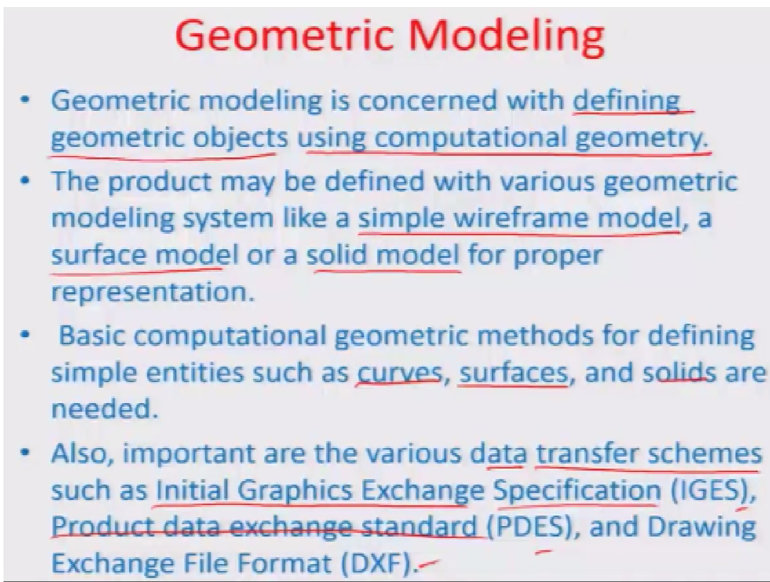
Design Practice - 2
Prof. Shantanu Bhattacharya
Department of Mechanical Engineering
Indian Institute of Technology-Kanpur

Lecture - 05
Geometric Modeling

Hello and welcome to this Design Practice 2 module 5. We will be discussing now some topics on geometric modeling particularly how you can use various methods like of representation like simple wire frame method or even surface model method or even solid model method for a proper representation related to different geometries at the 2D or 3D space.

(Refer Slide Time: 00:37)



So as far as geometric modeling is concerned it is really about how you define geometric objects and this you do using computational geometry and so therefore one is about how you represent the object, another is about you actually do in a predictive mode or more in a let us say in a computational mode the coordinate mapping of any particular geometry. The product may be defined with various geometric modeling systems.

There can be simple wireframe base models or surface models, even solid models for proper representation of the products. And some basic simple entities for example entities like curves, surfaces sometimes solids. They are needed to define such geometric representations and so in this particular module we will be studying more related to some of those simple geometries which can in integration with each other result in a more complex shape or form and also it is important for one to learn whether you know what you do out of this data.

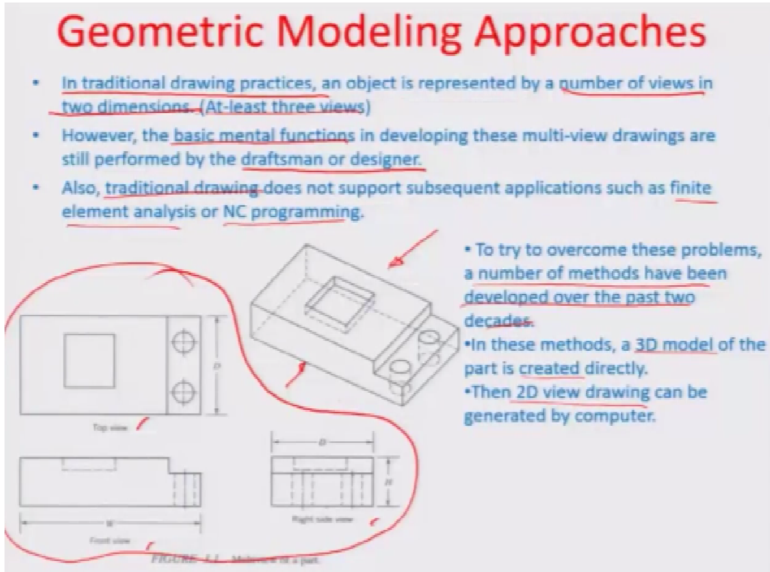
So for example once the data is generated, the numeric data is generated behind a geometry there has to be a use to it and the use can come either in terms of being able to handle that data to model something physically using a variety of manufacturing processes like for example 3D printing or for example computer numeric controlled machines and so there has to be an ability for all these CAD systems to not only be able to handle data, compute data but also to somehow translate data between different machines.

