FastCAM Software Series

FastCAM®

Drawing Guide

The World Standard in Profiling Software

Table of Contents

Introduction

Conventions used in this manual

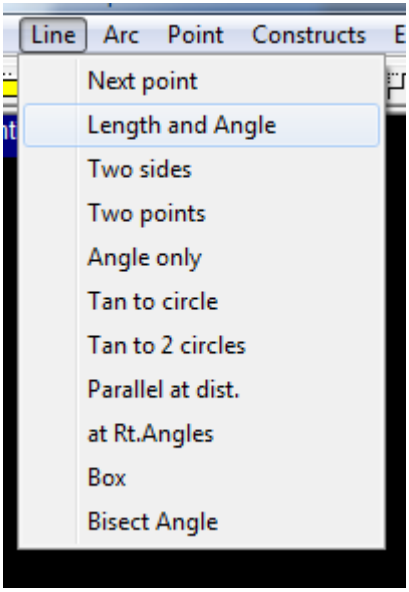
Bold items

These refer to actions. For these you will be directed what to **click/do**.

Dropdown Menu > Target

The added "**>**" means the **Target** you need to click is within a **Dropdown Menu.** You need to first click on the **Dropdown Menu**, and then the **Target**.

E.g. **Line > Length and Angle** refers to this option:



Data to enter

When there is a value to be entered, it shown in Italics. There are also a few hints in the document that are also highlighted with italics

Drawing Units

Please also note All Drawings are Metric. However there is no significant difference between drawing in metric units and drawing in Imperial units. In fact you can do all the drawings as they are presented here in Inches.

Difficulties

There are 3 different levels of difficulty within this document. Each has a different style of writing, designed to teach you different elements of the drawing editor.

Beginner

This is a thorough walkthrough of the procedure to create basic shapes. It covers almost all actions, and is designed to get you familiarized with the Software and its basic functions, such as creating points, lines, and arcs. As well as where different menu options reside

Intermediate

These are for more complex drawings that draw on special functions present within the software. These are designed for people who have a basic understanding of FastCAM and its abilities. It is not as in depth as the Beginner guide.

Advanced

These drawings are complex. These focus more on how to interpret the drawing and draw it. As such they are not as in-depth into the actual procedure within FastCAM, as you will be expected to be quite proficient with using FastCAM to draw.

READ THIS FIRST – Important FastCAM Controls

Left Click - Select

This will select a point or an option in FastCAM. Unless otherwise specified, an instruction to "**Click**" refers to a left click.

e.g. Enter the Radius, *60.3*. Click **Enter**.

Right Click - Mode Exit

In FastCAM a right click is used as a **cancel operation**, so if you find yourself stuck in a mode, just right click repeatedly to exit it.

Undo Button

If you find you have made a mistake, click the **Undo** Button to remove it.

Redo Button

If you want to re-do an option you just Un-did, click the **Redo** Button.

New Drawing Button

To quickly start a new drawing click the **New** File button

Open a Drawing Button

To re-open a drawing file, just click on the **Open** file button, navigate to the file, and open it.

Save Drawing Button

To Save a drawing, click the **Save** button, then name and save the drawing to a location of your choosing.

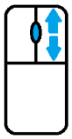
Zoom Window

Using the **View-Indicated Corners** option, you can zoom into a specified area of your drawing by selecting the corners of the area you wish to zoom in on.

Autoscale Button

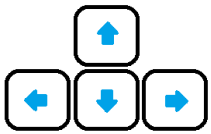
If you wish to view the whole drawing, click the **Autoscale** Button. This will change the zoom to fit the whole drawing in on your screen

Scroll Zoom



You can also use the **Scroll wheel** to zoom in & out, around where your mouse is located on the screen.

Moving Display



You can use the Arrow Keys to move your current zoom in the direction of the arrow pressed.

Beginner Drawings

Collar

Rating: Beginner

Time: 15 minutes

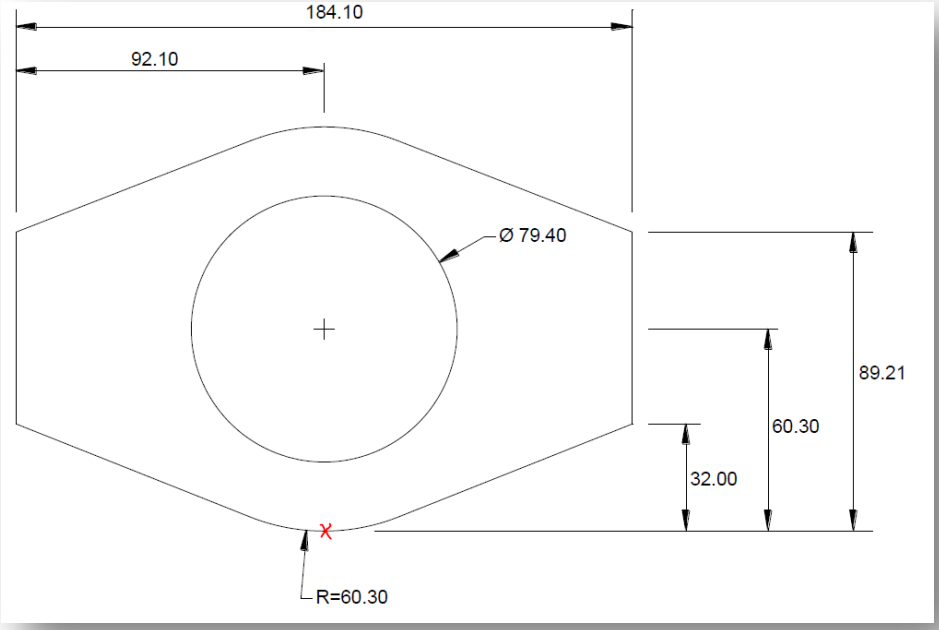


Figure 1 : The Collar Plate, with the origin indicated

Instructions

1. As with all drawings, choosing an origin is the first task you must complete. We will be using the Bottom Middle of the outside arc as the **Origin point** of the Drawing (the **Red** Cross)

a. We chose this point because all the vertical & horizontal points are dimensioned in relation with it.

2. First we will create the internal circle of the part. Click the **Circle** option

3. Next enter the DIAMETER of the inner circle. With the special '*d*' character at the end to designate it as a diameter, not a radius, *79.4d*. Click **Enter**

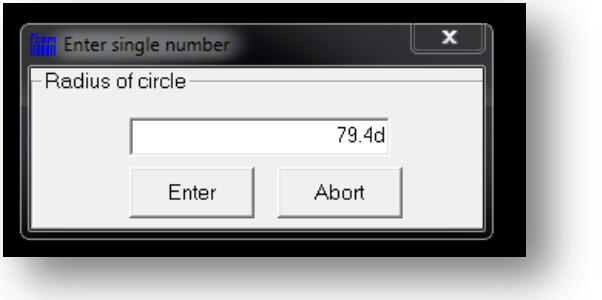


Figure 2 : The Diameter of the inner circle, with special 'd' character at the end

4. Next it will ask you where you wish to place this circle. **Right Click** to bring up the *Point Menu.*

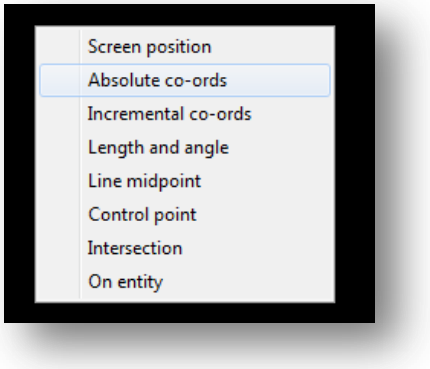


Figure 3 : The Point Menu

5. Click **Absolute Coordinates**
6. Fill in the center of the circle's coordinates as per the drawing, from our Origin (*0,60.3*) point, and click **Enter.**

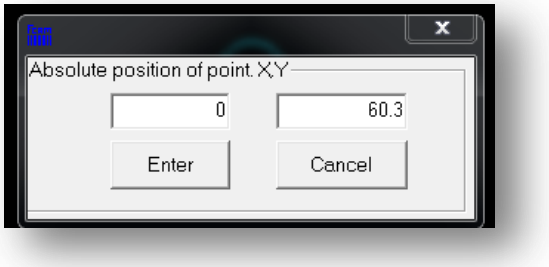


Figure 4 : The Centre of the Circle

7. Click **Cancel**, on the subsequent circle absolute coordinate location, and then **Right Click repeatedly**. (This will exit the add circle mode)
8. Re-size the drawing with the **Autoscale** button.

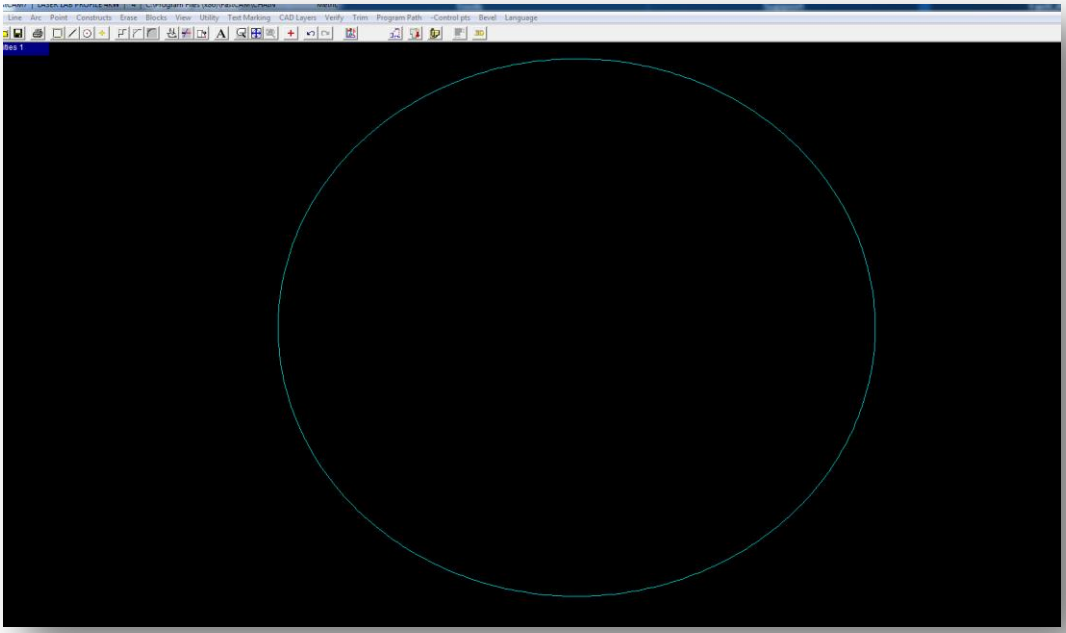


Figure 5 : The circle after it is created

9. Now we need to create the 4x points around the collar. These Points will be used to build the rest of the drawing. Click on the **point** button

10. **Right Click** to bring up the *Point Menu* again. *(refer to earlier screenshot)*
11. Click **Absolute Coordinates**
12. Add points for the top and bottom of the straight segments on the left and right of the drawing, as per the red circles below. With the **absolute coordinate** window open, input the following:

A. *X = 92.1,* *Y = 32.0,* Click **Enter**
B. *X = 92.1,* *Y = 89.21,* Click **Enter**
C. *X= -92.1,* *Y = 89.21,* Click **Enter**
D. *X= -92.1,* *Y = 32.0,* Click **Enter**

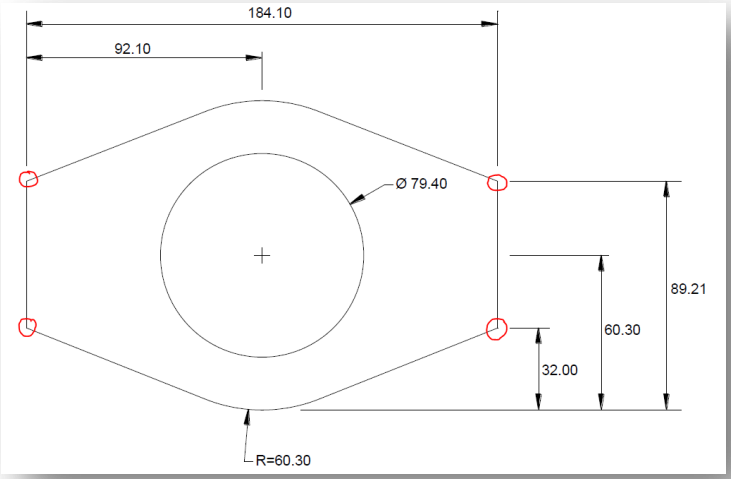


Figure 6 : **The points that are needed, as highlighted by the red circles**

13. Click **Cancel** and **then Right Click** (outside the point menu), to exit the add point mode.
14. Click **Autoscale**

15. Now we will add a concentric construction circle for the exterior top and bottom arcs. Click the **Circle** option

16. Enter the Radius, *60.3*. Click **Enter**.

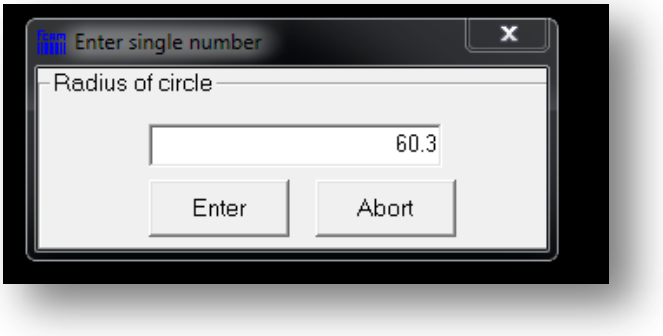


Figure 7 : The Outer Circle Radius

17. **Cancel** the Absolute window if it appears, and you will go to the *Points Menu*
18. **Or Right Click** to bring up the *Points Menu* again. *(refer to earlier screenshot)*
19. Select **Control Point** from the list.
20. **Click** on the Red Cross to bring up the control points of the drawing

21. **Click** on the green cross at the center of the first circle. This is the control point for that circle.

