Computer Integrated Manufacturing
Professor. Janakarajan Ramkumar
Department of Mechanical Engineering & Design Program
Indian Institute of Technology, Kanpur
Lecture 07
Computer Graphics (Part 2 of 4)

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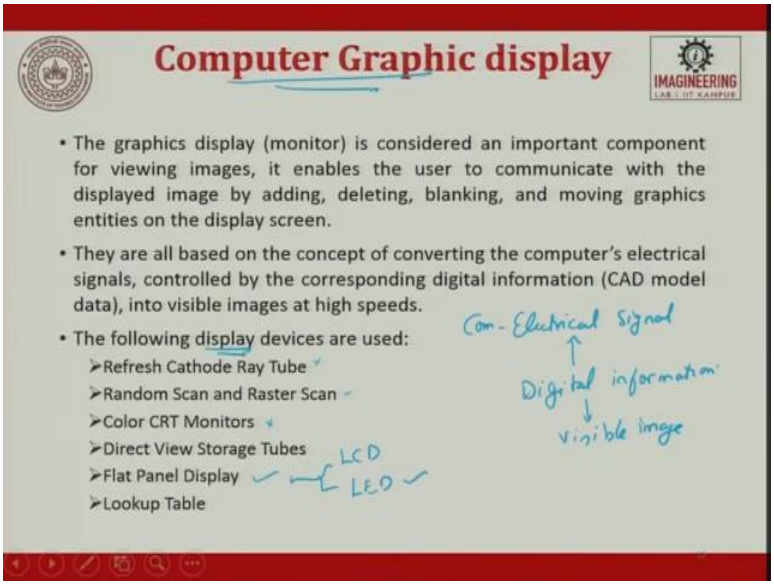

So now, let us get into Computer Graphic Display. Computer Graphic Display, the graphic display monitor is considered an important component of viewing image. Without the monitor whatever you develop, how are you going to it? So, the visualization of the complete CAD happens only because of the graphic display there. It enables the user to communicate with the display image by adding, deleting, blanking, moving graphics entity on the display screen.

They are all based on concepts of converting the computer's electrical signal, controlled by the corresponding digital information into visible image at high speeds. So, electric, electrical signals, again which comes from a computer, then it is controlled by digital information which is nothing but CAD dimensions and other things, and which in turn is converted into visible image at a very high speed.

The following display devices are used today, refresh cathode ray tube, slowly, slowly the cathode ray tube is going away, random scanning and raster scanning, color CRT monitors, CRT itself is slowly, slowly going but even now for the higher end machines we still have

some CRT screens, then direct view storage tubes, flat displays have come up in a big way, you again you have LCD and LED today, LED is told to be more energy efficient, and then you also have something called as a lookup table. These are all the devices which are available for computer graphical display today.

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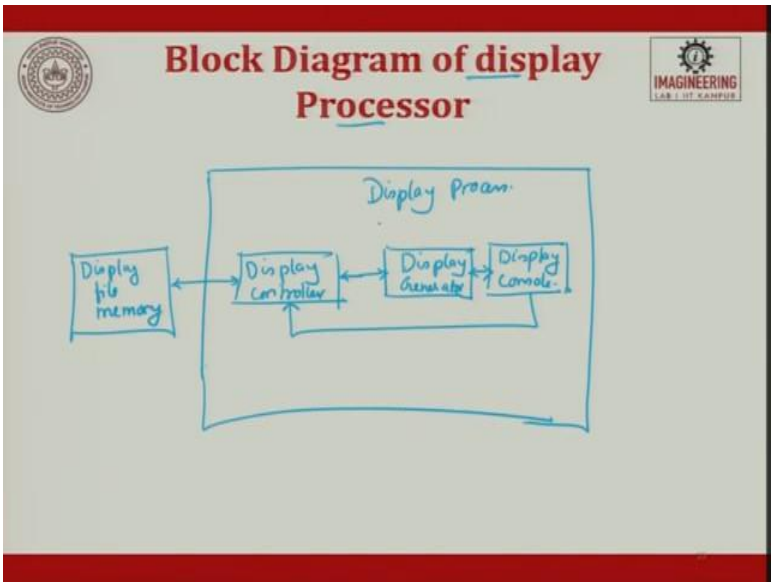

Let us see, the block diagram for display process. So, if you see the block diagram for display process, this is the display process. So you have display control, then you will have display generator, then you will have display console. So, all these fellows will be communicating with each other, then the console also will be trying to communicate with the controller. So, this all will be back and forth communicated with the display, so display file memory. So, this is a block diagram which will talk about the display processor.

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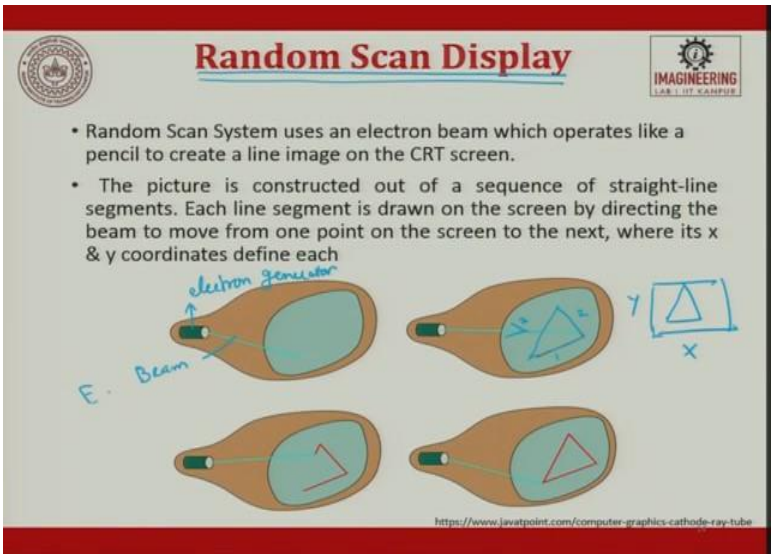

Now, let us look into random scan display. How does this random scan display work? Random scan display uses an electron beam, you see a beam which is coming out from a electron generator. So this is electron generator, this is the beam which is an electron beam. Random scan system uses an electron beam which operates like a pencil to create a line image on the CRT screen. The picture you see here it hits, then it draws and then it goes.

