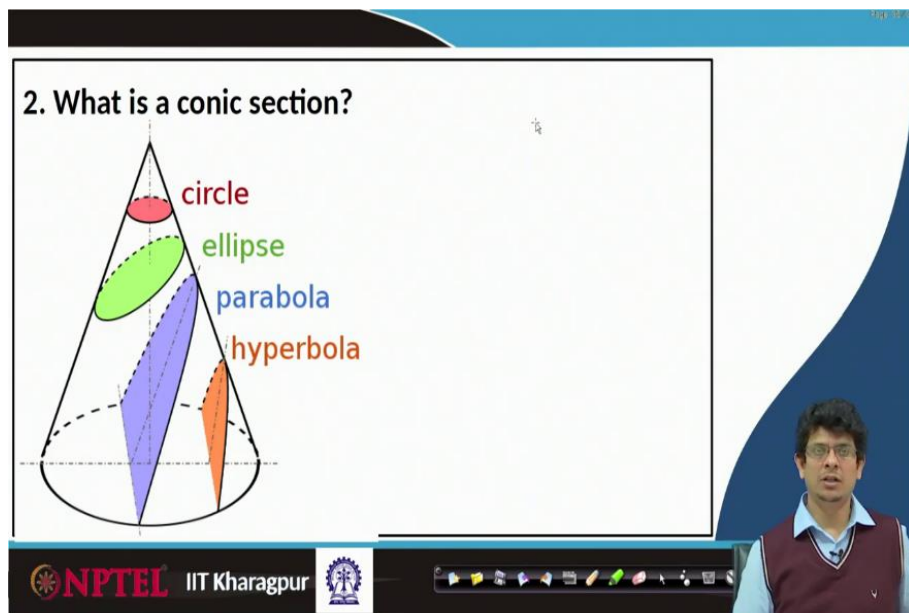


Engineering Drawing and Computer Graphics
Prof. Rajaram Lakkaraju
Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur

Module - 02
Lecture – 13
Conic Sections – V

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Conic sections, there we have learned many things like a horizontal slice to a right circular cone gives us circle, slant edges give us ellipse, further parabola, and hyperbola.

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2. How to construct conic sections?

Four methods are available for Ellipse construction

1. Focus-Directrix method
2. **Concentric circle method**
3. Oblong method
4. Arc of circle method



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In today's class, we will learn two special methods to construct ellipse, one is the concentric circle method, and the other one is the oblong method.

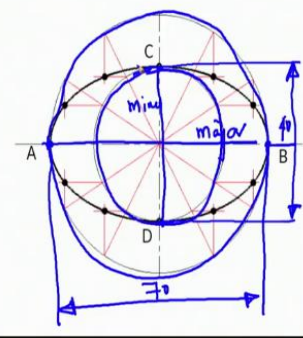
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Concentric circle method for ellipse


for example, draw an ellipse with major axis $AB=70$ mm and minor axis $CD=40$ mm

Steps to construct:

1. Draw the major axis $AB=70$ mm and minor axis $CD=40$ mm, bisecting each other at right angles at O



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In the concentric circles method, two concentric circles are drawn from there how to construct an ellipse based on the major axis, minor axis given for an ellipse. We will draw two circles of two different radii concentrically, and then join the lines to construct this, an ellipse.

Let us look at that through an example. For example, draw an ellipse with a major axis 70 mm and a minor axis 40 mm. For that purpose, what we have to do is to draw a horizontal line, which

we call major axis, in this case, AB 70 mm and minor axis with 40 mm. Furthermore, these two bisect with each other at right angles at O.

So, let us look at this. So, AB points on a horizontal line; these are 70 mm apart. Furthermore, the minor axis for an ellipse supposed to be 40 mm, that means, if we are extending these lines, they should not be get intersected that is a way one has to draw, and this part supposed to be 40 mm.

Furthermore, if we see carefully, this is 70 mm major axis, so the diameter of this entire circle itself is 70 mm. The other minor axis is at 40 mm. By drawing one more circle, we will be in a position to construct an ellipse.