And for that there are certain exchange transfer schemes which have been set up, data transfer schemes internationally and people generally designing CAD platforms follow such schemes. So one of them is for example the initial graphic exchange specification IGS or product data exchange standard PDES or a drawing exchange file format DXF. So most of it you use in your normal rhythmologies while handling CAD.

You can save data as dot DXF or dot PDS. But the question is whether we understand of what it means when we save it in a certain format and it is all about the talking between various CAD systems and various other machines which should be able to manufacture what you are drawing and that is exactly what is the reason for storing in a particular pattern or storing with a certain algorithmic or programming logic.

So at the end of all the geometric modeling activities we would like to sort of delve into a little bit into this area as well, give you a feel of how what you do with the data that you have generated in the CAD, the numeric data that you have generated in the CAD after doing all these sketchings, schematics etc. that you do on a you know computer screen. So let us start one by one deciphering the different approaches for geometric modeling.

(Refer Slide Time: 03:54)



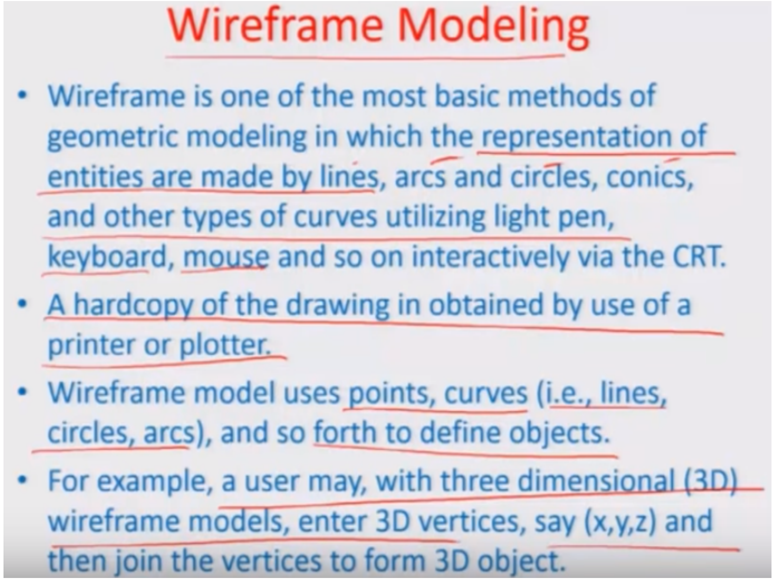
So in traditional drawing practices as you know, an object is represented by different views. There can be the front view, side view, you know and generally there are 3 views which would express the object in totality for example you can see this representation of a geometric object which is actually in the isometric form shown right here and in different views.

The top view for example or the front view or the side view is represented here in this particular section of the slide. So in order to draw the top view or front view or side view by looking at a physical object it does apply a lot of basic mental functions and when we are talking about you know an intelligent approach of modeling all this in a CAD profile, we must be able to give that programing logic.

So the basic mental functions are still involved you know which is done by a draftsman or a designer to figure out from a 3D shape how the respective views would look like. Also the other important fact is that if we look at something like finite element analysis or maybe aspects related to computer numeric control and how programming may be done the traditional drawing format with a draftsman trying to give a basic mental picture etc. does not really support a lot of these engineering tools which are available for the design.

To try to overcome these problems a number of methods have been developed over almost let us say the several last several decades and such methods could typically mean a 3D model being created through coordinate machine or a 2D view of a drawing that can be generated by a computer and we are going to look into some of those aspects.

(Refer Slide Time: 06:10)