So you can see here, it is first drawing a line, then it is extending, then it will close. So this, the picture is constructed out on a sequence of straight lines, 1, 2 and 3 segment. Each line segment is drawn on the screen by directing the beam, this is a beam, which moves from one point of the screen to the next. Where its X, Y coordinates define each other. So since it is a plane, you have only X and Y, so it is going like this. So, these are the X and Y coordinates which are displayed, such that you can try to produce the image what you want.

So, this is how a random scan display works. Now, we are getting into the graphics, how is it getting displayed?

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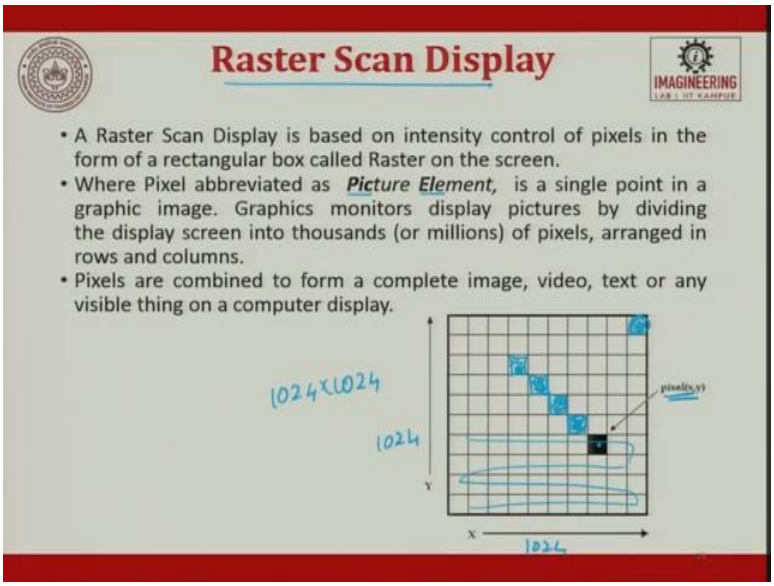

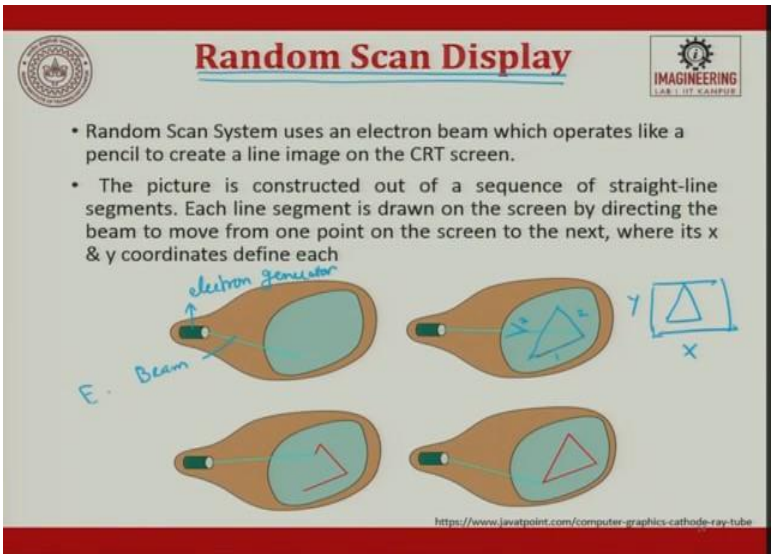

Next, a raster scan display is based on the intensity control of pixel in the form of a rectangle. So, the entire screen which I said, X and Y is divided into several small pixels. This is a pixel, which I said, X and Y. A raster scan display is based on intensity control of pixels in the form of a rectangular box called raster on the screen, so it moves; where pixel abbreviates as picture element, pixel, is a single point in a graphic image. The graphics monitor displays picture by dividing the display screen into several thousands of pixel.

Today we talk about 1024 X 1024, so this is 1024, this is also 1024. So, so many number of pixels will be there. So this is 1 pixel, so this is a point. The pixels are combined to form

a complete image, video, text or any visible thing on a computer screen. For example, I try, will try to shade it. Now, what I have done, I have activated pixel, I have certain pixels, so I know the X, Y coordinates as I told you earlier.

So, now what I have drawn is a line. So, that is what is raster scan display. First was random scan, next is raster scan. Raster scan means it goes like this.

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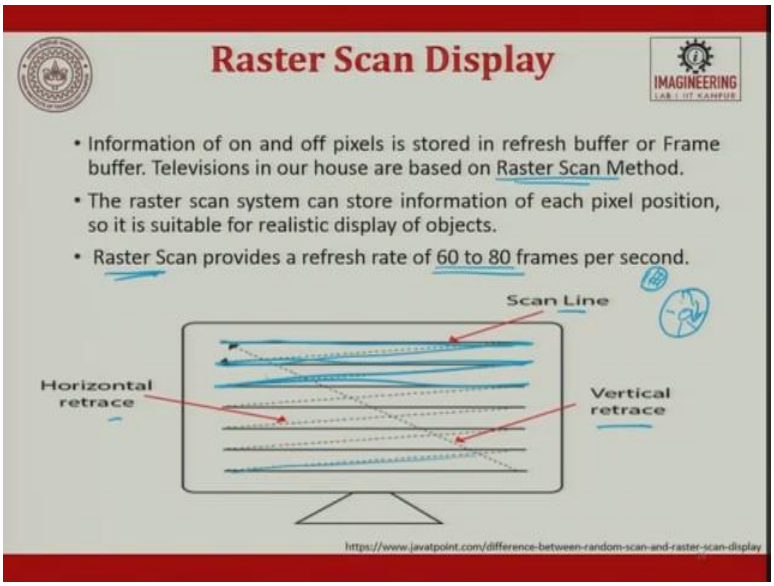

The information of the on and off pixel is stored in a refresher buffer or a frame buffer. Televisions in our home are based on raster scan methods. The raster scan system can store information of each pixel position, so it is suitable for realistic display of the object. The raster scan provides refreshment rate at 60 to 80 frames per second. So, when you do 60 to 80 frames per second, you will not realize that as though there is a cut between the first scene and the next scene, first frame and the next frame.