(Refer Slide Time: 03:15)

Concentric circle method for ellipse

for example, draw an ellipse with major axis 70 mm and minor axis 40 mm

Steps to construct:

1. Draw the major axis AB=70 mm and minor axis CD=40 mm, bisecting each other at right angles at O
2. Draw two circles with AB and CD as diameters. Divide both the circles into 12 equal parts and number the divisions as A, 1,2,3, ..., 10, B, and C, and 1', 2', 3'.... 10' and D

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So, the first step, we have to draw two circles with AB and CD as diameters. After that, divide both the circles into 12 equal parts. So, let us pick the outer circle, this one. For this outer circle, the diameter is 70 mm; one has to divide into 12 equal parts. It can be 12, 24 equal number of parts one has to make it for both the major axis base circle and also minor axis base circle. Here we are going to make 12 parts. So, A begins with that 1, 2, 3, 4, 5; the sixth one is again B.

So, the first part, the second part, third part, fourth, fifth, sixth these are equal parts. On the bottom side also, so because of symmetry again 1, 2, 3, 4, 5, 6; in total, 12 parts we are going to construct.

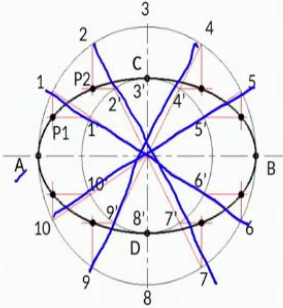
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Concentric circle method for ellipse

for example, draw an ellipse with major axis 70 mm and minor axis 40 mm

Steps to construct:

1. Draw the major axis $AB=70$ mm and minor axis $CD=40$ mm, bisecting each other at right angles at O
2. Draw two circles with AB and CD as diameters. Divide both the circles into 12 equal parts and number the divisions as $A, 1, 2, 3, \dots, 10, B$, and $C, 1', 2', 3', \dots, 10'$ and D



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And the names what we are making is beginning with A all the way to 1, 2, 3, 4, 5, and again B starting with 6, 7, 8 and 9 and 10, and again it goes to A. Similarly, if we by making this equal division, that means, we will be in a position to really draw such kind of normals for this major axis circle.

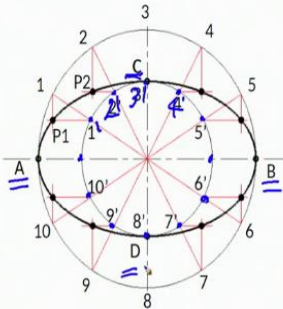
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Concentric circle method for ellipse

for example, draw an ellipse with major axis 70 mm and minor axis 40 mm

Steps to construct:

1. Draw the major axis $AB=70$ mm and minor axis $CD=40$ mm, bisecting each other at right angles at O
2. Draw two circles with AB and CD as diameters. Divide both the circles into 12 equal parts and number the divisions as $A, 1, 2, 3, \dots, 10, B$, and $C, 1', 2', 3', \dots, 10'$ and D



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Once it is done, we will extend those lines, so that there will be minor axis base circle also divided into 12 equal parts. The outer ones we are going to name it as 1, 2, 3, 4, 5; inner ones we are

going to name it like 1', 2', 3', 4' and so on. This is the convention what we are going to use. On major axis, the letter is A and B; on minor axis, the letters are C and D.

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Concentric circle method for ellipse

for example, draw an ellipse with major axis 70 mm and minor axis 40 mm

Steps to construct:

1. Draw the major axis AB=70 mm and minor axis CD=40 mm, bisecting each other at right angles at O
2. Draw two circles with AB and CD as diameters. Divide both the circles into 12 equal parts and number the divisions as A, 1,2,3, ..., 10, B, and C, and 1', 2', 3'.... 10' and D
3. Through 1, draw a line parallel to CD.
Through 1', draw a line parallel to AB. Mark P1 at their intersection

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After the division of these 12 equal parts, we draw a line parallel to CD, through the first point. We have identified the first point is 1 parallel to CD; CD line is this one. Parallel to this CD line we are going to draw a line at 1. Similarly, we will draw at 2; 3 is already there. At 4 also we will draw, 5, 6, 7, 8, 9 and 10 points also we will draw.