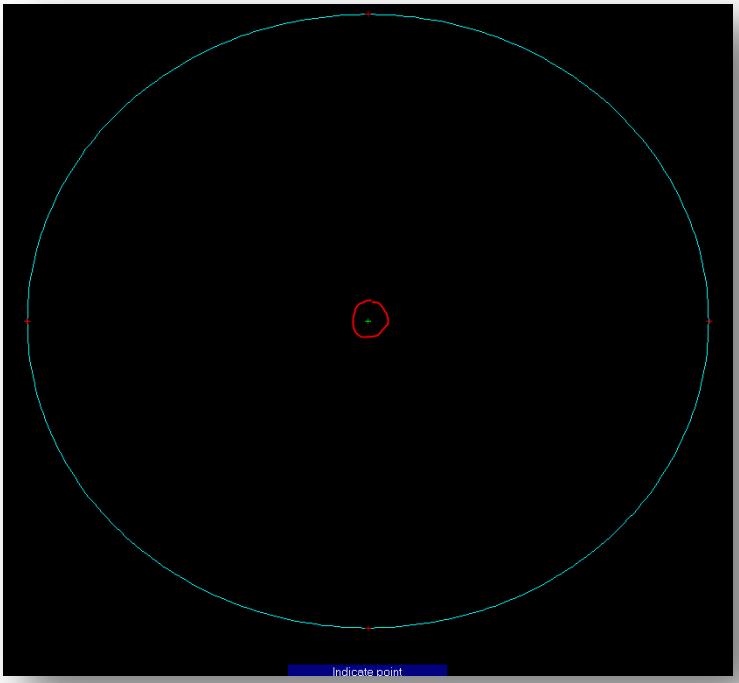


Figure 8 : **The Middle Circle with control points turned on**

22. **Autoscale**

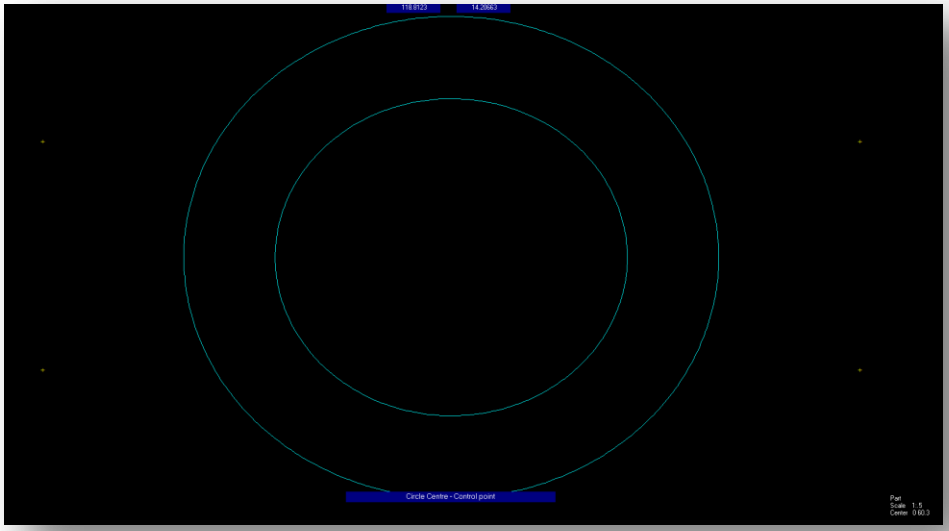


Figure 9 : **The two circles, and the 4 points**

23. Click on the **Line 2-points** button

24. **Right Click** to bring up the *Points Menu* again. *(refer to earlier screenshot)*
25. Select **Control Point** from the list.
26. Create the Left Vertical Line, by **clicking** on the top left & bottom left points, which we created earlier. *(check the next image for a preview)*
27. Create the Right Vertical Line, by **clicking** on the top Right & bottom Right points, which we created earlier. *(check the next image for a preview)*

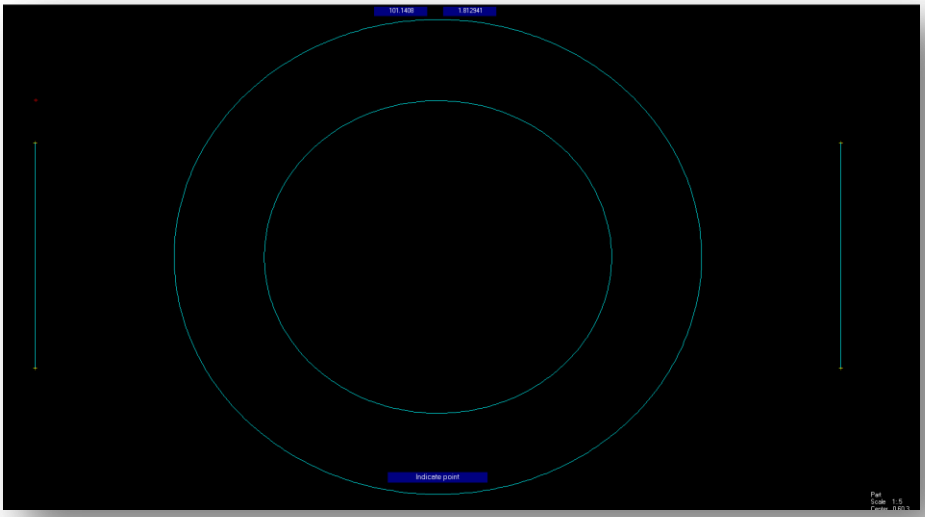
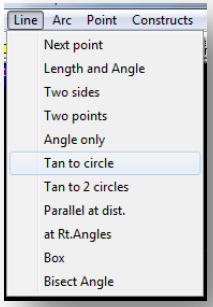


Figure 10 : **The two circles and the two vertical Lines**

28. **Right click** three times to exit the add line mode
29. Click on the **Lines > Tan to Circle** *(Tangent to Circle). We will be using continual placement of tangential lines, so if for any reason you exit the* ***Tan to Circle*** *mode, just repeat this step.*



30. **Click** on the top left arc of the outer Circle, close to where the tangent would join the circle.
31. Select **Given Point**
32. Then **click** on the Top left control point of the left vertical line, for the top left tangential line.

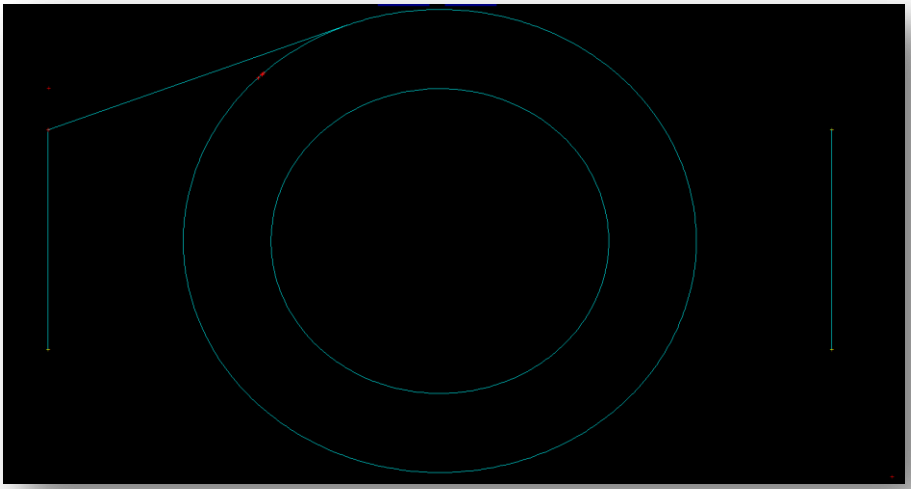


Figure 11 : The Tangent for the Top Left Corner

33. **Click** the bottom left arc of the outer circle, again close to where the tangent would join the circle
34. Select **Given Point**
35. **Click** the bottom left control point of the left vertical line,, for the bottom left tangential line

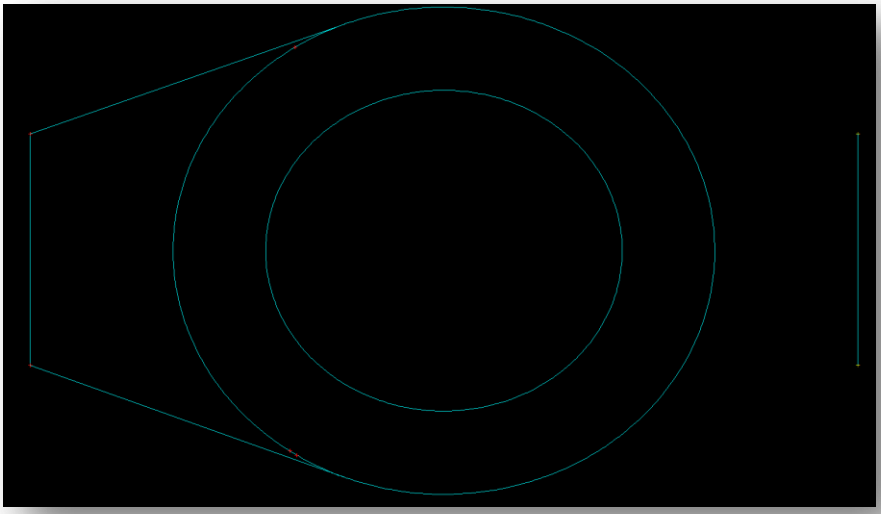


Figure 12 : The Bottom left tangential line created

36. **Click** the bottom right arc of the outer circle, again close to where the tangent would join the circle
37. Select **Given Point**
38. **Click** the bottom right control point of the right vertical line, for the bottom right tangential line

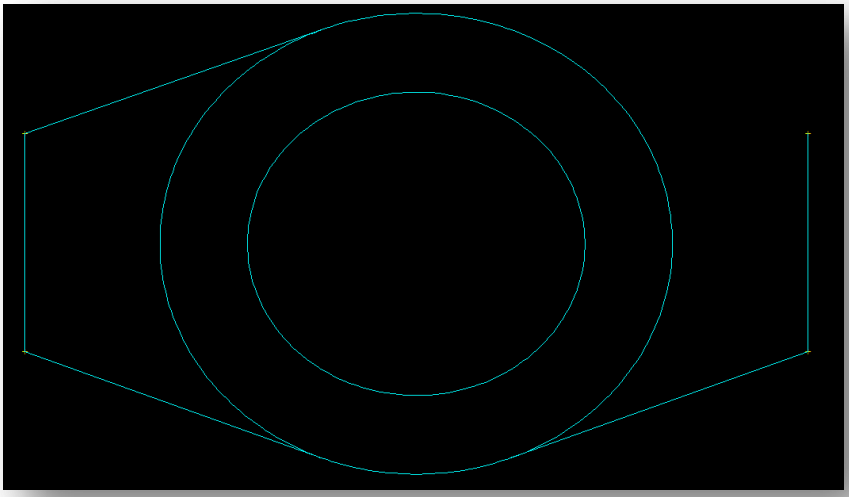


Figure 13 : **The top right tangential line created**

39. **Click** the top right arc of the outer circle, again close to where the tangent would join the circle
40. Select **Given Point**
41. **Click** the top right control point of the right vertical line, for the bottom right tangential line

