned features closer to the viewer appear bigger, than those which are farther. So, though perspective projection is very close to what you and I look at, it is not that preferred in engineering drawings, the reason is because it distorts the view, what do I mean by distortion? It means that let us say the size of the cube is let us say here it is 50 millimetres, but when you draw it on the projection plane, depending on how far or close your projection plane is, the size of the cube what you will draw there might be 40 millimetres or 30 millimetres, which means you are not looking at the true length.

So, which means you are distorting the dimensions of the object, not just that let us say I am holding it in this fashion, and you are looking at perspectives, even though this is a cube which means all the sides are equal, because of the perspective projection not all sides look the same length, so they get distorted, and you will be looking at different lengths.

There is an other way to look at it, even this angle which we know it as 90 degrees on this corner, when I hold it in this fashion and you are looking at a perspective instead of 90 what you will see is something different, it might be 120, 130 or 140 degrees. So, these are the distortions we are talking about, it distorts the length, it distorts the angles. So, good thing about perspective is very quickly you can understand the object, but it is hard to know the exact dimensions of the object, looking at the perspective projection.

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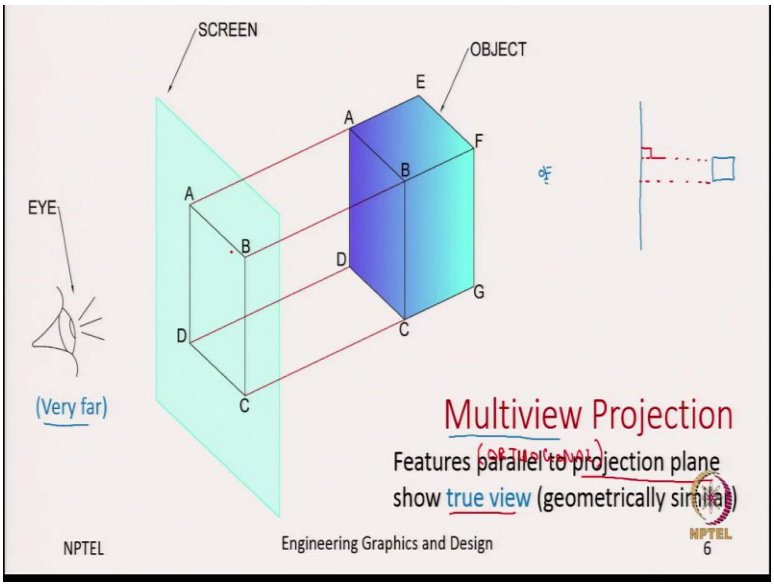