Once that is done, through 1' draw a line parallel to AB. 1' is this point. AB line is this. Parallel to that, we will draw a line. Similarly a 2', 3' intersecting point, 4', 5' we will draw. Once we are doing after that, we have these intersection points which are away from the inner circle and into that outer circle.

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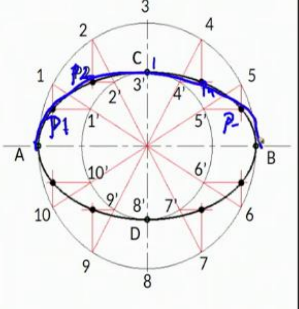
Concentric circle method for ellipse

for example, draw an ellipse with major axis 70 mm and minor axis 40 mm

Steps to construct:

1. Draw the major axis AB=70 mm and minor axis CD=40 mm, bisecting each other at right angles at O
2. Draw two circles with AB and CD as diameters. Divide both the circles into 12 equal parts and number the divisions as A, 1, 2, 3, ..., 10, B, and C, and 1', 2', 3'... 10' and D
3. Through 1, draw a line parallel to CD. Through 1', draw a line parallel to AB. Mark P1 at their intersection

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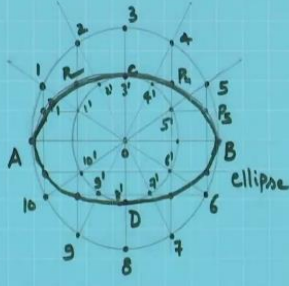


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So, these points we will name it as P 1, P 2, P 3, this is P 3, which is already C, P 4, P 5, and B and so on. Once we have these points, we join them to get the top part of the ellipse.

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Concentric Circle method



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So, let us do that on the page. Ellipse with major axis 70 mm. So, let us draw 70 mm, 70 mm, the first point we are marking there, 70 mm we are marking, this is the one. And this is the major axis. So, by using bisector, we will be in a position to identify the center; otherwise, now it is 35 units. Once it is done, we will construct a circle which pass through both the points, let us name them: the first point is A, the second point is B, let us call this centre as O. We have to draw a perpendicular line.

So, if we have a drafter, it is relatively easy; otherwise, we use this set of scales and extend this is the line. So, the centre will be done; after that, we have to draw 40 axis diameter circle, that means, 20 millimetres radius we are going to pick; this is 20 mm. So, carefully pick measure 20 mm from here draw a circle. After that, we have to divide this one. So, let us name this point C and D.

Once it is done, we have to divide this into 12 equal parts. Let us count like the first part, second, third parts on this figure. So, the third part means let us use our protractor 30 degrees, again 60 degrees and 90 degrees. Let us join these lines. And similarly, join these points. Similarly, on this side also mark these points 60 degrees, and on this side 30 degrees. Let us join through this. So, we make 12 parts. Let us label them this point is 1, 2, 3, 4, 5, 6, this 7, 8, 9, 10 points. Similarly, inside points, 1', 2', 3' which is c', next one is 4', 5', and this is 6' B any point is there. So, let us call 6', 7', 8', 9, 10' done.

Now, what we have to do is, the second step let us look at that second step is through 1, draw a line parallel to CD; so through 1, draw a line parallel to CD. So, if we have a ruler scale, we could have drawn it in that way otherwise let us use our scale. We have this 90 degrees line, because they are bisecting. So, adjust the scale carefully and draw a parallel line. Similarly, a 2 draw a parallel line; 3 already there; at 4 also draw; 5 also we have to draw that line. So, let us do that it 5. So, vertical lines we have drawn.

Now, at 1' onwards, we have to draw horizontal. For 1 this is the horizontal line which is mapped with the grid. So, let us label this point as P 1. Similarly, at 2, we have to draw a horizontal line to intersect it is more or less at this point. 3, similarly at 4, also intersect this point. At 5, this is precisely on the grid map; so connect that. Once it is done, label them P 2, P 3 is already there, this is P 4, P 5 points.