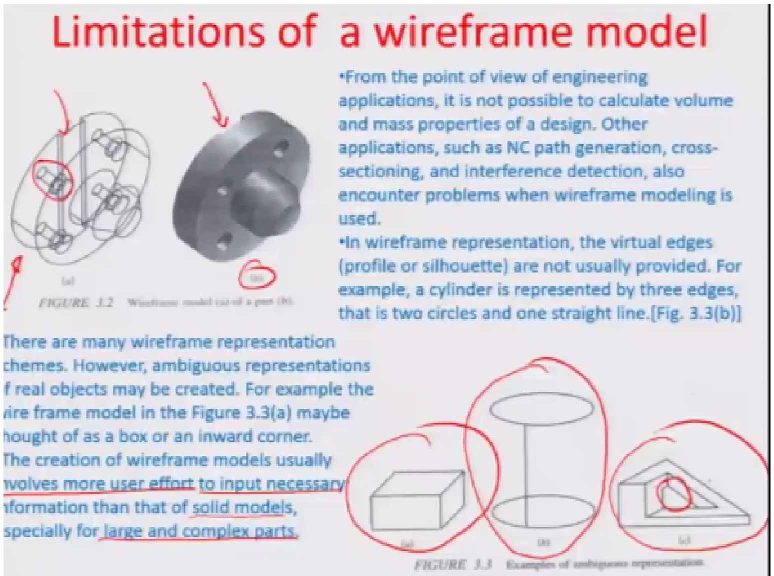


So the first aspect is how you represent through the most simplified form which is known as the wireframe modeling, is one of the most basic methods of geometric modeling and in this particular method you represent some entities which are regular in shape through you know very well defined geometric entities which exist like lines, arcs, circles, conics other types of curves and this can be either done using a light pen pointing in 2 way cathode ray tube screen or keyboard.

And that is where the technology assistance has happened so that you could draw on a screen and automatically there is a representation in terms of numeric data which comes up. So there is a translation between what you are doing on the screen and the numeric data which is coming up. So you can use that you know using various input output devices and other device can be a mouse for example and a hard copy of the drawing can further be obtained from screen using a printer or a plotter.

And as I already told you earlier that the wireframe model uses some basic you know geometries like points, curves, lines, circles, arcs so on so forth to define various regular objects when it comes to slightly regular objects are slightly complex objects which are of more appropriate engineering interest you need to use another concept of synthetic curves as I am going to point out later. So a user for example may with 3-dimensional wireframe models enter 3D vertices say x, y, z and then join the vertices to form the 3D object 3D shape.

(Refer Slide Time: 07:58)



And something like this would emerge for example when we are looking at the part which is here in figure B, the wireframe model may look something like this where only the boundaries are being scanned or taken in terms of coordinates and laid out but sometimes these wireframe representations can be highly confusing from a point of view of representation. The though process may be highly ambiguous.

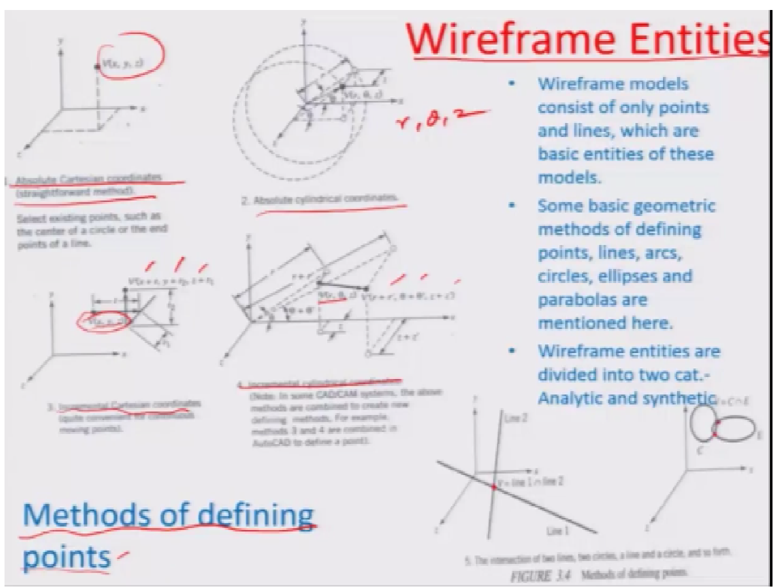
For example let us say if we look at this particular geometry represented through a wireframe model, how do you know whether this geometry represents a cuboid or a inward corner. If you look at the geometry you could actually see both, an inward corner of a cubicle silhouette or you know even a cubicle box. So this is the complication which is created through the wireframe modeling.

For example in this particular geometry how do you know whether this part is protruding out or inwards or by just looking at this particular geometry which actually describes a cylinder, how is one able to figure out how the cylinder is positioned with respect to another complex drawing. For example this is a cylinder which is represented by two circles and two lines. But with respect to this whole complex line and if I look at it in assembly farm it appears to be very complex to decipher which part is the cylinder and which part is the normal geometry.