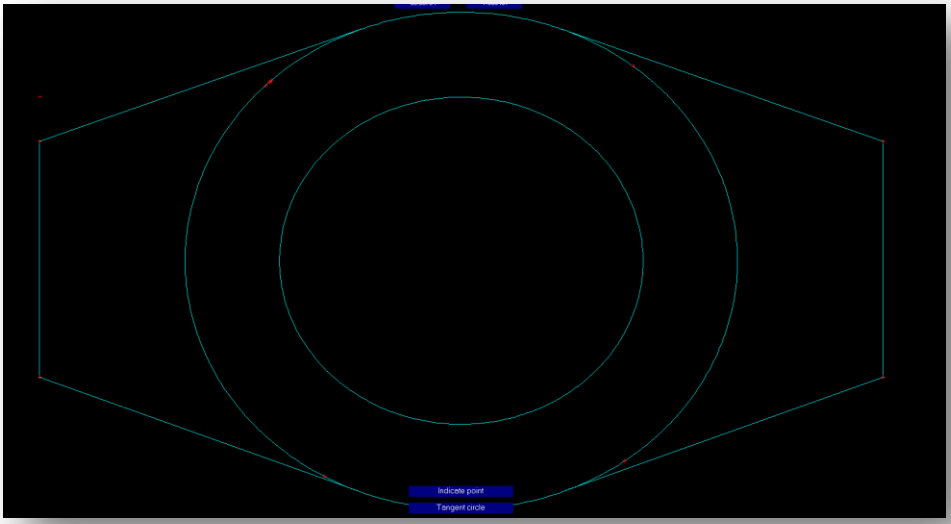
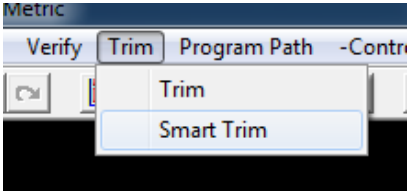


Figure 14 : **The completed Shape, ready for Trimming**

42. **Right click** twice to exit *tan to circle* mode.
43. Next we need to remove the two extra interior arcs. We can do this by using the **Smart Trim** Feature. Click **Trim > Smart Trim**



44. **Left click** on the two extra interior arcs to remove them.

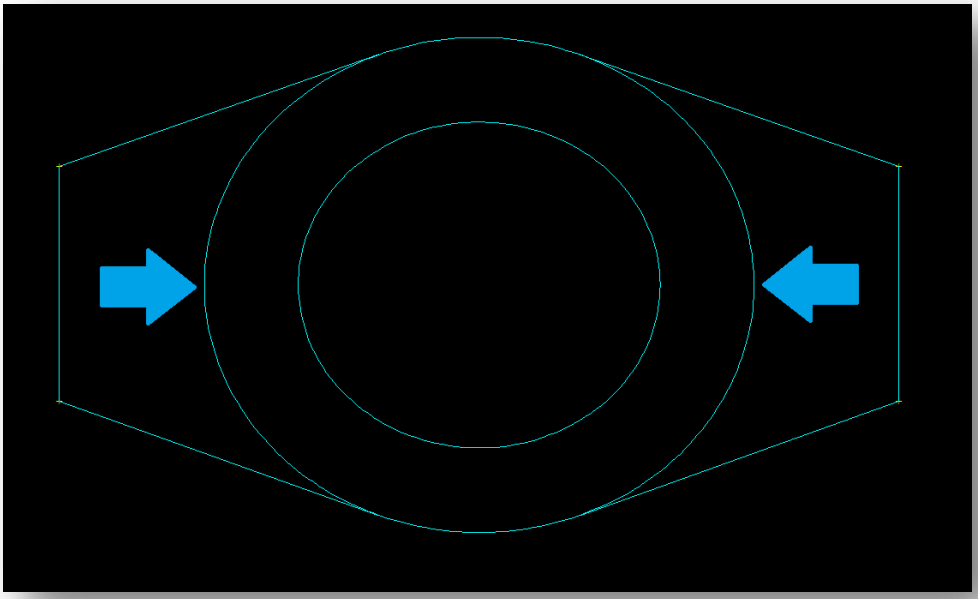


Figure 15 : The two lines that require trimming

45. **Right Click to exit** smart trim mode.
46. **Autoscale**

Finished Drawing

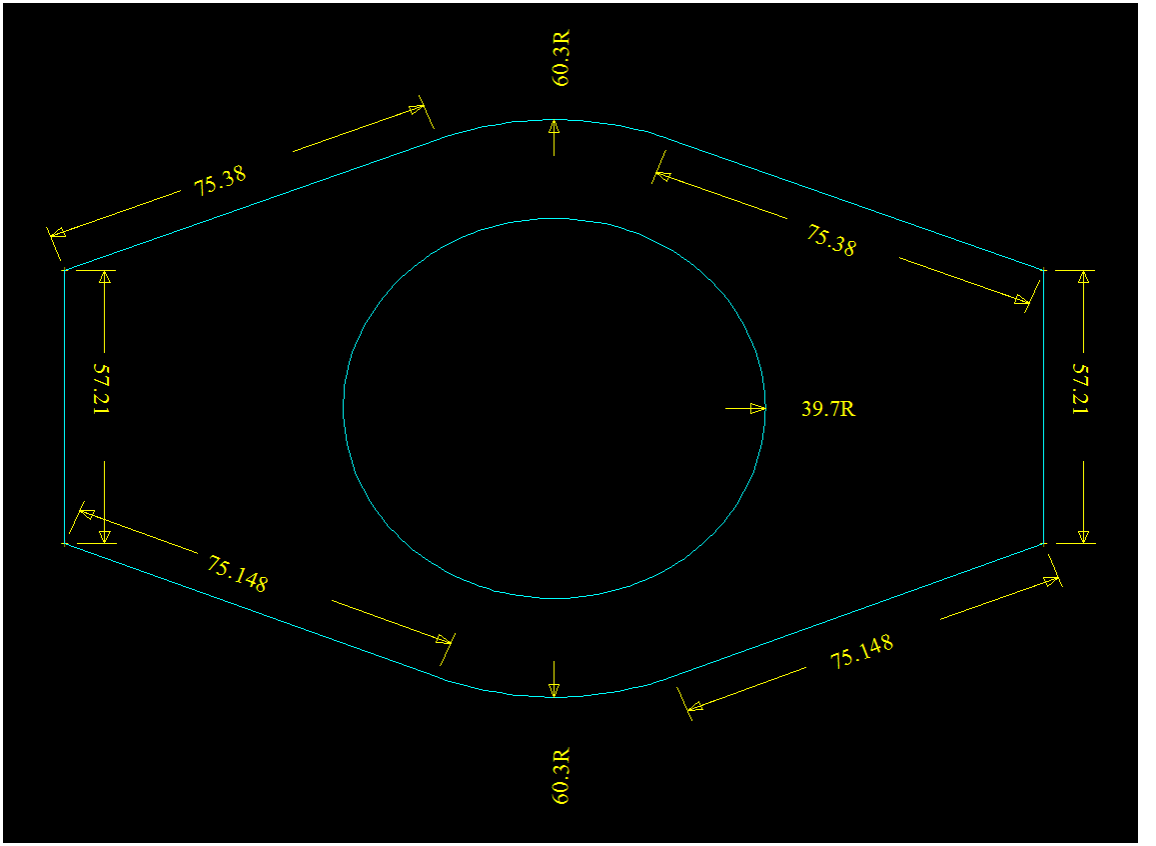


Figure 16 : The Complete Collar Drawing

47. The Collar is now complete!

Widget

Rating: Beginner

Time: 12 Minutes

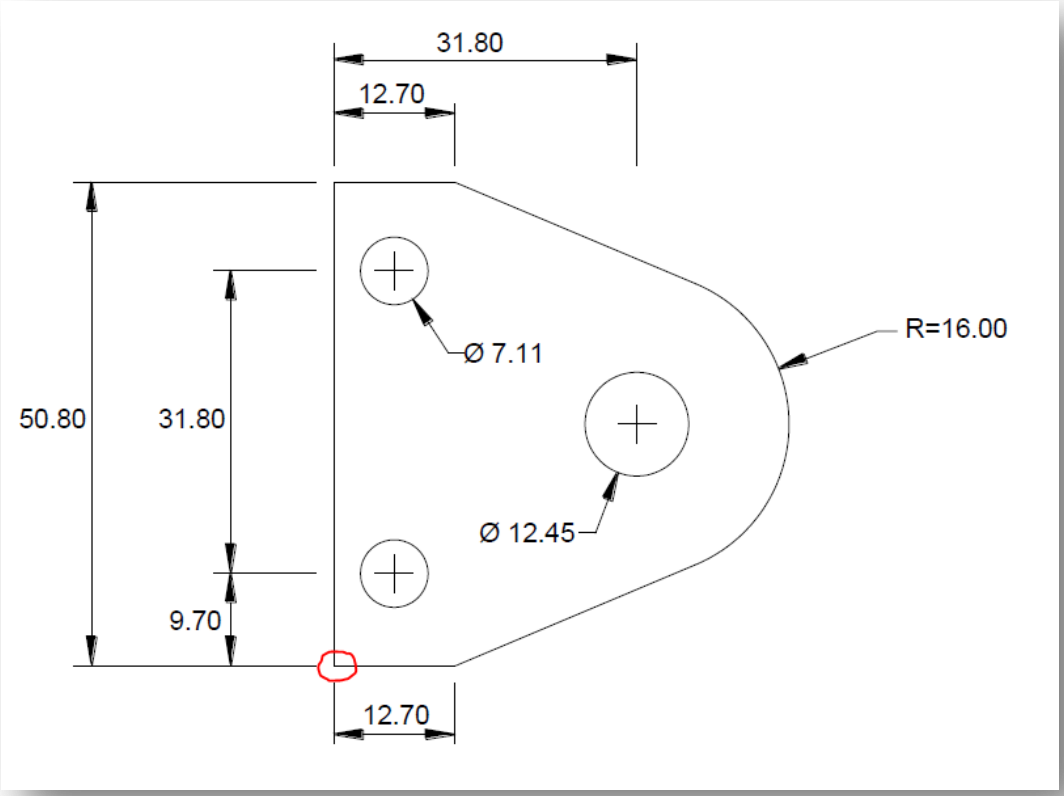


Figure 17 : The Widget, with our origin indicated

Instructions

1. As always, the first question is where to set the origin of the piece. In this case we will select the bottom Left corner of the piece as our Origin. As highlighted in the red circle. We chose this spot, as most of the dimensions are in relation to this point.
2. First we will create the outside lines. Begin by clicking on the **Box** option

3. Fill out the Width and Height, which as per the drawing is *12.7* and *50.8*. Then click **Enter**

Figure 18 : The Box Dimensions

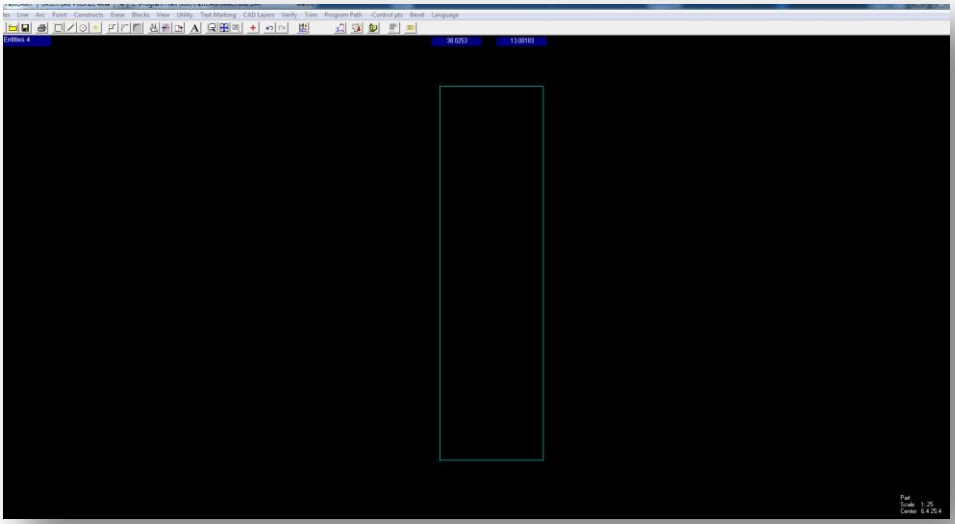


Figure 19 : **The freshly created Box**

4. Next we will create the two left side Circles. Click on the **Circle** button.

5. From the drawing, we can see they are of Diameter 7.11. So Enter *7.11d* into the text box. With the special '*d*' character at the end to designate it as a diameter, not a radius Click **Enter**