Now, draw a freehand sketch which is passing through A P 2 C 3 P 4 P 5 and B. So, if we have French curves one can smoothly construct a nice line which is passing through that C P 4 P 5 and B. Similarly, one will be in a position to construct at bottom lines also. Let us construct those.

So, 1 and 10 points are on the same line which we have to extend. Similarly, at 2 and 9 points are on the same line, extend this 9 and 7 also in the horizontal plane. So, wherever it is intersecting locate those points, these lines are also extendable, and this is the other point. So, let us name this. Extend this 5 also this point. If we have more number of points, the curve looks nice and smooth.

So, let us join by freehand. This is the way one will be in a position to construct it. If we have 24 points or perhaps 48 points, we get a better picture. This is an ellipse. This is by concentric circle method. If we know the major axis and the minor axis, one will be in a position to construct this.

(Refer Slide Time: 17:59)

Concentric circle method for ellipse

for example, draw an ellipse with major axis 70 mm and minor axis 40 mm

Steps to construct:

4. Obtain P2, P4, P5, etc., in a similar way.
5. Draw a smooth closed curve through A-P1-P2-C-P4-P5-B-P6-P7-D-P9-P10-A

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Concentric circle method for ellipse

Let us

draw an ellipse with minor axis 40 mm on horizontal direction and the major axis 70 mm in the vertical direction

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So, we are done with horizontal kind of ellipse. If we would like to construct vertical ellipse that means, the major axis is aligned with x-axis are now horizontal plane that if it is aligned with the vertical axis, the same procedure we have to do. Instead of drawing dropping this one line, all

the way down we are going to project this all the way this one line onto the horizontal axis, it is more like by symmetry. It turns out to be this kind of circle, please practice this example.

(Refer Slide Time: 18:48)

2. How to construct conic sections?

Four methods are available for **Ellipse** construction

1. Focus-Directrix method
2. Concentric circle method
- 3. Oblong method**
4. Arc of circle method

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Oblong method for ellipse construction

for example, draw an ellipse with major axis 100 mm and minor axis 50 mm

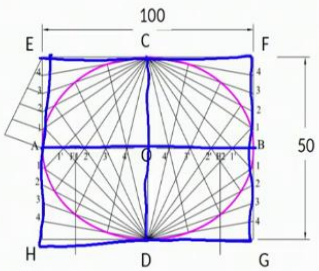
The diagram shows a rectangle with vertices E, C, F, D, G, H. The major axis is labeled 100 and the minor axis is labeled 50. The ellipse is constructed using the oblong method, with points A, B, C, D, E, F, G, H marked on the rectangle and the ellipse.

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After doing this concentric circle method, we will go with the oblong method. In this oblong method, we construct a rectangle based on the major axis of 100 mm. Here, the minor axis for this ellipse is 50 mm.

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Oblong method for ellipse construction
for example, draw an ellipse with major axis 100 mm and minor axis 50 mm



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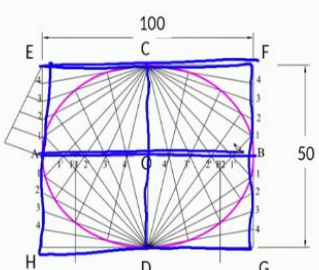
For that purpose, what we have to do is, first of all, draw AB line, draw CD line orthogonal to each other. Then construct a box a rectangular box where EF is equal to AB line.