So, this is what the horizontal rastering which goes, this is what is horizontal. You can also do a vertical rastering, this is vertical rastering. And this is a scan line, so every time it goes then it comes here, it goes like this then it comes down. So, these are called as scan lines, these are called as horizontal lines and these are called as vertical rastering or retrace. So, this is very important. This is how it is done and this is done at very high speeds. So, this you would have even realized in your day to day affairs.

If your fan rotates at a certain speed, then let us assume the other side, the fan is kept in open air, so this rotates at a certain speed. So, if you synchronize the speed with which you are watching the fan, and fan is running and then if your synchronization happens, you can see the scene in front of the fan happening without seeing the fan blades. So, this is just a synchronization. So, if you do that you can also try doing it in your fan. So, this is also frames per second. The eye is getting cut and then the new scene comes into action.

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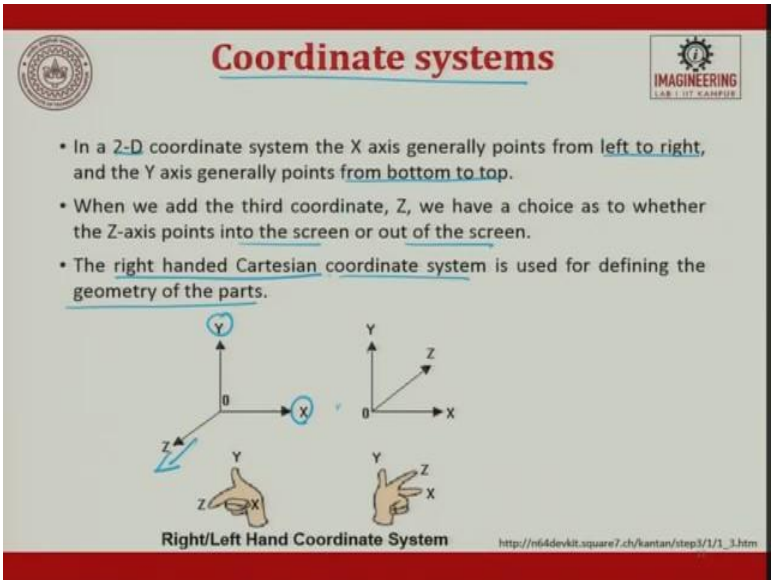

When we talk about coordinate system, there are 2 types of coordinate system. One, is called as the right hand coordinate system, the other one is called as a left hand coordinate system. So 2D, 3D is an extrapolation of 2D. So, what we do is, we will first try to understand 2D and then we can try to move towards 3D. In a 2D coordinate system, the X axis generally points from left to right and the Y axis generates point from bottom to top.

When we add the third coordinate, Z we have a choice as to whether the Z points into the screen or out of the screen. The right hand Cartesian coordinate system is used for defining the geometry of the part. What is right hand system? Right hand system is, so you put your, you take your right hand system and then you put your X and Y. So, this is your X, this is your Y and Z comes out of the screen. So generally, we try to follow right hand Cartesian coordinate system for doing any mathematical transformation in a screen or in CAD. So,

is it clear? 2D, 2D we talk about left to right and bottom to top, and then Z is in the screen or outward of the screen. Right hand, right hand coordinate system is out of the screen.

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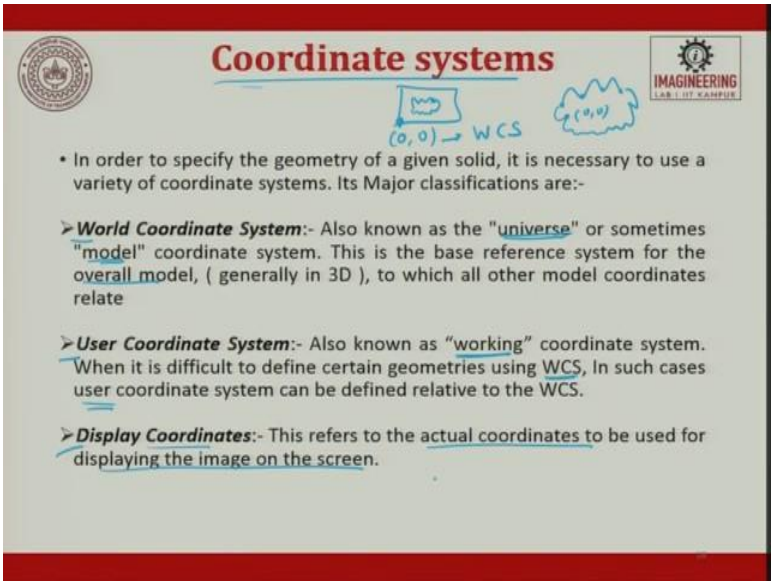

When we talk about coordinate system, there are 3 types of coordinate system generally followed in CAD. One, is called as the world coordinate system, the other one is called as user coordinate system and the third one is called as display coordinates. The world coordinate system is also known as universal or universe, or sometimes model coordinate system. It is the base reference system, for the overall model to which all other model coordinates are related.