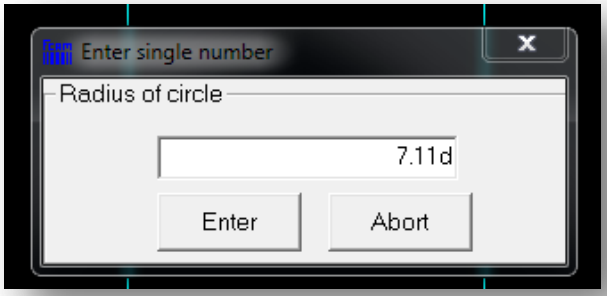


Figure 20 : **Entering the Diameter of the left Circle, with the diameter special character**

6. Next it will ask you where you wish to place this circle. Immediately **Right Click** to bring up the Point Menu.

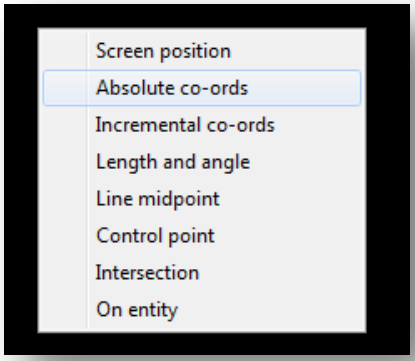


Figure 21 : **The Point Menu**

7. Click **Absolute Coordinates**

8. Next we need to input the absolute coordinates for the first circle, which we will say is the bottom left circle. The Y Coordinate is given, as *9.7***.** The X Coordinate we can assume is in the middle of the straight along the bottom, so *12.7/2 = 6.35*. Click **Enter**

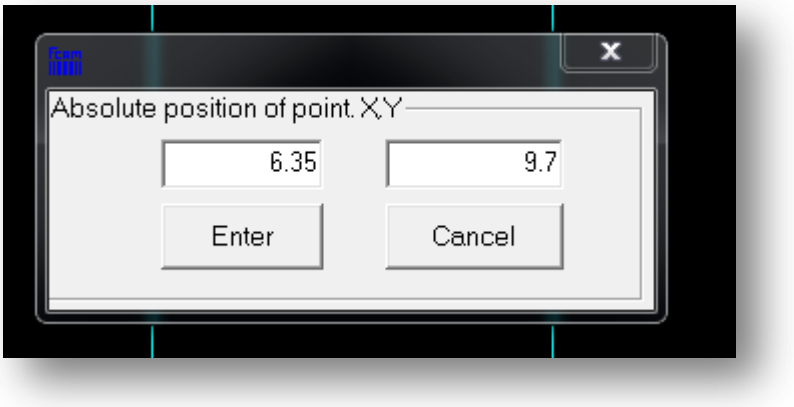


Figure 22 : The Bottom Left Circle's Absolute position

9. It will place the first circle. Then click **Cancel**, on the screen when it tries to place the second circle. This will take you to the *Points Menu*.
10. Select **Incremental Co-ords.** *(Incremental Co-ordinates)*
11. It will then ask you for the reference position, make sure it is the center of the first circle, as below, and click **Yes**.

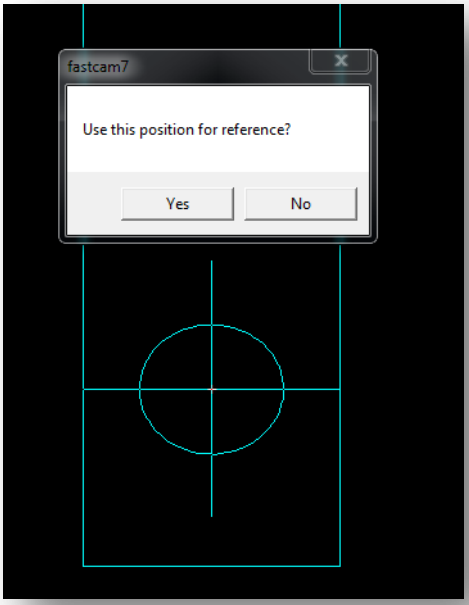


Figure 23 : **FastCAM Incremental Mode asking you to confirm the position for reference.**

12. Enter the incremental coordinates from that first circle, which will be simply, *X=0, Y=31.8*. Click **Enter**

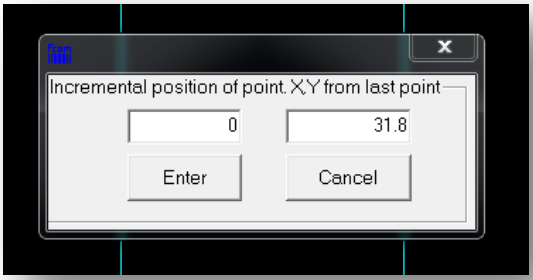


Figure 24 : The incremental Coordinates to create the second circle

13. Click **No,** to the subsequent position reference window. Then **Right Click twice** to exit back to the main screen. *(once to exit the position reference selection, and once to exit the point menu)*

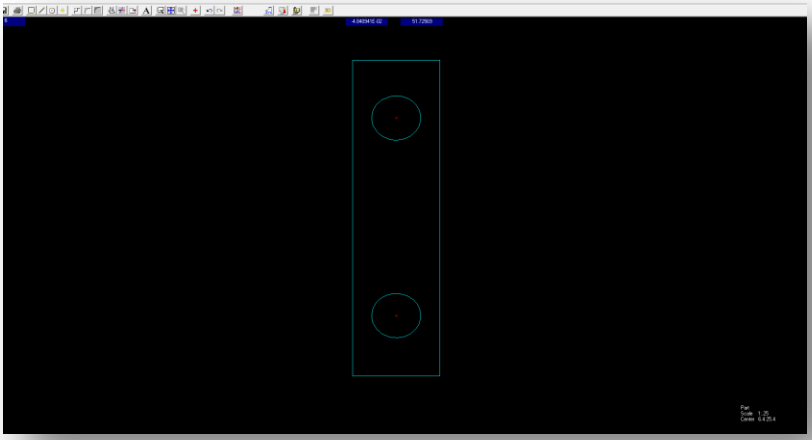


Figure 25 : The Left hand side of the Widget

14. Next we need to build the right side of the widget. To start this we will build the right circle. Click on the **Circles** Option

15. Enter *12.45d* for the Diameter of the Right circle, and use the “d” special character to indicate it as a diameter. Then click **Enter**

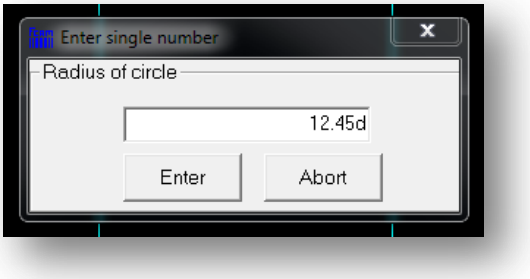


Figure 26 : **Diameter of the Right side circle, with the special "d" character**

16. Get to the Points Menu by clicking **No** to the position reference window, if you are still in incremental mode, and then **right clicking.**
17. Select **Absolute Coordinates**
18. The X Dimension is known, as *31.8*. However we need to figure out the Y position, which we assume is half the height of the left vertical line, or *25.4.* Click **Enter**

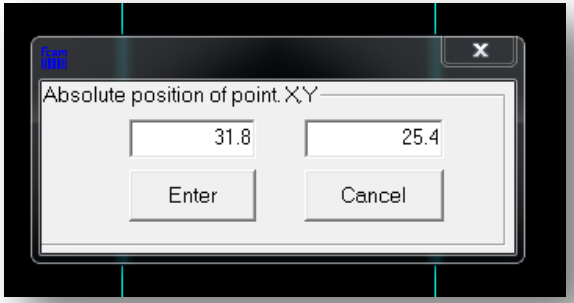


Figure 27 : **The Right hand circle Coordinates**

19. Click **Cancel** when it asks you for the next circle's position, and **Right Click** to exit.

20. Next we need to create the circle that will serve as the outer arc. We can assume it is concentric with the smaller circle we just created, so click circle

21. Enter *16* as the radius then click **Enter.**
22. As you should still be in **Absolute Coordinates**, enter the center point**.** *This should be remembered from the last circle, if not, it is (31.8,25.4).*

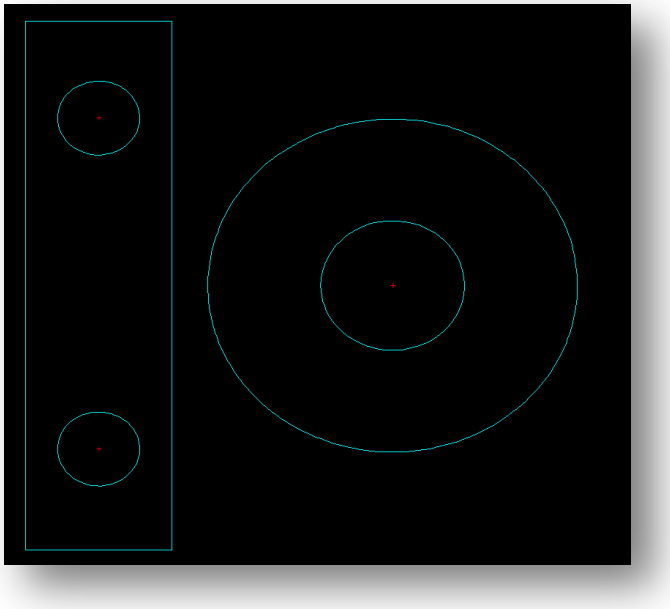


Figure 28 : **The two right side circles built**

23. Next we need to build the Tangent points from the outer right circle to the top and bottom of the left side box. Click **Line > Tan to Circle**. *(Tangent to Circle)*

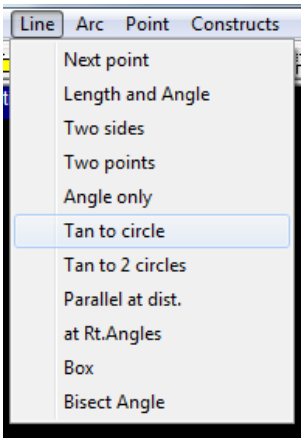


Figure 29 : The Line Menu, from which we select Tan to Circle

24. **Click** on the top right arc of the outer right side circle
25. Select **Given Point**
26. Then **click** on the top right corner of the box on the left. It should create the tangential line, and look like the below:

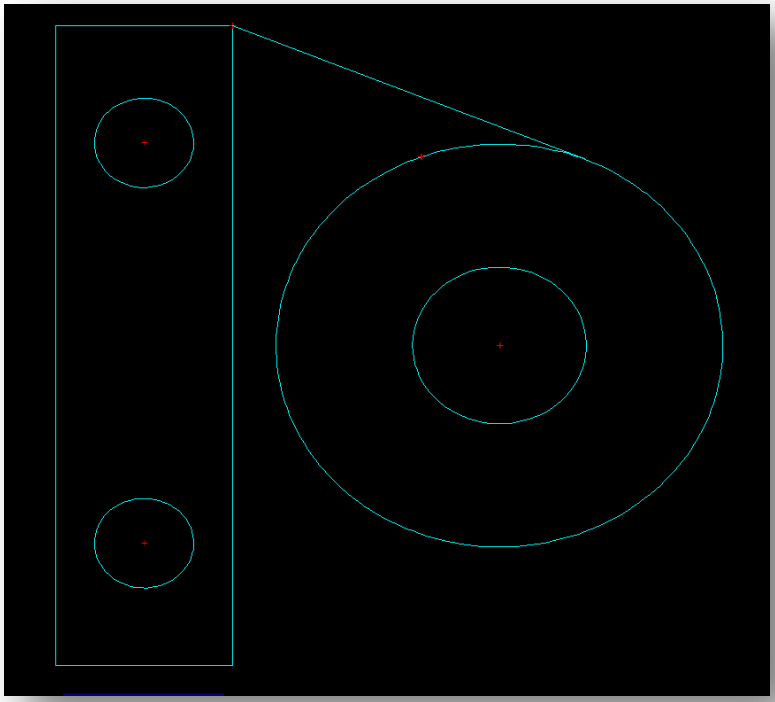


Figure 30 : **The top tangential line created**

27. You should still be in the Tan to Circle mode, and can **quickly repeat** this for the bottom side tangential line.
    a. **Click** the bottom left arc of the outer right circle
    b. Select **Given Point**
    c. Then **Click** bottom right corner of the box on the left.