So the creation of wireframe model is usually also involve more user efforts to input necessary information and therefore the strategy changed into a slightly higher complex technology which is called solid models. And for large and complex parts, people started using solid modeling approaches. So before we get into the details of solid modeling we would like to just talk a little more about how you represent some of these basic shapes, the shapes that I just mentioned, point or straight line or arcs or circles or conics which are used to represent regular geometries.

So it will give you an idea of how the emergence happened in terms of different models, modeling aspects.

(Refer Slide Time: 10:22)



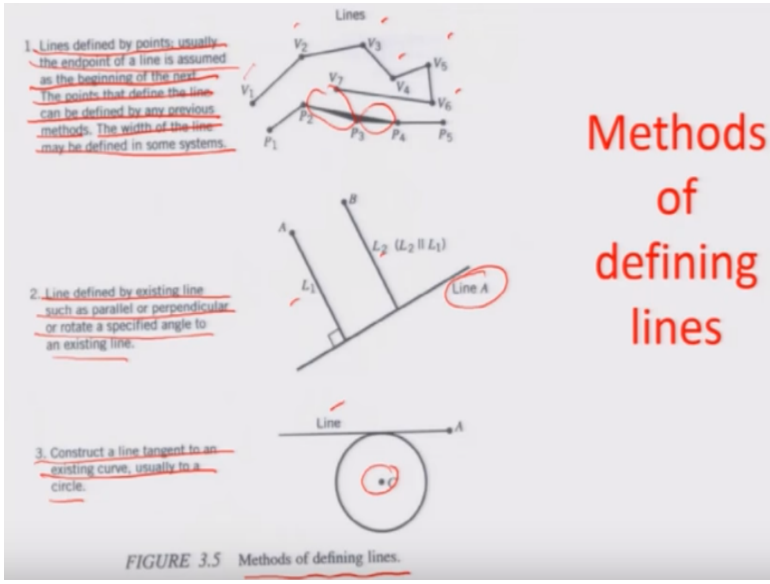
So if you looked at different wireframe entities, the first entity which comes into mind is how do you define points and there are many ways of defining points for example point can simply be defined using a absolute Cartesian coordinate straightforward method, selecting the existing point such as the center of a circle or the end point of a line would automatically align it with generating three coordinates with respect to x, y, z with respect to a Cartesian coordinate in which this point is being mapped.

There can be points represented through absolute cylindrical coordinates for example here you can see the coordinate has varied into R and theta and z okay which represents the position of a point in space. It can also be a incremental Cartesian coordinate for example there is already one point represented here for example V x, y, z and then you move exactly T T1 and T2 in the three different directions and so a new point formulates based on the earlier point and the movement, incremental movement which is x + t, y + T2, z + T1.

So this is how you can again represent points. You could also do a incremental cylindrical coordinate where from let us say Rz theta you are removing by R dash theta dash and z dash to find out a new coordinate. R + R dash, theta + theta dash and z + z dash. So you have such representations on a absolute coordinate, Cartesian coordinate system or a incremental Cartesian coordinate system and similarly an absolute cylindrical and incremental cylindrical coordinate system.

Points can also be represented by intersection of two geometric shapes like lines for example line 1 and line 2 are intersecting here to formulate a point of intersection. Or even two conics or two circles for example these two ellipse are indicating the formulation of two new points in space because of the intersection that they are being carried out. So either you have intersection of several geometries which would define the points or you have absolute or incremental definition of points based on different coordinates which would exist. So these are the some of the very basic methodologies of defining points.

(Refer Slide Time: 12:46)



There can be similar kind of methodologies for looking at other geometries for example there can be methods of defining lines. Lines can be defined by points, usually the end points of a line is assumed is the beginning of the next. The points are defined, the line can be defined by any previous methods. The width of the line maybe defined in some systems. So you can see the width for example defined here okay or you can see a point to point mapping which represents different lines.

Points have been of course represented in space through variety of techniques as shown earlier in the last slide. Lines can also be defined by existing lines such as parallel or perpendicular to each other. So if supposing there is a line A and I say that line L1 and L2 would be perpendicular they would automatically be parallel to each other in some sense. So that is how also you can define parallel lines. You can rotate lines at a specified angle to an existing line okay.