For example, I tried to, this is a screen, I tried to define this is my (0, 0). So, then this is nothing but the world coordinate system. The other one is called as user coordinate system or it is called as also working coordinate system. When it is difficult to define certain geometries using world coordinate system, in that case we will use the user coordinate system. Suppose, this is the world coordinate system, I am drawing an object like this. So, it becomes very difficult for me to always refer to the world coordinate system and transform these points.

So, it is easier, now I shift my world coordinate system into a user coordinate system, make this point as (0, 0) so it becomes easy for me to define the entire CAD. So, that is nothing but user coordinate system.

The last one is display coordinates. It refers to the actual coordinates to be used for displaying the image on the screen. So, many a times on the screen you can see this display coordinates also come. When you use any of these softwares, where for CAD you can see world coordinate option, user coordinate option as well as display coordinate option given to you.

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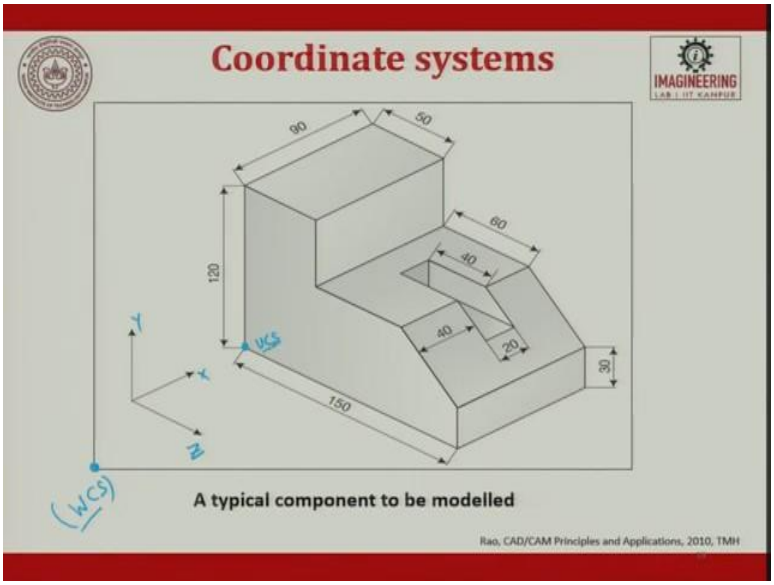

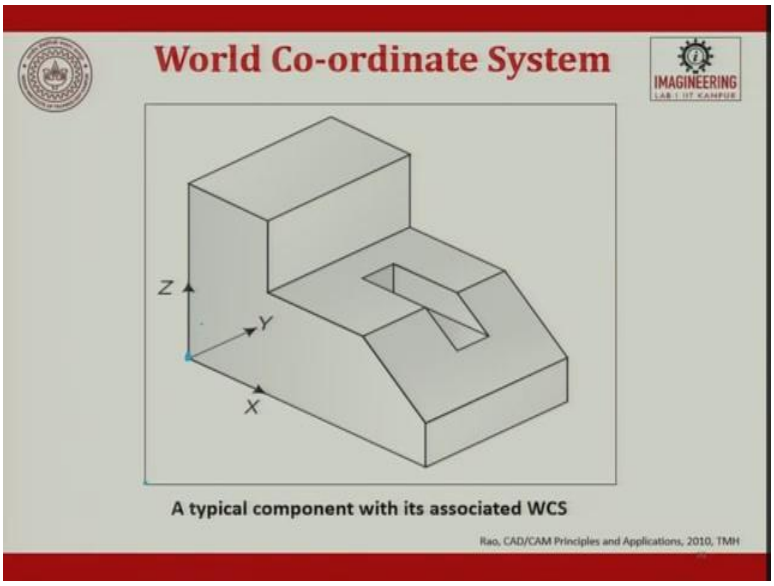

And, if you see that, this part, this point is called as the world coordinate system, this one is called as the user coordinate system. So, I started from here, shifted a point and then I started drawing this one, next, next, next, next, next, I started doing everything. So, this is a typical component which is 3 dimensional so you can see there X and Y, you can have it, this is Y, this is X and this is Z. So, you can have it. And then, this is how you draw.

So, the world coordinate system, user coordinate system and then you have one more which is called as display coordinate system.

So, a typical component which is associated with world coordinate system you see here, I have transformed this into this. So, this is called as a world coordinate system. Earlier I was trying to take the frame as world coordinate system, now I have shifted the world coordinate system here. So, that is what it is.

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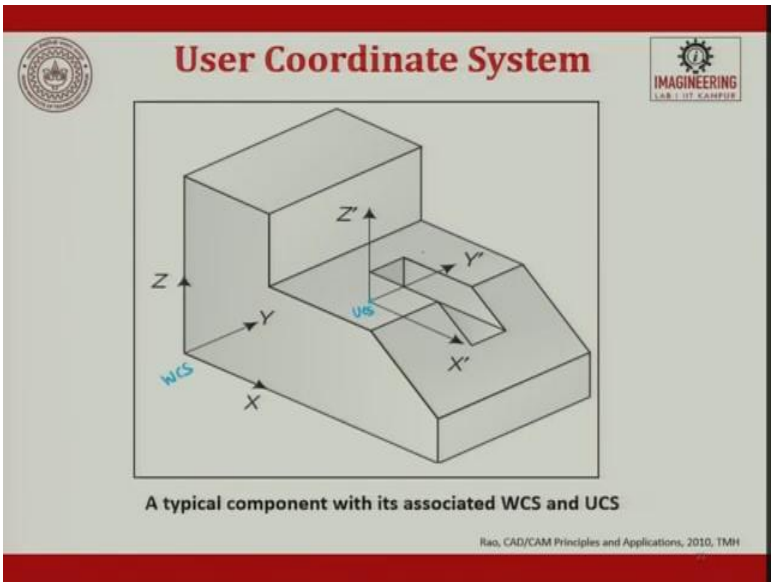

Now, in this I am trying to take this point as my user coordinate system. This becomes world coordinate system, this becomes user coordinate system. So, now it is easy, I will draw everything with respect to this and finally I will say, what is the relationship with this reference to this. I can get the operation done, or the product developed.