    If you accidentally left the tangent to circle line mode by right clicking, just repeat steps 23-26
28. **Right Click** twice to exit Tangent to Circle Mode
29. You should now have the full shape created. Click the **Autoscale**

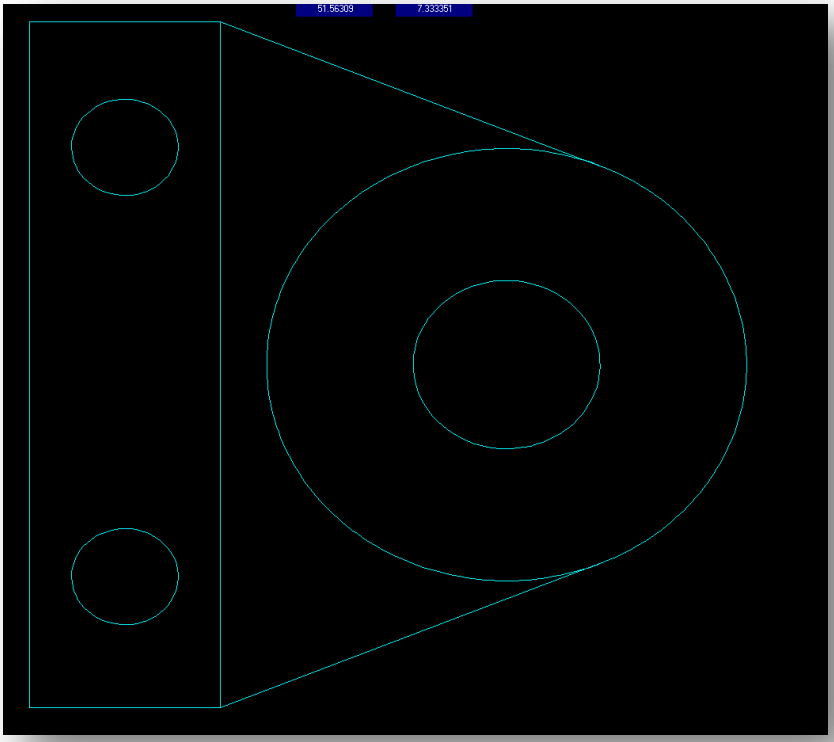
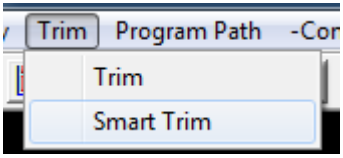


Figure 31 : **The Full shape, before trimming**

30. Lastly we need to trim the extra lines. Click **Trim > Smart Trim**.



31. **Left click** on the extra line & arc, the right Vertical Line, and the left side of the outer right arc.

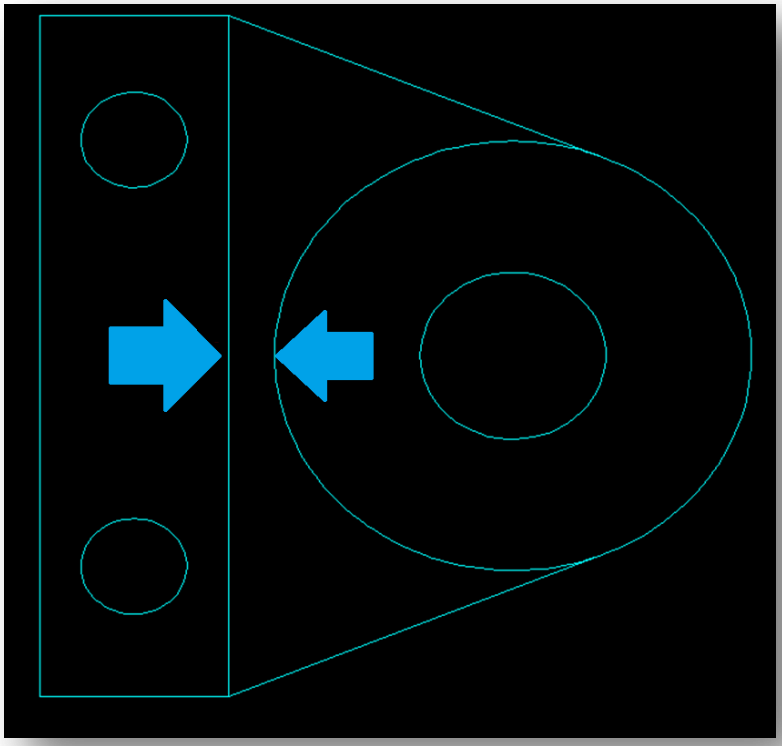


Figure 32 : The two lines that need to be trimmed

32. **Right Click** to exit the smart trim mode.
33. **Autoscale**

Finished Drawing

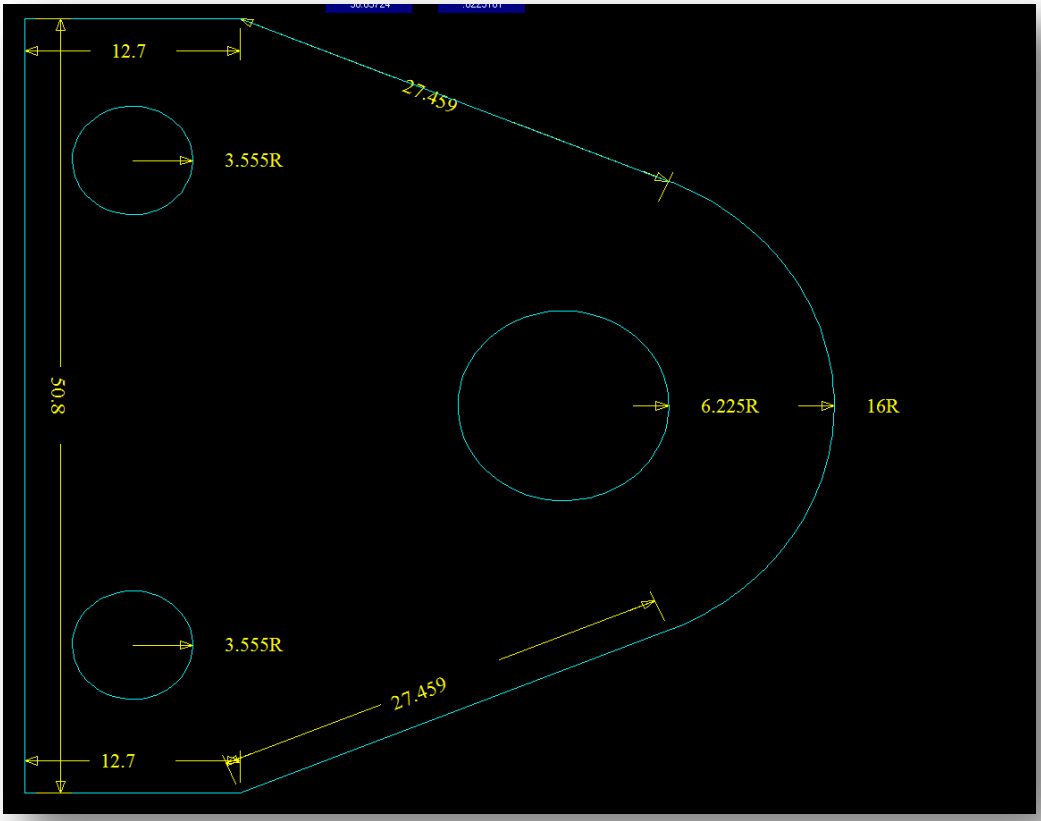


Figure 33 : The Completed Widget Drawing

34. The Widget has been completed!

Shackle

Rating: Beginner

Time: 15 Minutes

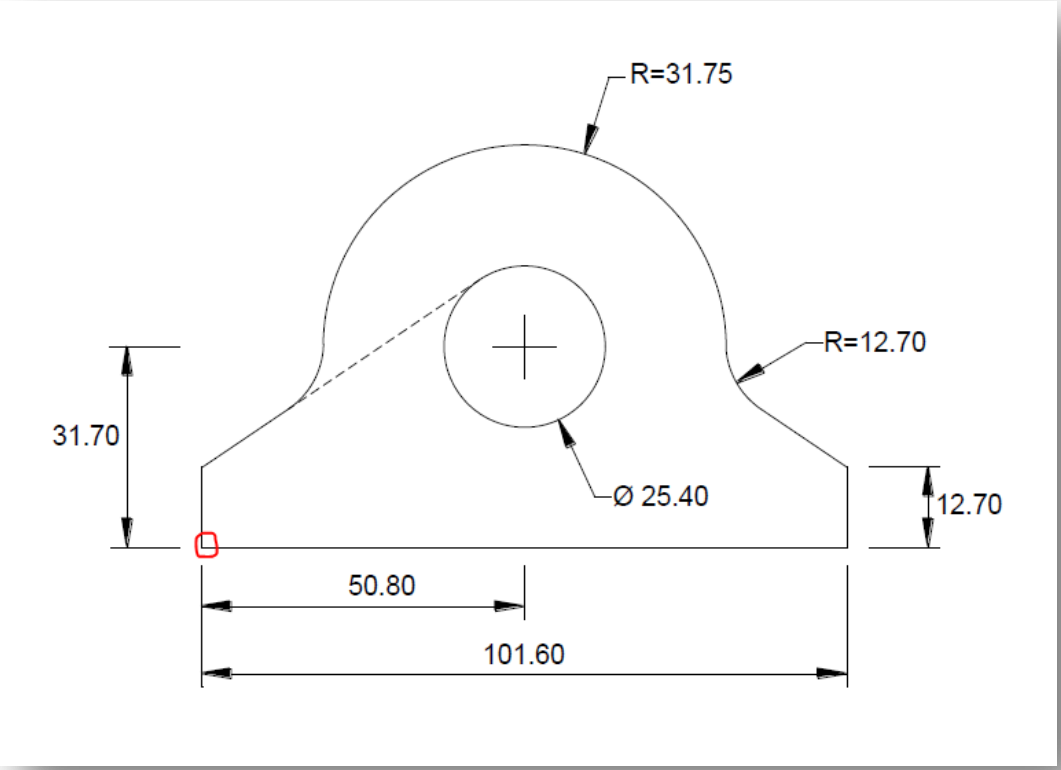


Figure 34 : The Shackle, with our origin indicated

Instructions

1. First we pick our origin point for the drawing. In this case, as there are quite a few dimensions coming from the bottom left corner, so we will select that as our origin point.
2. We will begin by building the bottom 3 lines, by making a box. Click on the **Box** option:

3. Enter the dimensions of the Box, *101.6 wide & 12.7 high*, and click **Enter**

Figure 35 : The Box inputs

NOTE: As this is the first element, it will default to draw it in the positive X and Y quadrant, with the bottom left point as the zero, as we wanted. You can prove this to yourself by drawing a control point at 0,0, once you have drawn the box.

4. Next we will build the internal hole. Click on the **Circle** button

5. Enter the diameter of the circle, *25.4d*, with the special “d” character at the end to define it as a diameter. Then Click **Enter**.

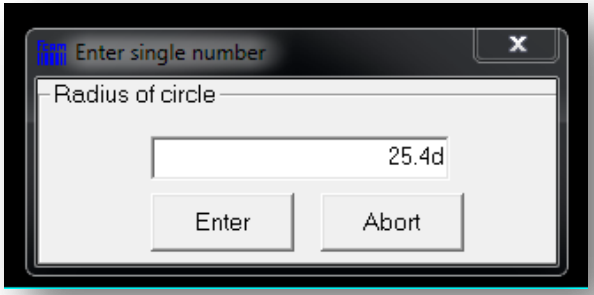


Figure 36 : The Box inputs

6. Next it will ask you where you wish to place this circle. Immediately **Right Click** to bring up the *Point Menu.*

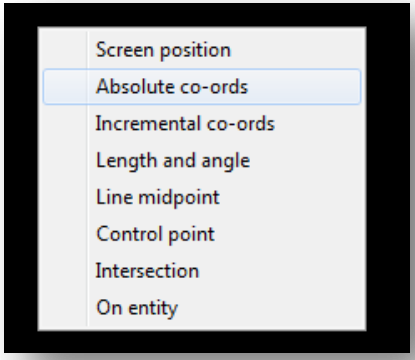


Figure 37 : The Point Menu

7. Click **Absolute Coordinates**
8. Fill in the center of the circle's coordinates as per the drawing, from our Origin (0,0) point, which is (*50.8,31.7*):

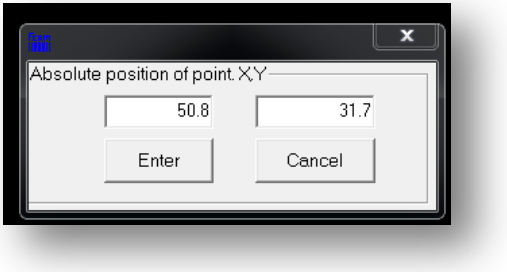


Figure 38 : The Centre of the Circle

9. Click **Cancel**, and then **Right click** to exit the point menu.
10. Re-size the drawing with the **Autoscale** button.