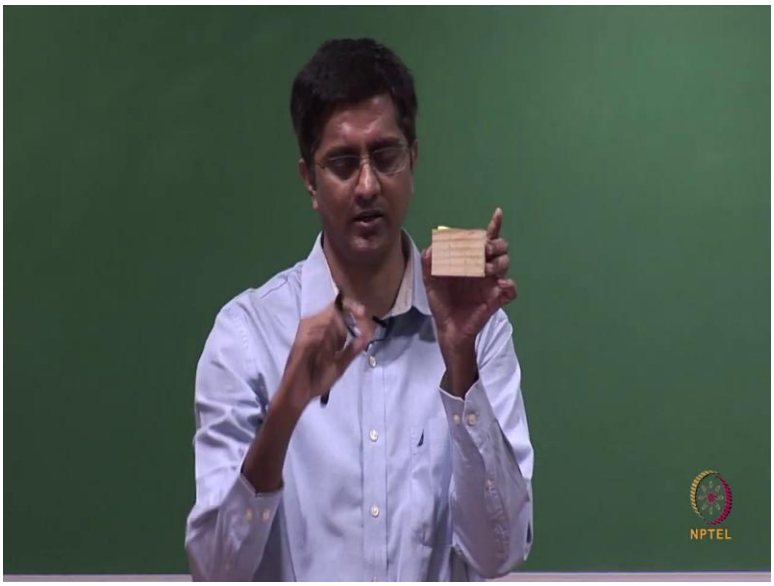

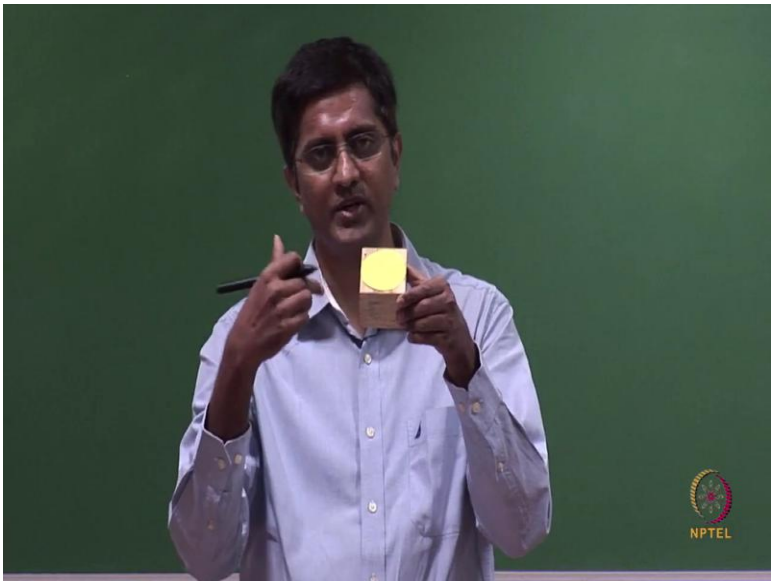

So, the other alternative is to go with multi-view projections. In multi-view projections, we put the observer very far, so here we have the observer, the object and the projection plane in between the observer and the object. And since I said this observer is very far what I meant was the projectors are all parallel.

So, now let us see again the same cube, you are looking from the friend and now since the distance is very far now we are saying that the projectors are all parallel. So, how does it intersect with the projection plane? It intersects these projectors intersect at an angle of 90 degrees. So, let us say the same thing, if you are looking from the top, here is your eye from where you are looking at and we said it is very far, this is the projection plane and let us say this is the object.

Now, if I am discussing about the projectors, these are the projectors and we see that these projectors intersect the projection plane at an angle of 90 degrees, perpendicular, that is why we also call these as orthogonal projection sometimes. So, in orthogonal projections, what you see is, let us say the length of BC on the object is 50 millimetres on the projection plane you will again see it as 50 millimetres.

The reason is features parallel to projection plane show true view, which means if you notice this line BC, is parallel to the projection plane, since it is parallel to the projection plane, the length of BC on the production plane will also be exactly the same, so it will show the true length.

Similarly, let us focus on this line segment AB, even line segment AB is parallel to the projection plane.

Since it is parallel to the projection plane, you will exactly have the same length even on the projection plane. So, now what is happening is we are able to capture the true length of the object in this multi view projections. So, we made two assumptions here, saying that the viewer, the observer is very far from the object and we are saying that you are looking straight into the object, you are not looking at an angle or you are not looking at multiple faces at a time, you are looking straight into one face of the object, that is when you get this multi view which has the true length for a simple object like a cube, but later we will see if the complexity of the object increases how do we handle these views.

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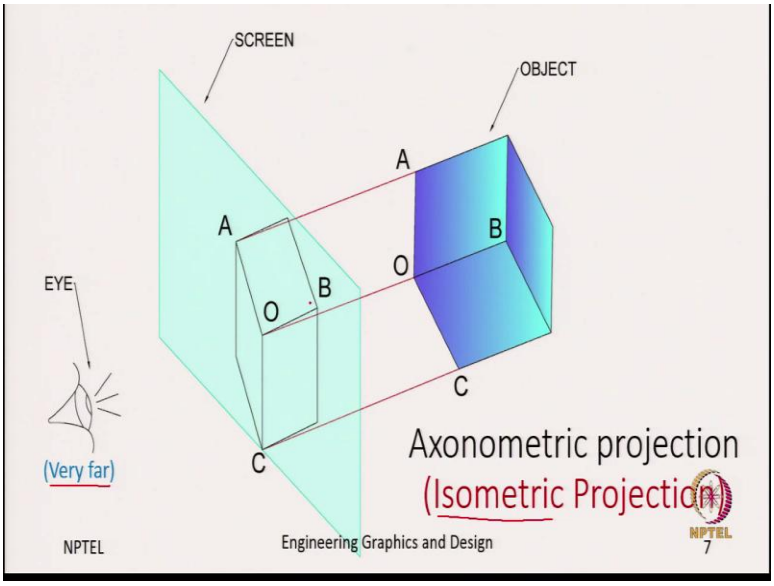

So, the other category is what we call as axonometric projections, there are multiple axonometric it is again a group of projections, but most commonly used in engineering practice is the isometric projection. So, what we mean by this is like previous multi-view projections we again say that the observer is very far, which means the projectors are all parallel.