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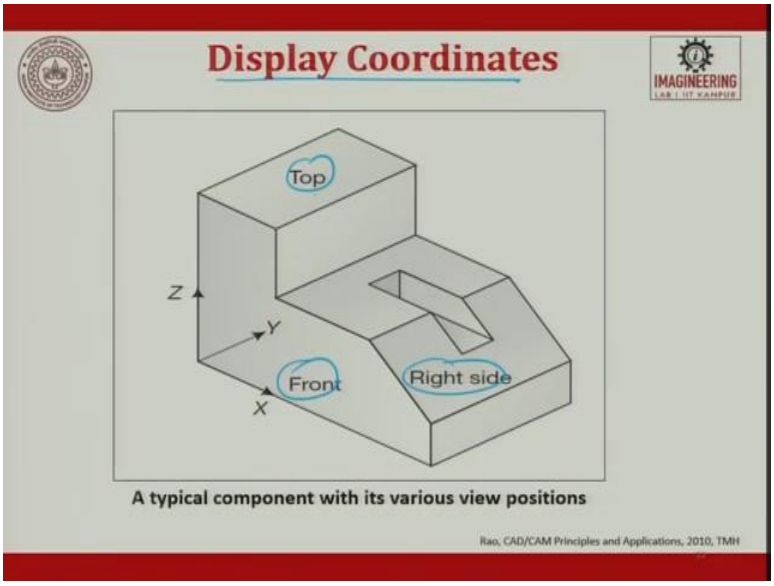

So, this is display coordinates which talks about top, front and side. So, this side, so right side view, front side view, top side. These are nothing but display coordinates.

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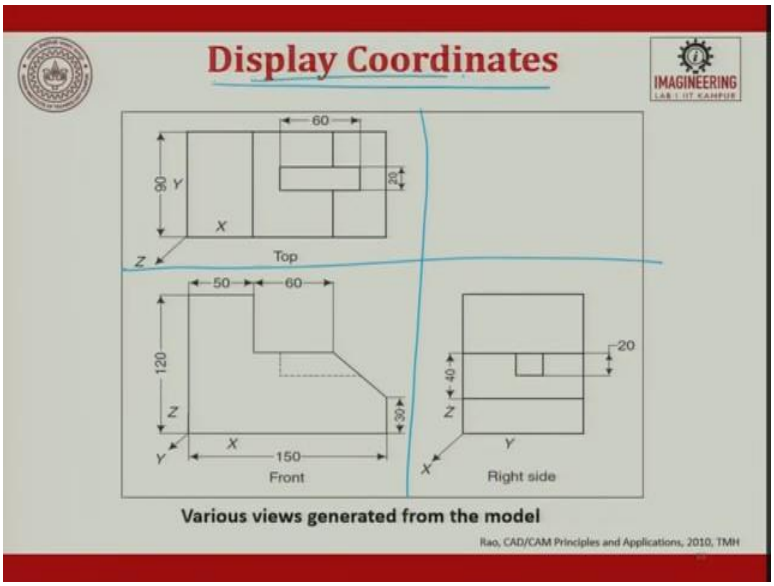

And this is, for that 3D object you can see here. Top, front and right side, all the three are generated. This is nothing but, a display coordinate system or display coordinates.

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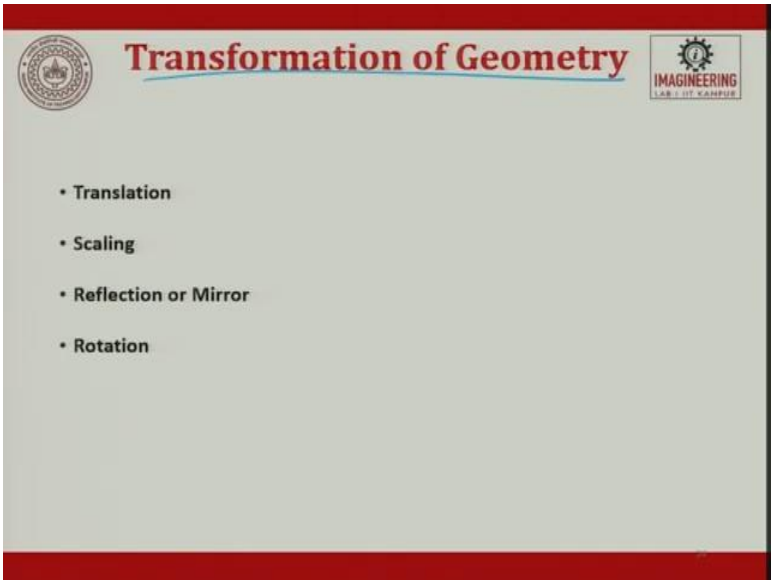

When we talk about, transformations. Before getting into transformations.

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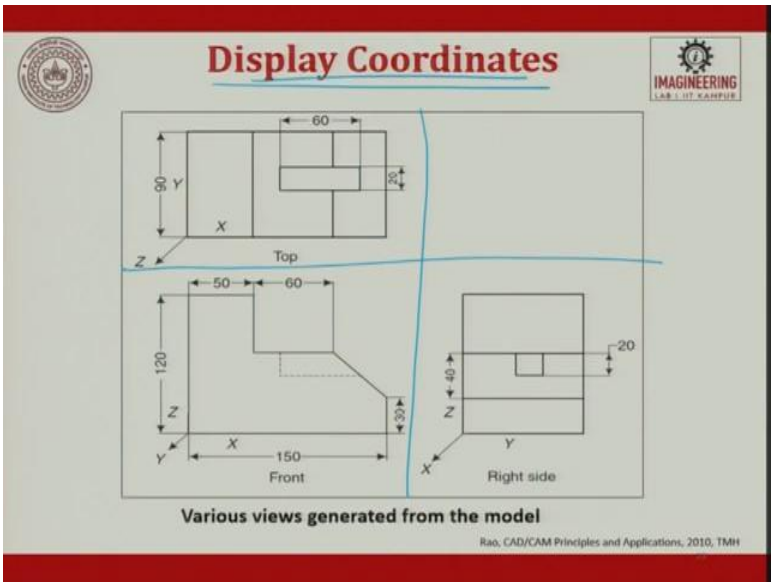