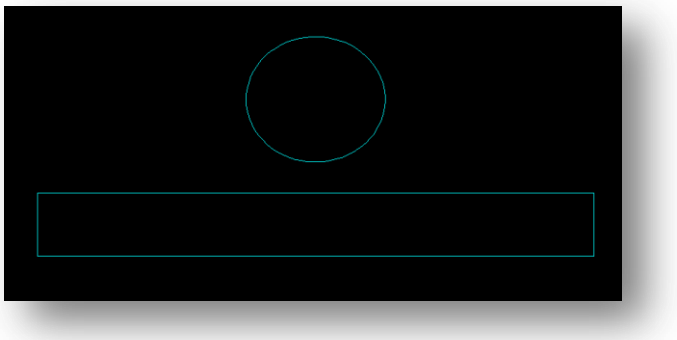


Figure 39 : The Partial Drawing, with a circle and the box

11. Next we draw the upper arc of the part, by drawing another circle. Click the **Circle** again

12. Enter the Radius of the Circle, from the drawing, as *31.75*. Click **Enter**

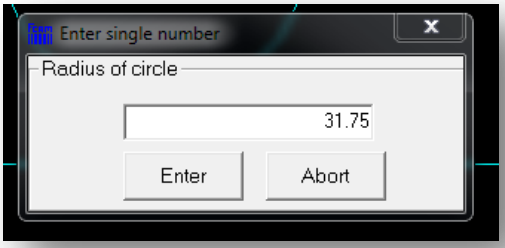


Figure 40 : The Upper arc circle's radius

13. The **Absolute coordinates** for the center of the circle will be the same as the hole circle's center, as we are assuming they are concentric. Enter the coordinates (*50.8,31.7*), and click **Enter**

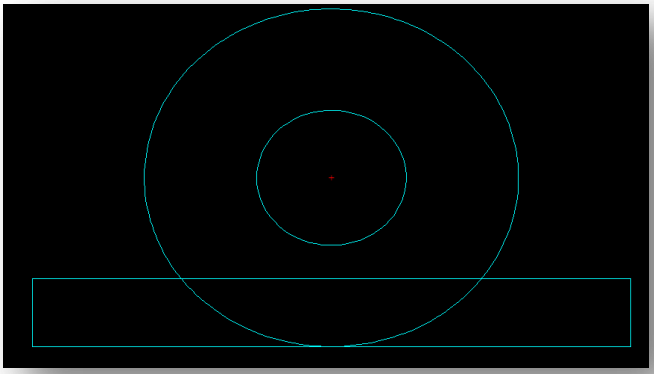
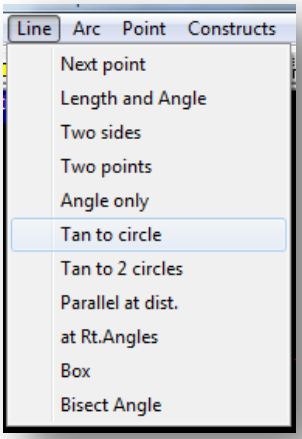


Figure 41 : **The Upper Arc and inner hole created**

14. Click **Cancel,** and then **Right Click** to exit this mode.
15. Next we need to build the straights on either side from the box, that are tangents of the inner hole. To do this, Click on the **Lines > Tan to Circle** *(Tangent to Circle)*



16. **Click** on the top left arc of the inner hole's circle
17. Select **Given Point**
18. Then **click** on the Top left control point for the box.

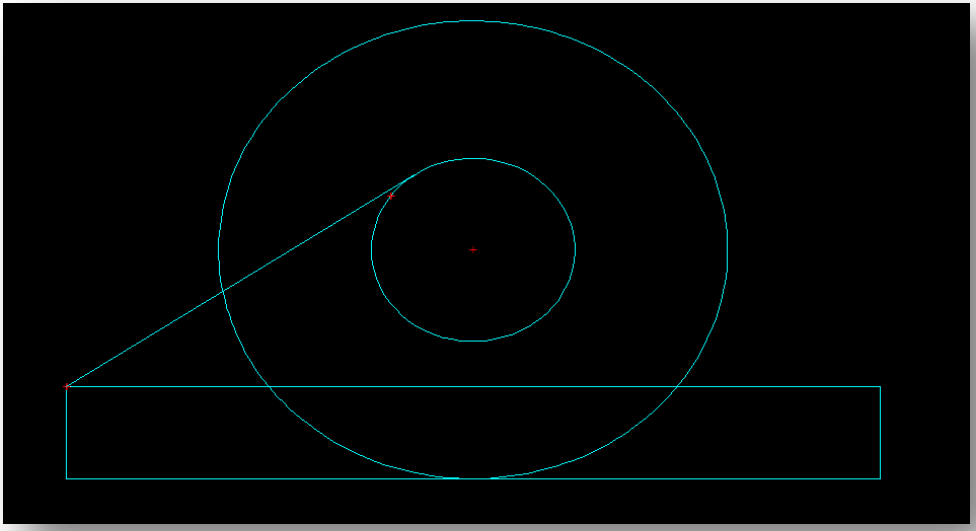


Figure 42 : The Tangent for the left side

19. Click on the top right arc of the inner hole's circle
20. Select **Given Point**
21. Then **click** on the Top Right control point for the box.
22. **Right Click** twice to exit the tangent to circle mode

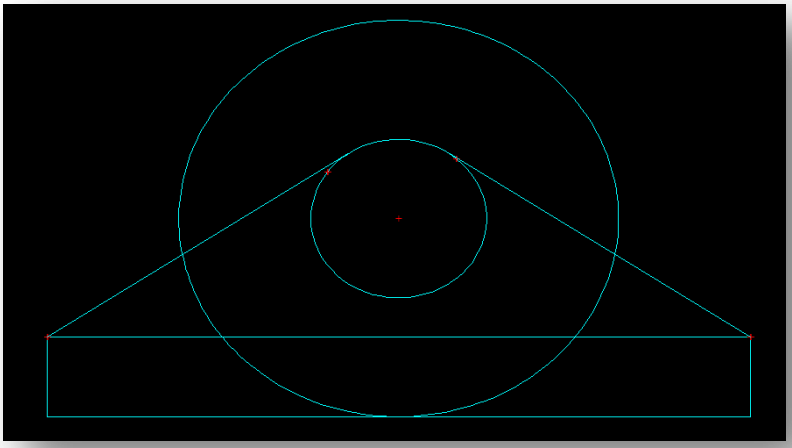


Figure 43 : **The Tangent for the left side**

23. Lastly we need to do a Fillet-Blend between the outer arc and the tangential lines we just built. Click the **Fillet-Blend** button.

24. Enter the Radius of the blend, *12.7*. Then click **Enter**.

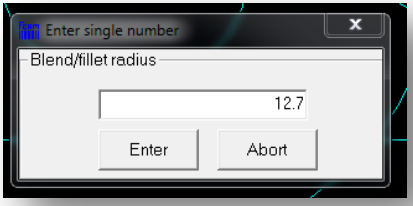


Figure 44 : **The Blend radius for the fillet**

25. It will then ask you to indicate the entities you wish to blend. **Click** *on the tangent and then the arc, close to the join where the blend will go*.
26. **Repeat** this for both sides. *See the image below for where to click, and in what order*

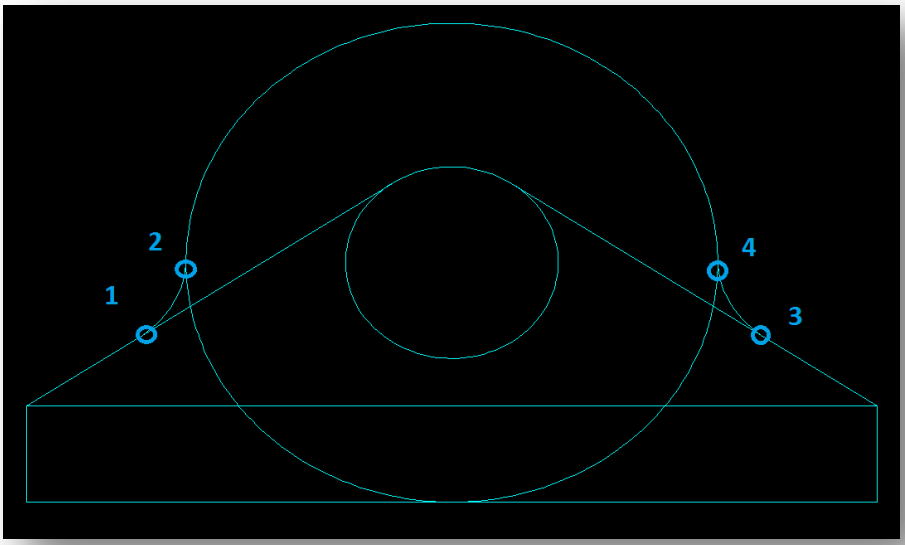
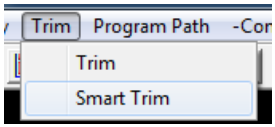


Figure 45 : **The Blends on the tangent to the outer circle**

27. Lastly we need to trim the extra lines. Click **Trim > Smart Trim**.



28. **Left click** on the extra arcs and lines to reduce the part down. **Right Click** to exit the smart trim mode. Lines marked with Red, need to be clicked with smart trim