So there can be a definition through an angle of a new line coming up because of rotation with respect to either a point or a line. You can also construct a line tangent to an existing curve, usually to a circle for example. There is a circle scene space and then line comes up just because by virtue of it being tangent to a particular circle at a certain point. So this is some of the ways of defining lines.

(Refer Slide Time: 14:13)

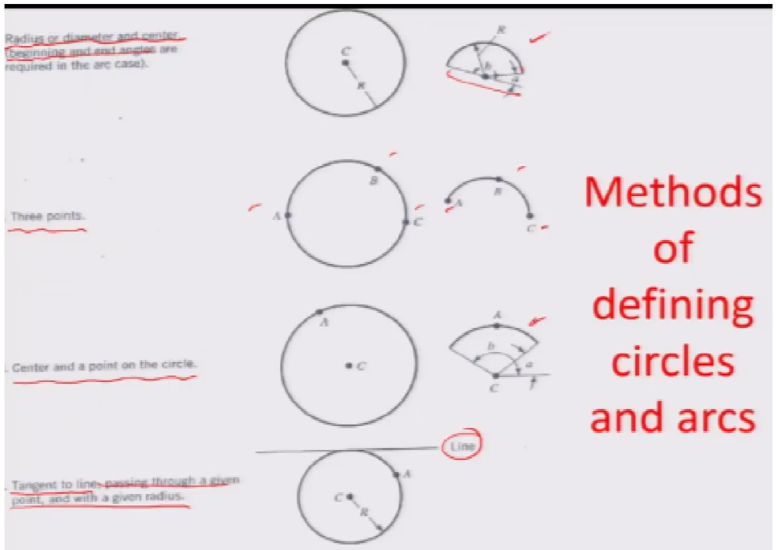


FIGURE 3.6 Methods of defining arcs and circles.

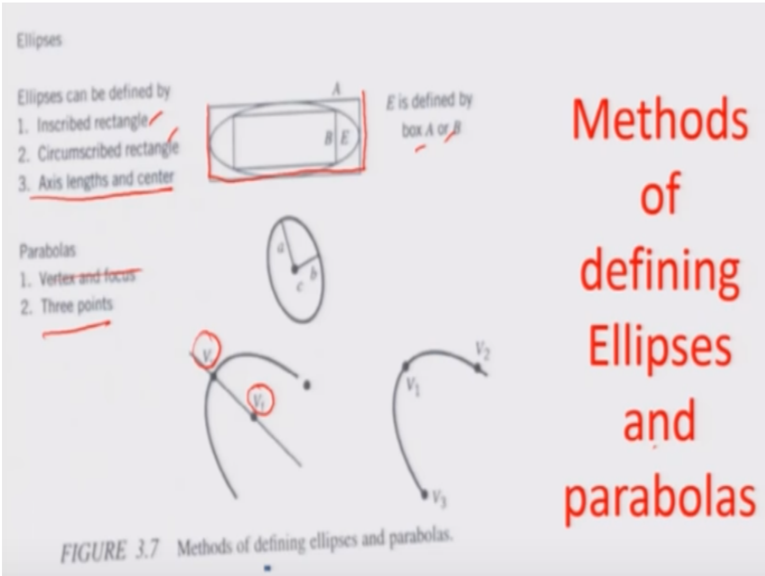
Similarly, you could have variety of ways to define arcs and circles. For example the basic representation of a circle could be a radius and a diameter. Radius or diameter in a center. So if you wanted to define an arc then you just need to have values related to beginning and end angles which are needed for the arc. For example this is representation of an arc. It starts from an angle B and goes all the way when the radius has an angle A with respect to this geometric diameter.

Circles and arcs can also be defined by three different points for example circle can circumscribe three points A, B, C as can be seen here or it can actually also partially result in an arc. Center and a point on a circle also can result in the finding of a circle because obviously the center to the point would be the radius and you are going to turn the radius 360 degrees to formulate the array of points which would represent the circle.

Similarly, if you had angles the initial and beginning, the initial and the final angles of how radius or how a point would behave with respect to another point that could also result in definition of an arc and a circle can also be defined as just in a way that a line was defined with respect to a circle. Circle can be defined as something which is having a tangent which would be a line which is already defined okay.