Let us relook into what all we have seen till now. We were looking into what is design?, then how do you define design?, then what are the different approaches for design?, how does a CAD drawn?, and then after the CAD drawing, so then we saw about display, there we saw about different types of rastering, then we discussed about coordinate systems wherein which we discussed about world coordinate system, user coordinate system, and display coordinates. So, this is what we have seen till now.

So, after this display, what is the next important thing which we have to know, we have to start looking into transformations, that means to say I have drawn a dot how will I shift to my dot from one location to the other location. And if I have to shift, what I have to do? I have to transform the data. So, now let us look into geometric transformations.

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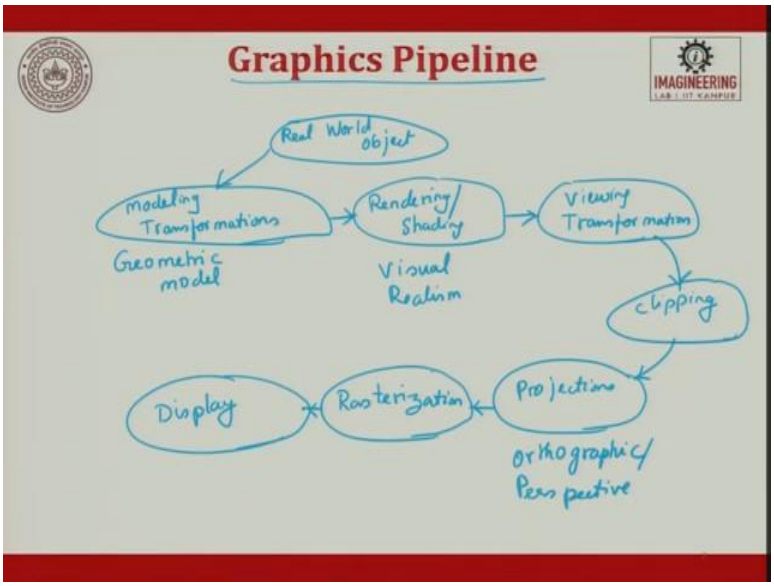

If you go back to this figure, what we drew, model and transformation. This is what is our next understanding which we are going to look into.

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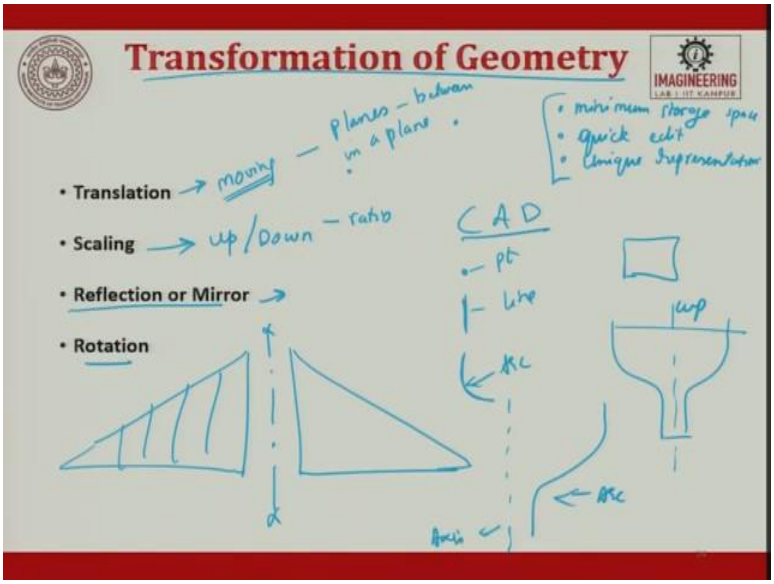

So here, we will start looking into 4 types and there are many things available, but basically if you understand 4, all the other things are small editing over the understanding process.

Translation, translation means it is moving from one point to another. If you basically see in CAD, if I know to define a point, if I know to define a line, if I know to define a radius, then there ends the matter. Any object I draw, I can split them into points, lines and arcs. If I know to define all the three, then I can draw any complicated component very easily. So now, if I draw these things, the first thing I would like to do is I would like to move. Translation is nothing but moving from one plane to the other, so moving planes, between planes, or in a plane, you can do that.

Next is scaling, scaling is I already told, up and down in terms of ratios. So, it can be zoomed up, it can be zoomed down and here in which you can follow some ratios. So, if you draw a figure like this, you can try to zoom up and then zoom down. It is a simple mathematics which is goes on, such that these things happen without any error in the basically drawn object.

Next one, is mirror or reflection. What is mirror or reflection? I would try to draw this side of the axis, now I want to get the other side of the axis. So, I define this point and I do a mirroring operation on this line, I get the other side. So, that is nothing but reflection and mirroring transformation. And at last is rotational transformation. Rotational is, suppose if I want to make a cup, what I do is I try to create an arc and then I put a center line. Now, when I try to rotate 360 degrees, I spin out and get a cup.

Why is this operation require? Because in CAD one of the most important point is minimum storage, minimum storage is very important. So, when you try to buy any CAD softwares, we always look for minimum storage space, quick editing and unique representation. So, these are the 3 things which we will always look at while buying a CAD software. So, when I say minimum space, storage space, so I defined an arc, I defined an axis and I say please rotate it so you get a cup. So, this is a cup, this is an arc, this is the axis. So, I try to get that.