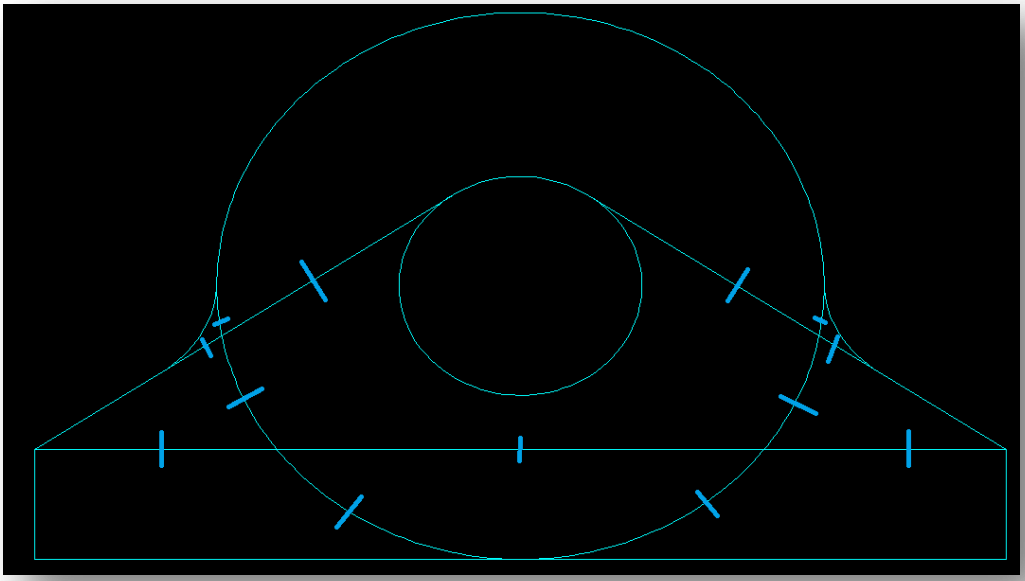


Figure 46 : **The lines you need to Smart Trim**

29. Click **Autoscale**

Finished Drawing

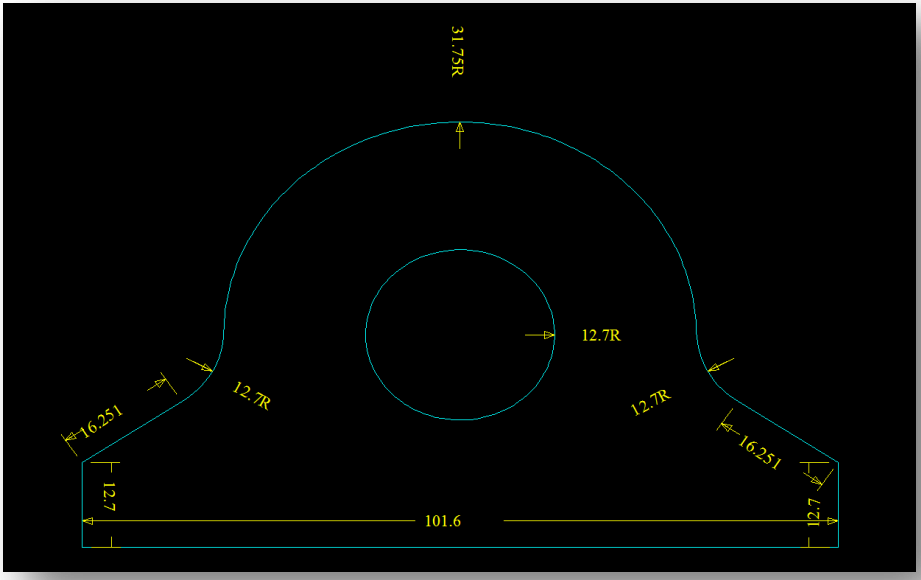


Figure 47 : The Completed Shackle Drawing

30. **The Shackle is complete!**

Intermediate Drawings

Sprocket

Rating: Intermediate

Time: 20 minutes

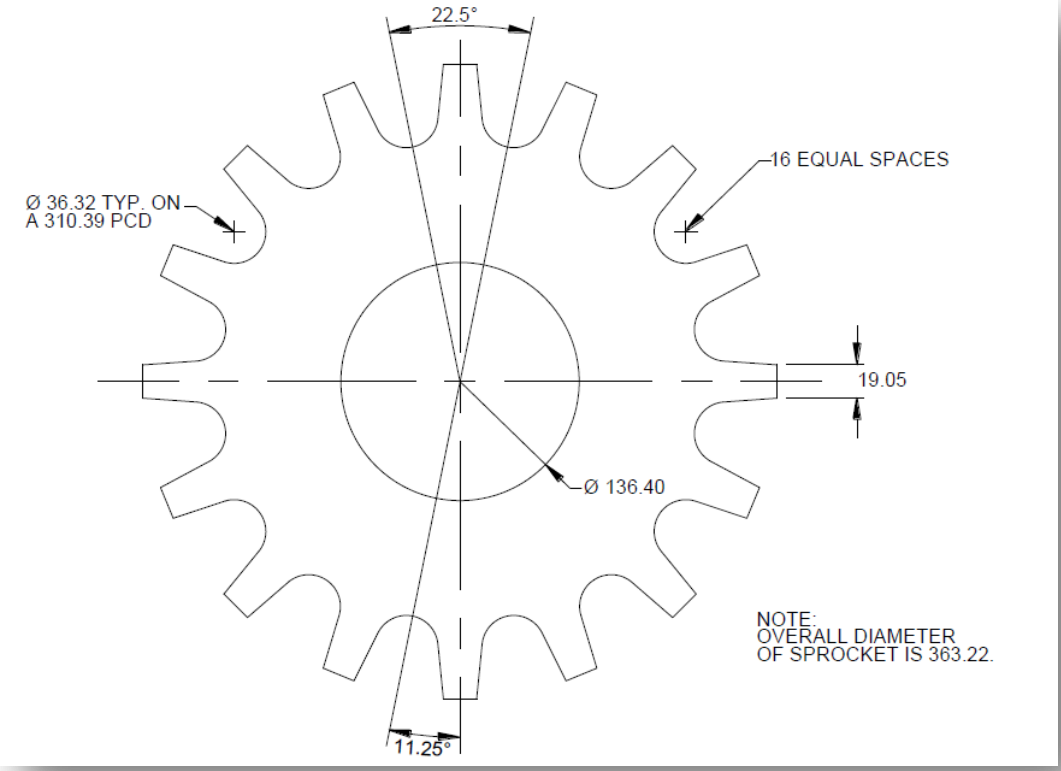
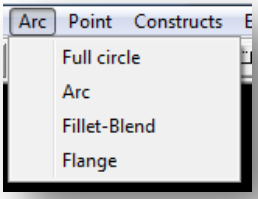


Figure 48 : The Sprocket

Instructions

1. As with all drawings, we need to begin by selecting an origin for the drawing. For this one, we will select the center of the sprocket.
2. We will begin by creating the two outer circles, the PCD circle, and the rim circle. Click **Arc > Flange**



3. It will then ask for ID (*Inner Diameter*), and OD(*Outer Diameter*). Fill them out and click **Enter**

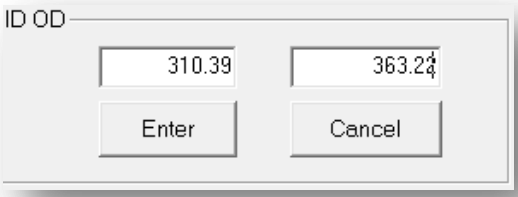


Figure 49 : **The Flange values, for the outer diameter and the PCD Diameter**

4. **Right Click** to bring up the points menu, and select **Absolute Co-ords**
5. **Set** the center of the flange at our drawing's origin *(0,0)*
6. **Autoscale** to resize the part.

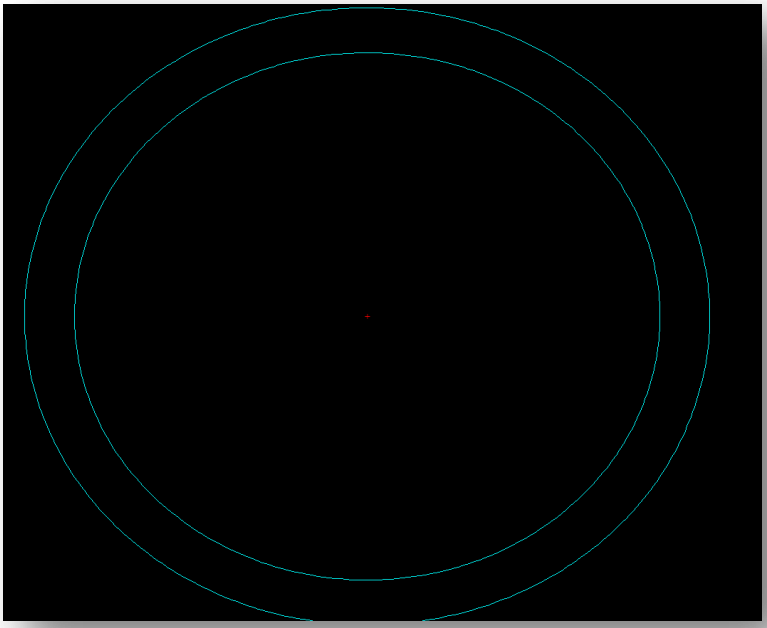
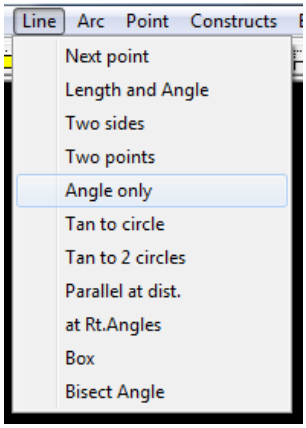


Figure 50 : Outer circle of the sprocket, and the inner PCD for the smaller arcs

7. Next we need to build a construction line from the origin to the outer circle, so we can put in our smaller inner arcs soon. Click on **Line > Angle Only**



8. Make sure to use the ORIGIN as the reference point. The crosshairs will show you what your current reference point is.

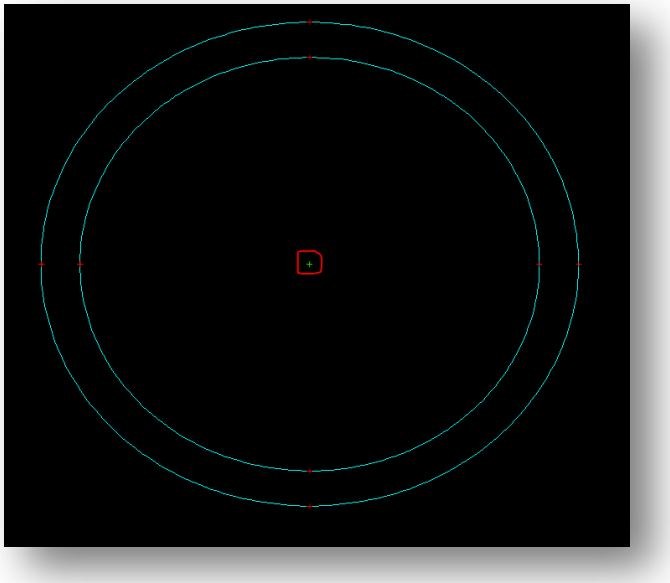


Figure 51 : **The origin as the reference for the Length & Angle**

9. Select **Direct Entry**
10. Input *11.25°,* as per the diagram, for the angle. Click **Enter**
11. **Repeat 5-8**, this time with an angle of *-11.25°. You must repeat from the **Line > Angle Only** step, otherwise you will be drawing a line with the same angle as before.*

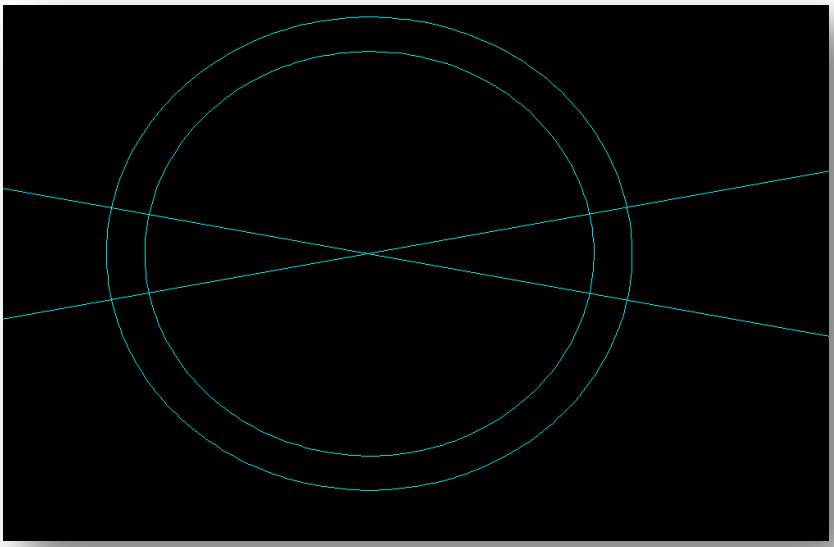


Figure 52 : The Two circles and two constructions lines

12. Next we need to build the two circles that will form the bottoms of the outside arcs on these lines. Click **Circle**

13. Enter the diameter of the inner arcs, *'36.32d'*. Click **Enter**
14. **Right Click** to bring up the points menu, and select **Intersection**.
15. **Click** on the top construction line on the right and then **click** the inner circle. This will add the first circle
16. **Click** on the bottom construction line on the right and then **click** the inner circle. This will add the second circle.

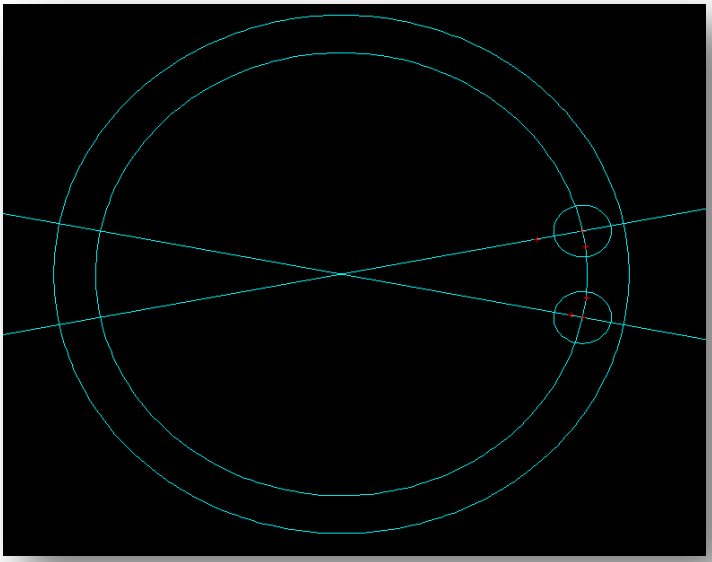


Figure 53 : **The interior arcs built**

17. Next we need to build more construction lines for the outside points. Click **Line > Bisect Angle**
18. **Click** on the Top construction line then **click** the bottom construction line. This will create a line that Bisects both the construction lines

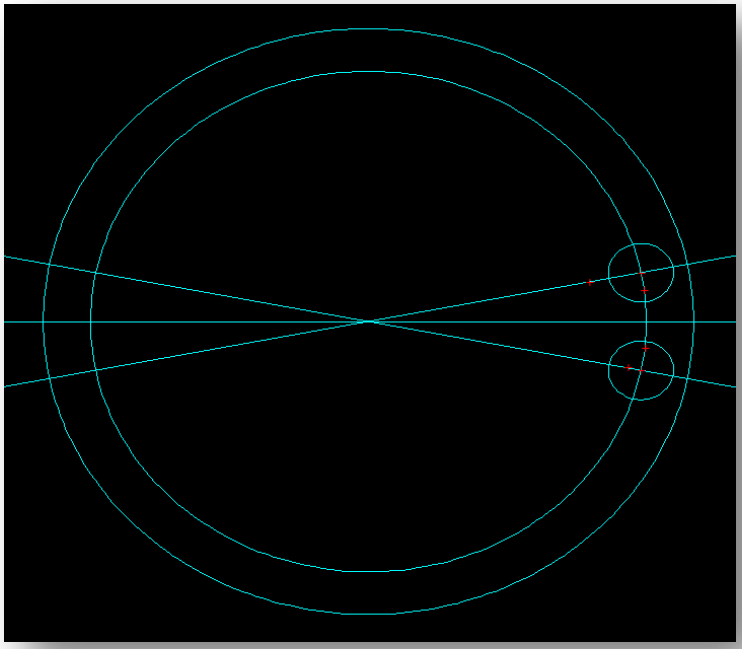
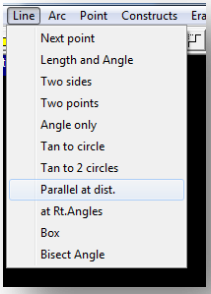


Figure 54 : **The Bisect Construction line**

19. Next we need to build two construction lines at a distance from this center line. Select **Line > Parallel at Dist.** (*Parallel at Distance)*



20. **Select** our 0° horizontal construction line that goes through the origin.
21. Set the distance as *9.525 (=19.05/2)*. Click **Enter**
22. Because there are two possibilities, above or below the center line, chose one, and **click on that side of the line**. This will create a line parallel to the original.
23. **Repeat steps 19 – 22**, this time clicking on the other side of the horizontal construction line that goes through the origin.