The second thing we are saying is, the object is now oriented such that you can look at multiple faces of the object. Since, you are able to look at multiple faces of the object, when you are looking it from right front, you get to see the pictorial of the object, pictorial means you will be looking at the three-dimensional view of the object.

Previously, in the last slide of multi-view, we only have seen the two-dimensional view of object, because we were only looking at one face. Now, in this isometric projection we are able to see the three faces because the object orientation is done in such a way. So, this is how we capture the isometric projection of this cube.

So, again the object is held and you are looking right into the object, which means and the projection plane is perpendicular to the projectors, so what I am trying to say is, again these projectors are all parallel and they intersect the projection plane at 90 degrees, so we can also call these as orthogonal projections, orthogonal because the projectors are perpendicular to the projection plane.

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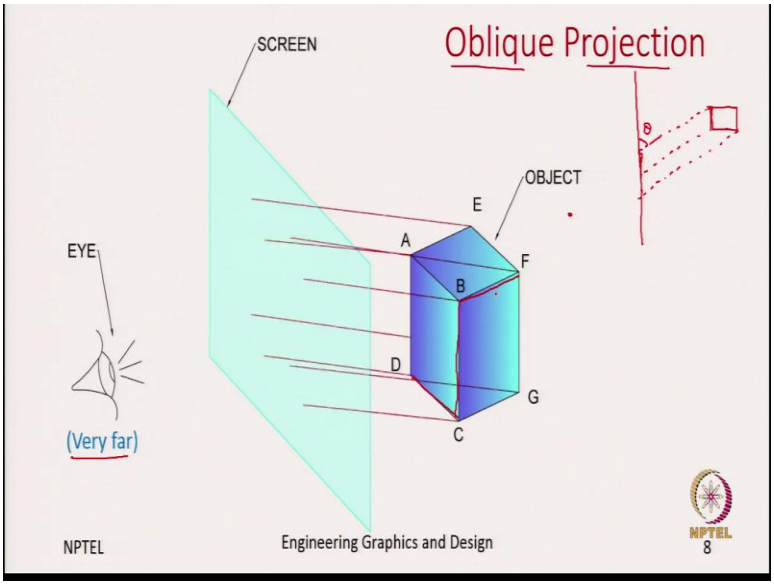

Lastly, we will be looking at oblique projections. So, it will be easy for me to explain about oblique projections if we see what we have here is the three things the object projection plane and the eye, so it will be helpful if we look at the top view of the of these observer projection plane and the object. Let us, say the object is here, we have the projection plane in front of the object and the viewer instead of looking right ahead of it he looks it at an angle.

So, since we are saying that the observer is very far we have all the projectors as parallel lines. So, how will the projectors look like? All parallel lines going towards the observer. So, now what we see is these projector lines intersect the projection plane at an oblique angle, so the angle is other than 90 degrees. So, here what is unique about this oblique projection is since this

edge is parallel to the projection plane even in the projection plane you will have the same length, which means let us say this is the width of the object and as well as the height of the object, so this is the width and this is the height.

Since both of them are again parallel to the projection plane you will be looking at the true length of this width and height. However, since the depth of the object is not parallel to the projection plane that length is different. So, in the oblique views we are able to capture both the true width and height however the depth will be distorted. So, now we have looked at the four different kinds of projections which are most commonly used in engineering practices. Now, let us try to summarize. So, this is how the object looks on the projected plane, but let us summarize.