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Oblong method for ellipse construction

Steps to construct:

1. Draw the major axis $AB=100$ mm and minor axis $CD=50$ mm, bisecting each other at right angles at O
2. Draw a rectangle EFGH such that $EF=AB$ and $FG=CD$



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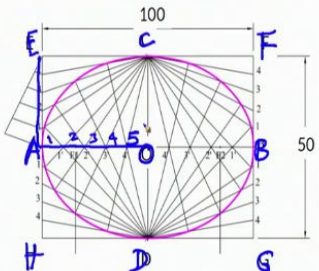
Then divide AO and AE into the same number of points

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Oblong method for ellipse construction

Steps to construct:

1. Draw the major axis $AB=100$ mm and minor axis $CD=50$ mm, bisecting each other at right angles at O
2. Draw a rectangle $EFGH$ such that $EF=AB$ and $FG=CD$
3. Divide AO and AE into same number of equal parts, say 5. Number the divisions as 1,2,3,4 and 1',2',3',4' starting from A



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The intersecting point is O this point is A . BCD for the rectangle this is HGF and E . Now, divide AO and AE . AO is this one; AE is this one, this quadrant of that rectangle into the same number of equal parts let us say 5. If we have 50 points, then accuracy will be nice, and we will have a very smooth curve. If we have less number of points, it may not be a very smooth curve; that is the only difference.

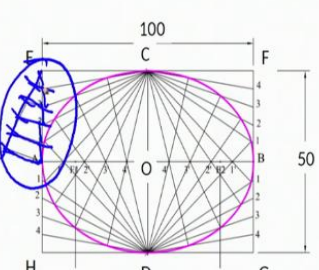
So, what we are going to do is divide AO into an equal number of 5 parts.

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Oblong method for ellipse construction

Steps to construct:

1. Draw the major axis $AB=100$ mm and minor axis $CD=50$ mm, bisecting each other at right angles at O
2. Draw a rectangle $EFGH$ such that $EF=AB$ and $FG=CD$
3. Divide AO and AE into same number of equal parts, say 5. Number the divisions as 1,2,3,4 and 1',2',3',4' starting from A



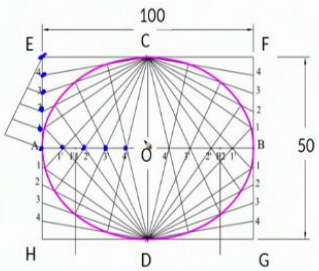
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Oblong method for ellipse construction

Steps to construct:

1. Draw the major axis $AB=100$ mm and minor axis $CD=50$ mm, bisecting each other at right angles at O
2. Draw a rectangle $EFGH$ such that $EF=AB$ and $FG=CD$
3. Divide AO and AE into same number of equal parts, say 5. Number the divisions as $1,2,3,4$ and $1',2',3',4'$ starting from A



The diagram shows a rectangle EFGH with major axis AB=100mm and minor axis CD=50mm. The center is O. The major axis is divided into 5 equal parts (1, 2, 3, 4, 5) and the minor axis into 5 equal parts (1', 2', 3', 4', 5'). Lines are drawn from C to the divisions on the major axis and from the divisions on the minor axis to D. The intersection points form the ellipse.

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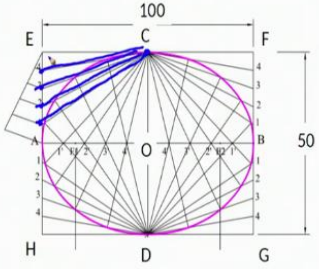
Then name after dividing that AO , AE into the same number of equal parts, let us say 5. Number the divisions as 1, 2, 3, 4. So, the division is this is A - first, second point, third point, fourth point, and eighth point. Similarly, $1', 2', 3'$ on the horizontal axis; $1', 2', 3', 4'$, and O .

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Oblong method for ellipse construction

Steps to construct:

1. Draw the major axis $AB=100$ mm and minor axis $CD=50$ mm, bisecting each other at right angles at O
2. Draw a rectangle $EFGH$ such that $EF=AB$ and $FG=CD$
3. Divide AO and AE into same number of equal parts, say 5. Number the divisions as $1,2,3,4$ and $1',2',3',4'$ starting from A
4. Join C with $1, 2$ and 3



The diagram shows a rectangle EFGH with major axis AB=100mm and minor axis CD=50mm. The center is O. The major axis is divided into 5 equal parts (1, 2, 3, 4, 5) and the minor axis into 5 equal parts (1', 2', 3', 4', 5'). Lines are drawn from C to the divisions on the major axis and from the divisions on the minor axis to D. The intersection points form the ellipse.