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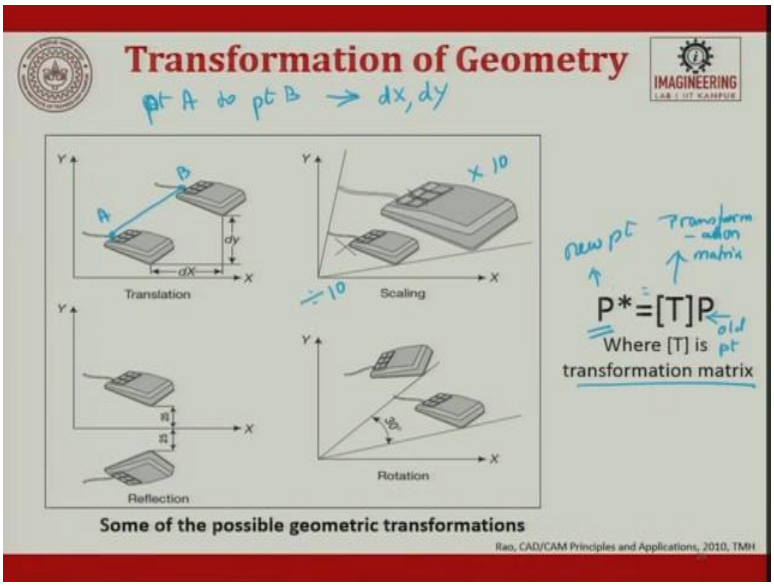

So, this is translation, I said movement from this point I have moved a delta X and then I have moved. So, when I wanted to move from here to here, what I have done is I have moved from A to B, is a point A to point B when I do, what is that I change in delta X and delta Y, few units to go to B. The scaling I have said, this is zoom scale up so it is multiply maybe 10 times, if it is scale down, it is nothing but divide by 10 times. This is the mirror, which I have already talked to you and this is the rotation which I am, which I was also talking to you.

You can do rotation about X, Y or you can do rotation about X, Y, Z also. So naturally, it makes little bit complex mathematics, but it is also doable. So, what is that we are trying to do in, finally in transformation is, we get to the new point. This is the new point wherein which we do a transformation matrix, transformation matrix.

Because, what happens behind the scene is only matrix multiplication and this is the old point. So, transformation matrix you multiply the old point with the transformation matrix depending upon your operation then you try to get a new point, then when you try to put the new point in a rastered screen, you try to see the operation is carried over.

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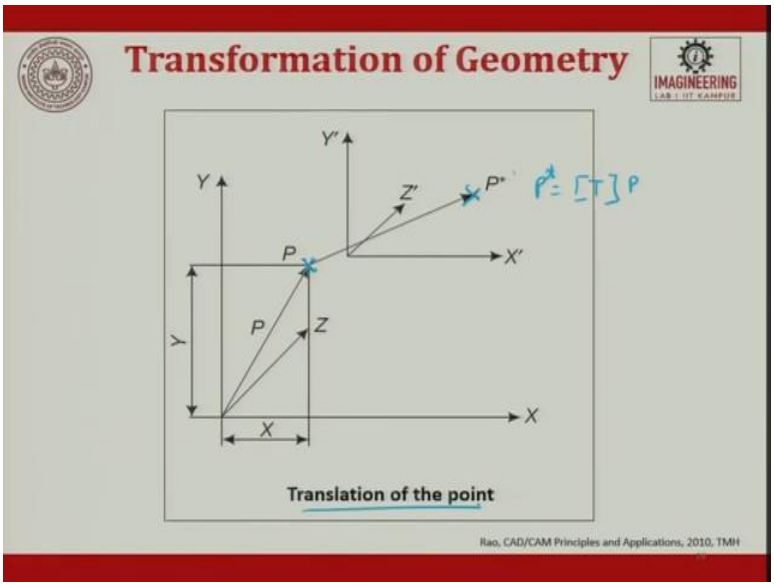

So, when we try to do a point transformation, this is what it is. So, you have a X, Y plane, so there is a point called as P. This point has to be moved to P dash, which is a new point. So, P dash is nothing but transformation into P. So, when I do that, I try to get to P dash point. So, this is what happens when you translate a point.

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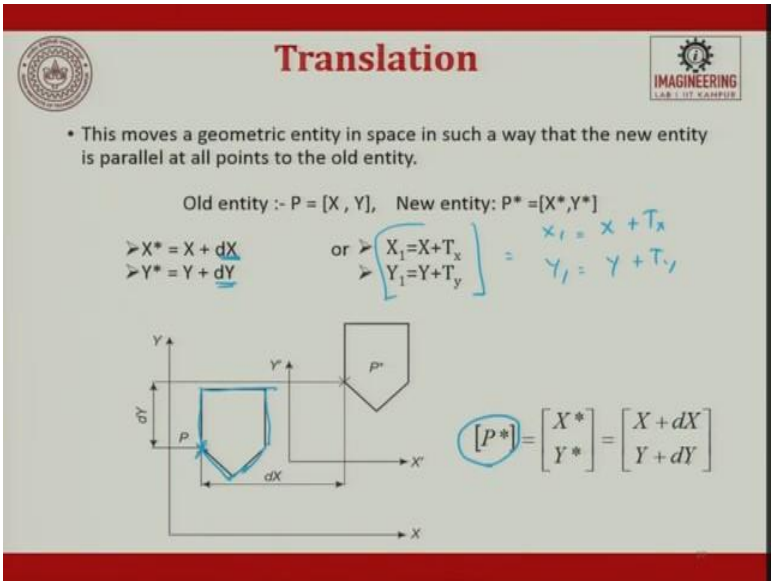