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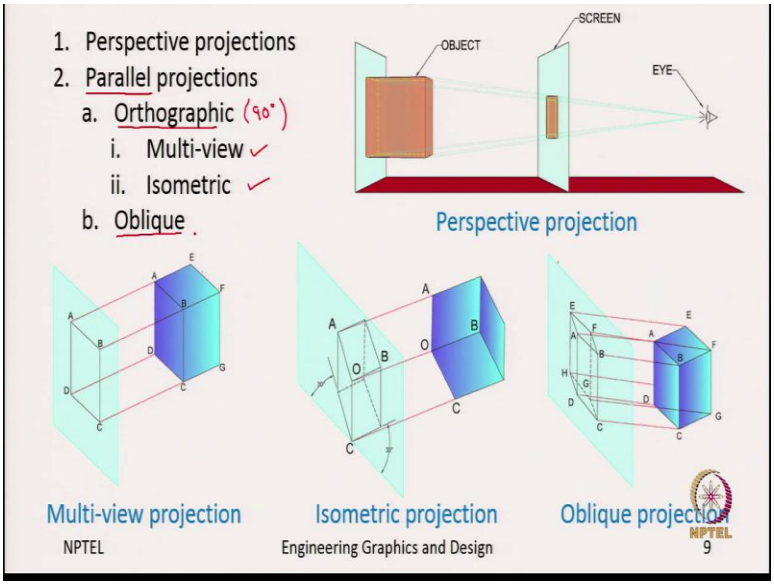

So, how is perspective projection different from the other three? It is different from the other three because the projectors are converging in the perspective. But the other three which is the multi-view, isometric and oblique projections, the projectors are parallel. So, now even in the parallel projections we have two categories one saying orthographic and the other is oblique.

Here orthographic refers to the angle between the projectors and the projection plane. So, when it is 90 degrees, we call them as orthography. So, we have again two which meet these criteria the both the multi-view as well as the isometric, both are orthographic because the projectors are making an angle of 90 with the projection plane. And in oblique as we looked at these projectors make an angle other than 90 degrees.

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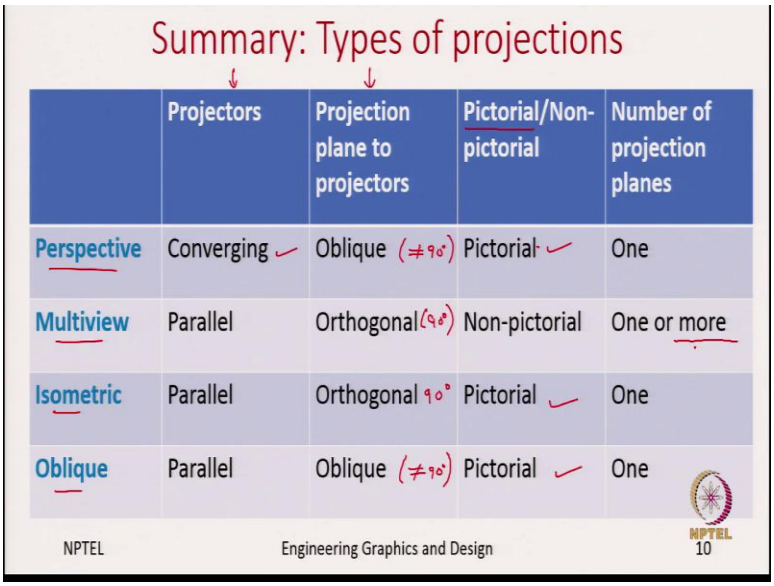

Finally, in a table let us look at how these four projections are different from each other. So, on the rows, we have this perspective, multi-view, isometric and oblique projections, first based on the projectors, we know that the perspectives are all converging, whereas the other three the multi view, isometric and oblique are all parallel.

Now, second category we are looking at is how the projection plane is with respect to the projectors. So, for perspective since they are converging, of course they are not making 90 degrees with the projection plane, so these are not equal to 90 degrees. Whereas for the multi-view and isometric we said they are orthogonal or 90 degrees.

And again, for the oblique, since we said they are intersecting at an angle, this is again other than 90 degrees and oblique. And lastly, this is very important to say that how is the object oriented with the projection plane, only in the multi view you have this properly aligned, so either it is parallel to the projection plane or perpendicular to the projection plane depending on which face you are looking at.

If you are looking at the front face, it is parallel, if you are looking at this face which is on the side, it is perpendicular. However, in the other three you can hold the object at an angle, where you can look at more than one face at a time, so in all perspective, isometric and oblique you can draw these pictorials.

Usually whenever we draw the pictorials one view is sufficient, however when we go to multi-view, we noticed that one view is not sufficient to completely describe the object, we need more

than one view, depending on the complexity of the object you will decide how many views you want to represent this object. This is the topic of the next lecture.