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Once it is done, join C with 1, 2, 3 points. C is this; 1, 2, 3 on the side axis; 1, 2, 3, 4.

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Oblong method for ellipse construction
Steps to construct:

5. Join D with 1' and extend it to meet C-1 at P1. Similarly, join D with 2' and 3' and extend them to meet C-2 and C-3 respectively to locate P2 and P3.

■ C -> 1, 2, 3, 4

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So, from there, draw lines, first one, the second one, the third one, the fourth one. From from C, we are going to connect 1, 2, 3, and 4 points. Once it is done, join D with 1' and so on. So, from D also we are going to join 1', 2'. So, C is on this side, D is on the other side. Join C onto this axis vertical axis join D with the horizontal axis.

So, 1', 2', 3', 4' will be in a position to get that. So, extend all these lines.

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Oblong method for ellipse construction
Steps to construct:

5. Join D with 1' and extend it to meet C-1 at P1. Similarly, join D with 2' and 3' and extend them to meet C-2 and C-3 respectively to locate P2 and P3.

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Let us pick first point C to 1; it goes all the way up to that point. When we are joining D to 1', this line goes all the way intersect at that point, then finally goes all the way. So, wherever it is

intersecting, let us stop it; let us call that point P 1. Similarly, from C to draw a line, all the way to the vertical axis.

Once it is done from D point, we have to go along that stop it where it is going to intersect 2. So, line by line, we identify, [nose] then indicate P 2, P 3, P 4, and the next point. So, once it is done from A, we will draw a smooth freehand curve. There is the way one quadrant of this ellipse can be constructed.

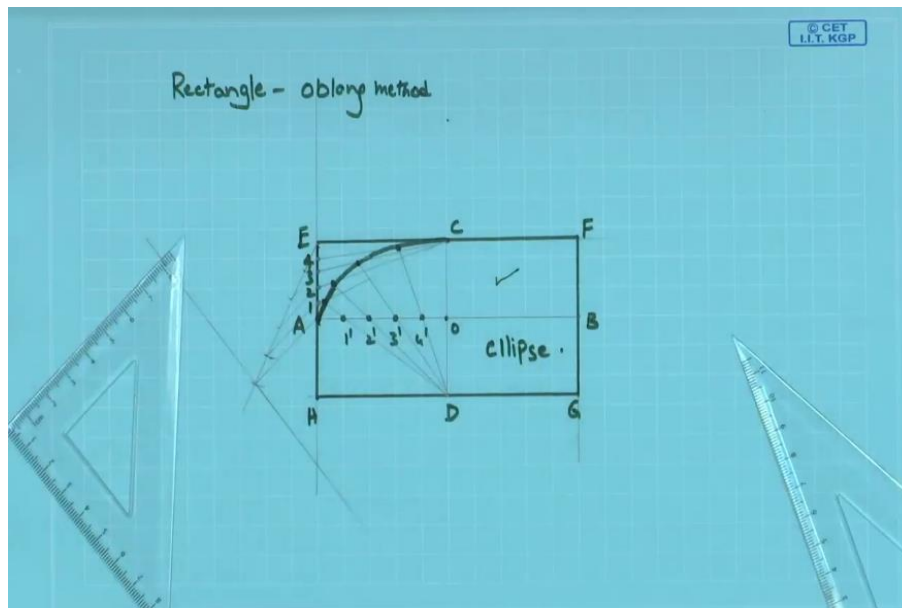
Once it is done, the same procedure we have to repeat it from C to B F line something like dividing into 1, 2, 3, 4 draw a line which goes C via 1. Similarly, from point D, all the way through 1', wherever it is intersecting, call that point; then from D go via 2', and similarly C via 2 wherever it is intersecting P 2. So, that identify these top portions also, one will be in a position to construct that. Same procedure one has to repeat it for this part also so that one will be in a position to identify these points, construct this curve.