So, this moves a geometric entity in space in such a way that the new entry is parallel at all points to the old entry. So here, we have taken an object, so this object is, this is a full

object, maybe a pencil or a hut, inward hut, whatever, 2D. So now, I try to take this as a reference point and I try to say move by delta X in the X, and move by delta Y in the Y.

$$X^* = X + dX \quad \text{or, } X_1 = X + T_x$$

$$Y^* = Y + dY \quad \text{or, } Y_1 = Y + T_y$$

So, when I try to do it, I try to do a transformation matrix, so the matrix comes like this, that is nothing but X1, Y1 is the new point. So, that is nothing but X plus Tx which is transformation, Y plus Ty. So, when I represented bat into mattresses, P star is nothing but X star, Y star, which is nothing but X dX, Y dY.

$$[P^*] = \begin{bmatrix} X^* \\ Y^* \end{bmatrix} = \begin{bmatrix} X + dX \\ Y + dY \end{bmatrix}$$

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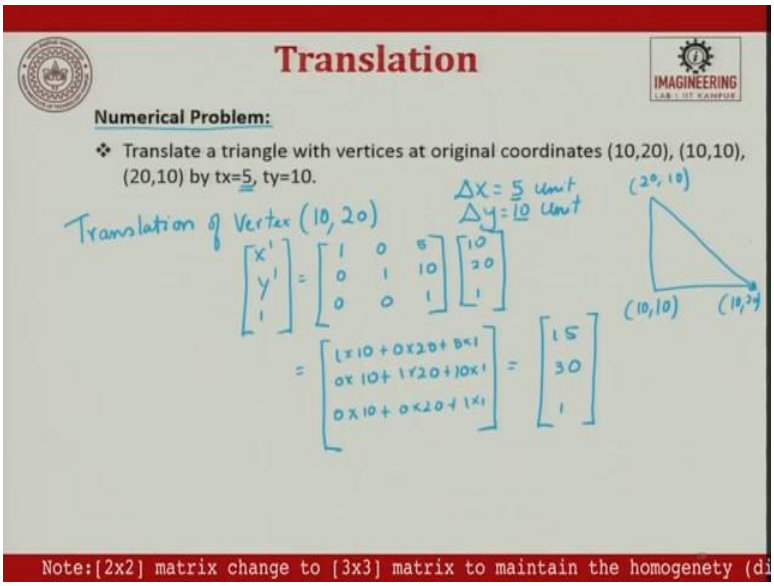

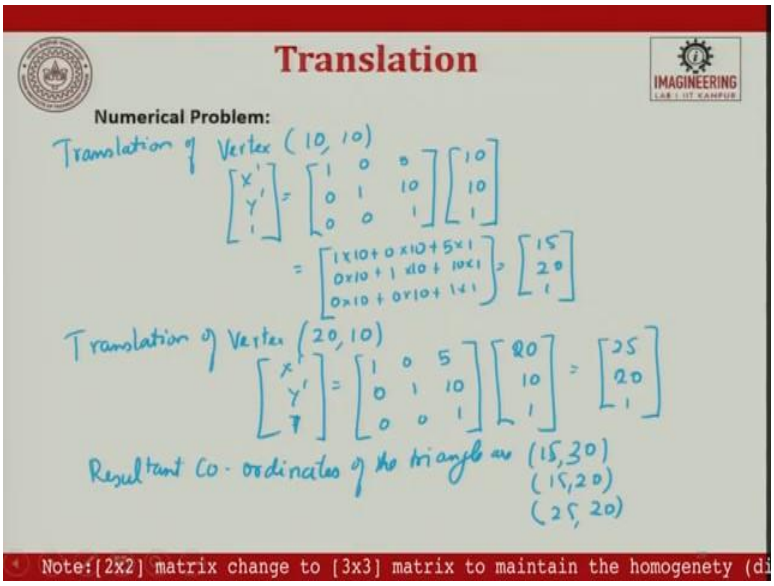

Let's see a simple numerical problem, to understand our transformation matrix and how does the operation happen. The problem given is translate a triangle with vertices at original coordinates of (10, 10), this is (10, 20) and this is (20, 10). So, this has to be moved by 5 delta X is by 5 units and delta Y by 10 units. So, now let us try to write down the translation matrix. Translation, 10 comma 20, so X dash, Y dash, 1, which is going to be the new point and here we are going to transform it 1, 0, 5, 0, 1, 10, 0, 0, 1.

Where is this 5 and 10 coming, these are the 5 and 10. So now, what is the existing position? I have 10, 20 comma 1. When I do the multiplication, I will get 1 cross 10, plus 0 cross 20, plus 5 cross 1. Next one will be 0 cross 10, plus 1 cross 20, plus 10 cross 1, next will be 0 cross 10, plus 0 cross 20, plus 1 cross 1. So, this will be equal to 15, which will be 30 and 1. Take this point, so we have done it.

So now, let us do the next one. So, translation of vertex (10,10), again we repeat. So, the new point X dash, Y dash, 1 will be equal to 1, 0, 5, 0, 1, 10, and then you get 0, 0, 1 into 10 cross, 10, 10, 1. So now, this will be written as 1 into 10, plus 0 into 10, plus 5 into 1. So, in the similar way if you do, let me do it quickly, 15 cross 20 cross 1.

I would like to check whether I made a mistake. So, on 20, 10, so this is 20 and 30. So, the translation of vertex 1 cross 1 will be this. When I do the translation of vertex, (20,10) will be X prime, Y prime, 1 since it is 2D we are putting Z as 1, so you will have 1, 0, 5, 0, 1,

10, 0, 1 multiplied by 20, 10 and 1. So, if you solve it, you will try to get 25, 20 and 1. So, now resultant coordinates of the triangle are 15 comma, 15 comma 20, 15 comma 30, 15 comma 20 and 25 comma 20.

So, we have translated the triangle in X direction by 5 units and Y direction by 10 units. And finally, what you get, is these are the coordinates for A, B and C. Thank you very much.