So if there is a defined line you can have a circle in a manner so that this line is a tangent to that particular circle. So tangent to the line passing through a given point with a given radius could be a circle. So these are some of the methods of defining circles and arcs.

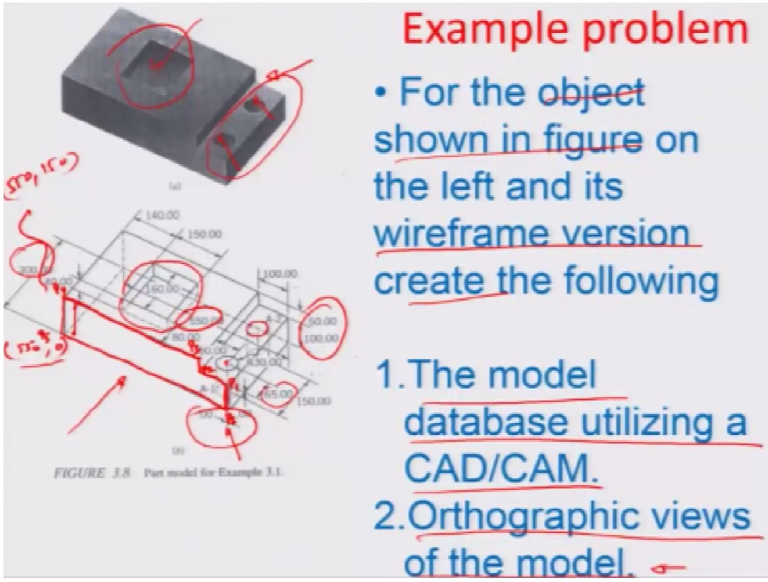
(Refer Slide Time: 16:00)



We also have methods of defining ellipses and parabolas and other conics. For example an ellipse can be represented through an inscribed rectangle or a circumscribed rectangle. You can see right here there is something which is you know circumscribing the elliptical shape and something which is you know inscribing and then you can also have axis lengths and centers which would define. So is defined by the box A or box B an axis and lengths and a center.

Similarly, parabola can be parabolas can be defined through a vertex and a focus for example in this case you have a focus point Vf and a vertex Vv which would define a parabola. You can also have three points representing the same parabola. So these are different methods of representing ellipses and parabolas. So now we start doing the wireframe modeling. Actually I will give you an example through which you would figure out how geometric data can be extracted through this approach of converting into simple shapes and form.

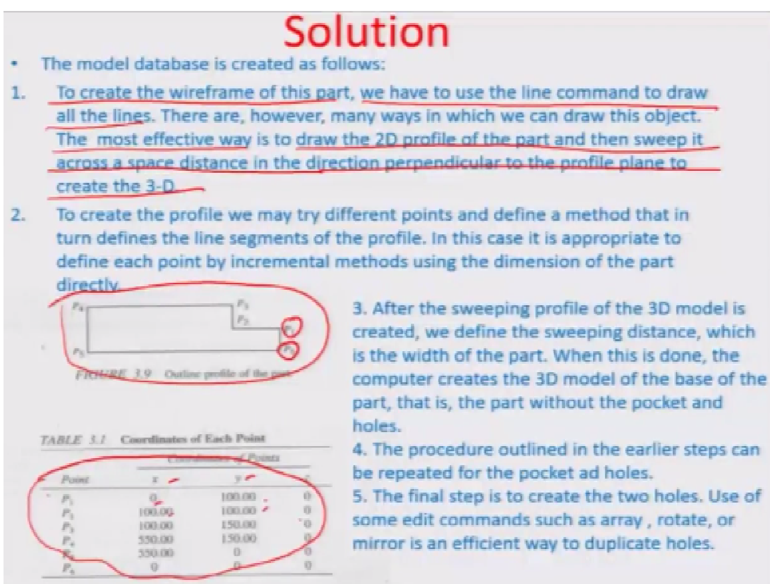
(Refer Slide Time: 17:03)



This particular geometry here is represented in terms of points and lines and then later on cylinders and cuboidal spaces are cut out from the concerned geometry. Let us say we want to create the wireframe version of the object shown in this figure and we want to model the database of numeric associated with this particular solid model so that it can be wireframe or it can have a wireframe representation.

And then from there we can extract things like orthographic views of the model etc. by extracting the right numeric data which can be plotted together to have the front view top view side view so on so forth.