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The slide displays the 'Oblong method for ellipse construction'. It includes a diagram of a rectangle with a width of 100 mm and a height of 50 mm. The top corners are labeled C and F, and the bottom corners are labeled D and G. The center is O. The top edge is divided into four equal parts, labeled 1, 2, 3, and 4 from left to right. The bottom edge is also divided into four equal parts, labeled 1', 2', 3', and 4' from left to right. Construction lines are drawn from each point on the top edge to the opposite corner on the bottom edge (e.g., C to 1', D to 2', etc.). The intersection points of these lines are labeled P1, P2, P3, and P4. A smooth curve is drawn through these points to form one quadrant of the ellipse. The text on the slide reads: '5. Join D with 1' and extend it to meet C-1 at P1. Similarly, join D with 2' and 3' and extend them to meet C-2 and C-3 respectively to locate P2 and P3.'

Let us briefly look at one quadrant of this, that means we will draw this rectangular box then construct this one-fourth quadrant of an ellipse. Let us do that. First of all, this is 100 mm by 50 mm; we have to construct it.

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So, let us note 100 mm on the paper. These are the points. Then 50 mm, we have to locate it. Draw a perpendicular bisector. So, here because this is a 50 mm, so it is relatively easy to locate 25 mm on this graph sheet for us, 25 will be at the middle. Once we have that, we can construct a perpendicular line. So, once it is done, we will be in a position to construct this part. So, this is, on this graph sheet, so go ahead construct down. Similarly, construct on the graph sheet all the way down. This distance supposed to be same as, so from here, let us mark and join these lines. So, we have constructed a rectangle, let us name it. Once it is done, name A, B, E, F, C, O, D, H, G. Now, we have to divide into an equal number of divisions here, already we have a grid network. So, let us divide that into equal parts, perhaps 1, 2, 3, 4. So, 1, 2, 3, 4, 5 equal parts are there, but now we cannot divide these equal parts 5 equal parts. So, for that purpose what we have to do is draw something like such kind of line. Use compass to locate 5 equal divisions, something like 1, from there 2, 3, 4, 5. Once it is done, join these divisions, one go parallel to that line. So, to go parallel to that line, let us draw a normal and so that we will have better support because we are not using any drafter here, so it is easy for us to go in this direction 2, 3, 4, 5. So, this is the way 1, 2, 3, 4, 5. Let us name it points 1, 2, 3, 4. Similarly, these points are 1', 2', 3', 4'. Now, what we have to do is from C to 4, C to 1, and so on. We have to connect. So, let us connect C point all the way to first point. So, C to 1, let us draw it 1, 2, 3, 4. Similarly, D onwards, we have to systematically connect it a line which is passing through 1' going to intersect there. D to 2'; 3', all the way to third line; from there, 4' to the fourth line. Now, mark the points, the first point this is the one, second, third, fourth, fifth, and this. So, our ellipse goes via these points; this is the way one has to construct. Furthermore, this part one has to construct by the division of an equal number of things. Similarly, this point has to be constructed by the

division of these things so that one will be in a position to complete the ellipse and this method what we call rectangle method or this oblong method.

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Oblong method for ellipse construction
Steps to construct:

5. Join D with 1' and extend it to meet C-1 at P1. Similarly, join D with 2' and 3' and extend them to meet C-2 and C-3 respectively to locate P2 and P3.
6. Obtain other points in the remaining three quadrants in a similar way. Alternatively, other points can be obtained by drawing lines parallel to AB and CD, through the points P1, P2, P3, etc. For example, draw P1-P6 parallel to AB such that P1-x=x-P6. Similarly, P2-y=y-P5, P3-z=z-P4 and P4-u=u-P9
7. Join P1, P2, P3, etc to obtain the ellipse.

Once we join this P 1, P 2, P 3, and so on, these are the points P 1, P 2, P 3, and P 4 via C; we will get this ellipse.

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2. How to construct conic sections?

Four methods are available for Ellipse construction

1. Focus-Directrix method
2. Concentric circle method
3. Oblong method
4. Arc of circle method In next lecture

So, in this lecture, we have learned about the concentric circle method and oblong method. In the next lecture, we will learn about the arc of circles methods to construct an ellipse. Thank you very much.