(Refer Slide Time: 17:48)



Point	x	y	z
P1	0	100.00	0
P2	100.00	100.00	0
P3	100.00	150.00	0
P4	550.00	150.00	0
P5	550.00	0	0
P6	0	0	0

So the best way to do this exercise is to be able to first model the database as follows. You create a wireframe of this part. We have to use the line command to draw all the lines okay. there are however many ways in which you can draw this object. Most effective way is to draw the 2D profile of the part and then sweep it across space distance in the direction perpendicular to the profile plane to create the 3D shape.

So we are trying to start with this particular plane right here okay which can be again defined through different coordinates. The coordinates are all mentioned here in terms of the dimensions okay. if I started from here let us say this is the 0, 0 would have a coordinate right here which would be having a dimension along the x direction, along the y direction of 0 and x direction of so this is 550 as the x is 550 as can be seen in this dimension here about the whole (()) (18:50) of the block.

So if I want to represent this geometry in terms of different points starting from let us say P1, P2, P3, P4, P5 and finally P6. So all these points can be represented like these coordinates. For example 550.0 can be used to represent E5 or because this dimension here is about 150 as it can be seen here, 100 + 50. So this right here can be 550, 150. So in this manner we extract all the coordinates of the position vectors P1 through P6 for each point.

And so you can see the various x, y values of this particular plane okay. This is the first step for doing the wireframe model. So you have 0, 100; 100, 100; 100, 150 so on so forth of all these values. You can actually go back to the figure and compute this yourself looking at the different dimensions and then you basically create steps of z from 0 which is actually this right here all the way to about 300 which is somewhere towards this corner.

So this is the first step of creating the whole solid block without any of these different you know cylinders or cuboids extracted or cut out of the particular geometry. So that is the first step towards creating the wireframe of the solid model. So with all the numeric data internally captured okay for these arrays of points P1 to P6.

So you could actually have the z data captured through having different values incremental values of z from 0 to C100 let us say if it starts with z equal to 50 so you have z50, 100, 150 and all these different you know P1 to P6 planes this geometry would repeat itself from at 0 then at about z equal to 50 then equal to z equal to 100 z equal to so on so forth up to z equal to 300. So you can have a series of these or a you know let us say parallel planes P1 to P6 which would represent in turn the solid geometry.

So we create the profile and then sweep the profile as I told you in the z direction okay and then what you can do is as the 3D model of the base part is created without the pockets that are being indicated the procedures outlined in the earlier steps can be repeated for the pockets and the holes okay. So in this case for example a cylinder needs to be pulled out. So you could actually create a circle with a center at a certain point which is being represented in this dimension here.

The circle actually has a center from this side of 65. So this is the first center okay and the radius that is being indicated here is 30. So you create this circle and create a through hole okay by creating two parallel circles across this step of the block and then you reflect this you know through a reflection command to the other side so that both the circles or both the cylinders can be taken out of the particular geometry.

Similarly, in the same manner you could create a numeric data of this particular geometry right here which is actually the pocket you know the four-sided pocket which has been created inside this block, five-sided I am sorry. So this way you could actually create the whole geometry through numeric as is outlined in this database right here and you can understand the complexity which is involved in creating numeric behind the geometry.

Because now you have a large data of points, cloud of points which has some relation with respect to each other okay but the advantage is that you do not need to again mentally compute or mentally apply your skill sets to look at the figure and see what is going to be the front top and so on and so forth. You can just extract the numeric in a manner like for example if you were to extract the numeric P1 to P6 okay this would represent in the front view okay.

Or it would be able to represent the front view and so there has to be certain rules or logic which has to be defined so that whatever you are doing mentally can now be done through numerics on a logical platform like a computational tool. So that is how you can create wireframe modeling to you know create a variety of different shapes and sizes. So I would like to actually now close this particular module.

But in the next module we will look at how curves are represented because not everything is regularly oriented. There are many irregularities associated with different figures and when we are talking about real engineering objects they are not so simple as a combination of this regular shapes like points, lines, arcs, circles etc. There are going to be much more involvement of you know curvy surfaces which can be giving some functionality to a product or a shape.

And so much more organic or complex shapes need to be involved there and so how do you plot such shapes through again computational tools would like sort of give you an idea in the next module. Thank you. Up till now bye bye.