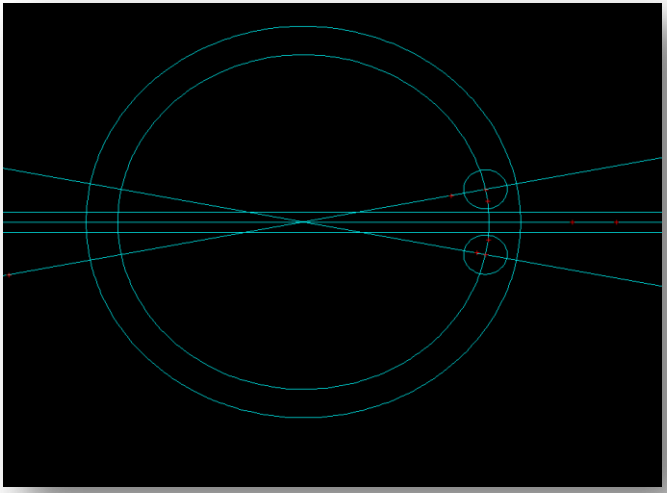
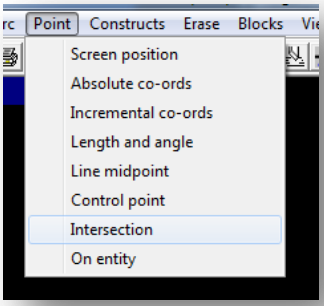


Figure 55 : The Horizontal construction lines created

24. Now we need to put down some control points on the intersection of the outer ring, and our two external Horizontal construction lines. Click on the **Point > Intersection**



25. **Click** on the top horizontal construction line, then click on the outer Circle of the Sprocket
26. **Click** on the bottom horizontal construction line, then click on the outer Circle of the Sprocket

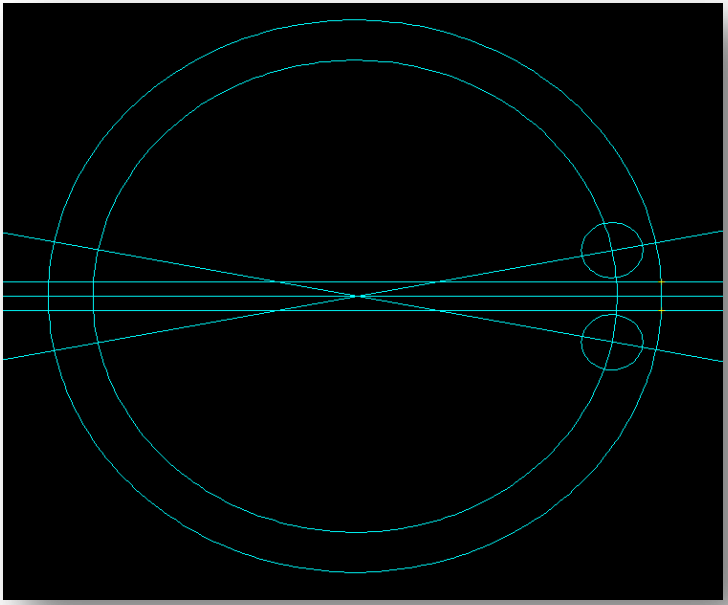
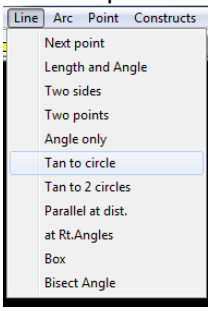


Figure 56 : **The construction lines and the points created on the sprocket's rim**

27. Now we need to build the tangent lines from the interior arc's circles to the freshly created points on the outer sprocket's circle. Click **Line > Tan to circle**



28. **Click** on the bottom of the two interior arc Circles
29. Select **Given Point**
30. Then **click** on the bottom intersection point of the horizontal line and the exterior circle of the sprocket
31. **Repeat 25-28** for the top interior arc circle, and the top intersection point. Zoomed in your result should look like:

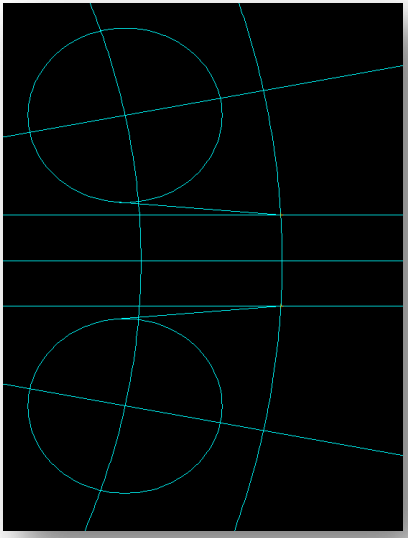
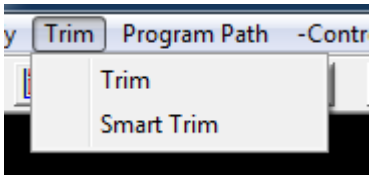


Figure 57 : **The interior arc circles with their tangents to the sprocket's outer circle**

32. Use the **Trim > Smart Trim** feature to remove all construction lines, down to the single gear tooth we have created. *Be sure to trim all the small lines that have formed around the small interior circles. Reference the last image to find which lines & arcs need to be trimmed.*



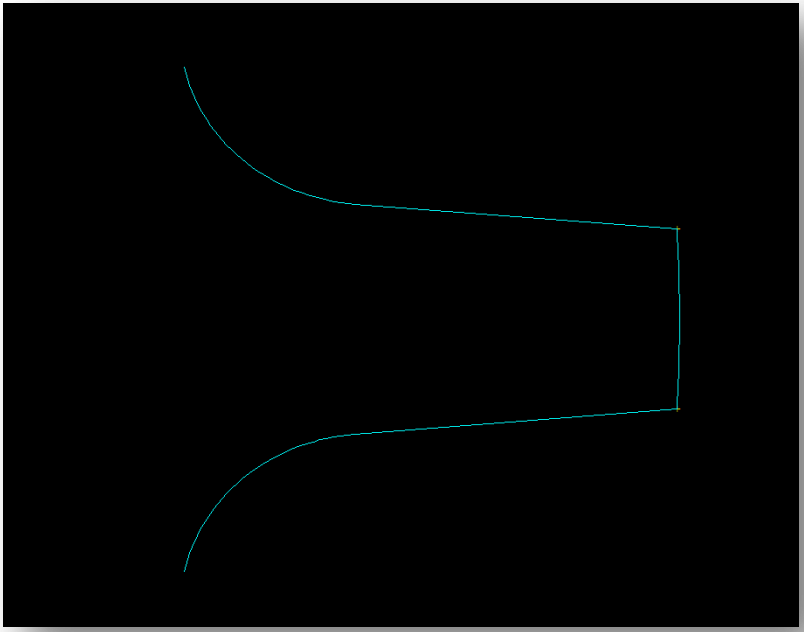
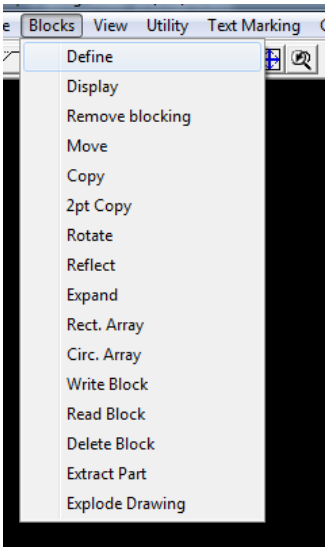


Figure 58 : **The Contour of one of the sprocket's teeth**

33. Now we need to copy this shape and array it in a circle around the gear to complete the drawing. First we must define this shape as a block. Click **Blocks > Define**.



34. Click **Window**
35. Click **All**
36. Using the window, **select** the Tooth Shape
37. Give it a block name & Click **Enter.**
38. Set the center of the part. **Select** the origin of the sprocket. *NOTE you may need to resize your screen and turn on control points to see the origin.*

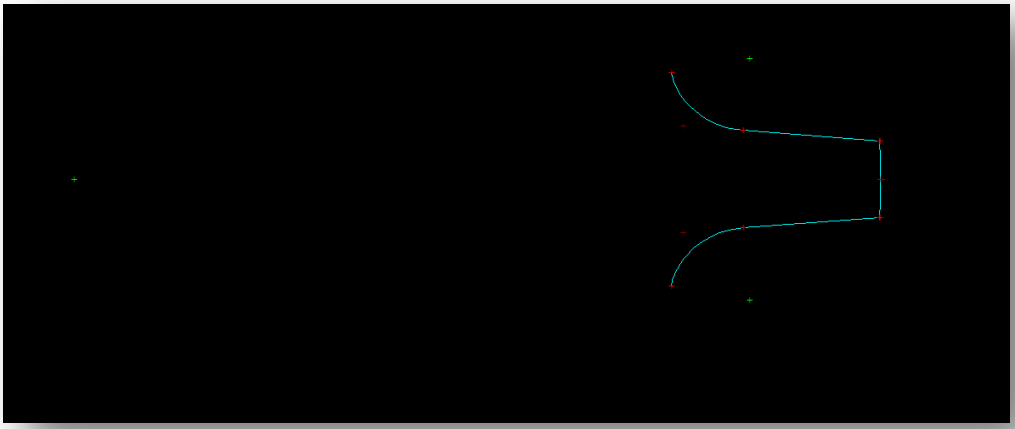


Figure 59 : **The Tooth with the origin of the Sprocket visible as the small green cross on the left**

39. If you have successfully blocked the shape, click **Blocks > Display** to confirm

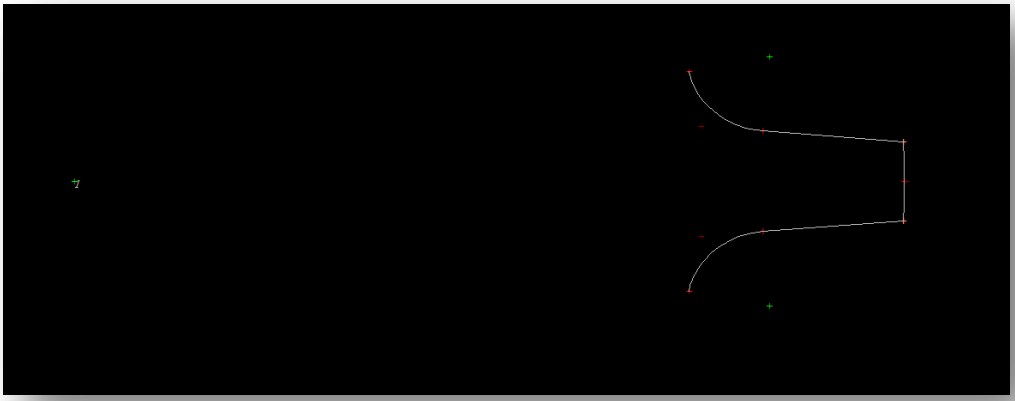


Figure 60 : **The Blocked Tooth**

40. Lastly, Click **Blocks > Circ. Array** *(Circular Array)*
41. **Select** the Origin of the Sprocket as the Rotation Centre
42. Enter the total number of teeth for the drawing, *16*. Click **Enter**
43. Enter the rotation angle, *22.5°*. Click **Enter**
44. Click **Yes** if it is satisfactory.
45. Finally add the interior circle. Click **Circle**

46. Enter the Diameter of the inner circle as '*136.40d*'. Click **Enter**
47. Using either **Control point,** or **Absolute Coordinates** set the center of the circle as our Origin *(0,0)*

Finished Drawing

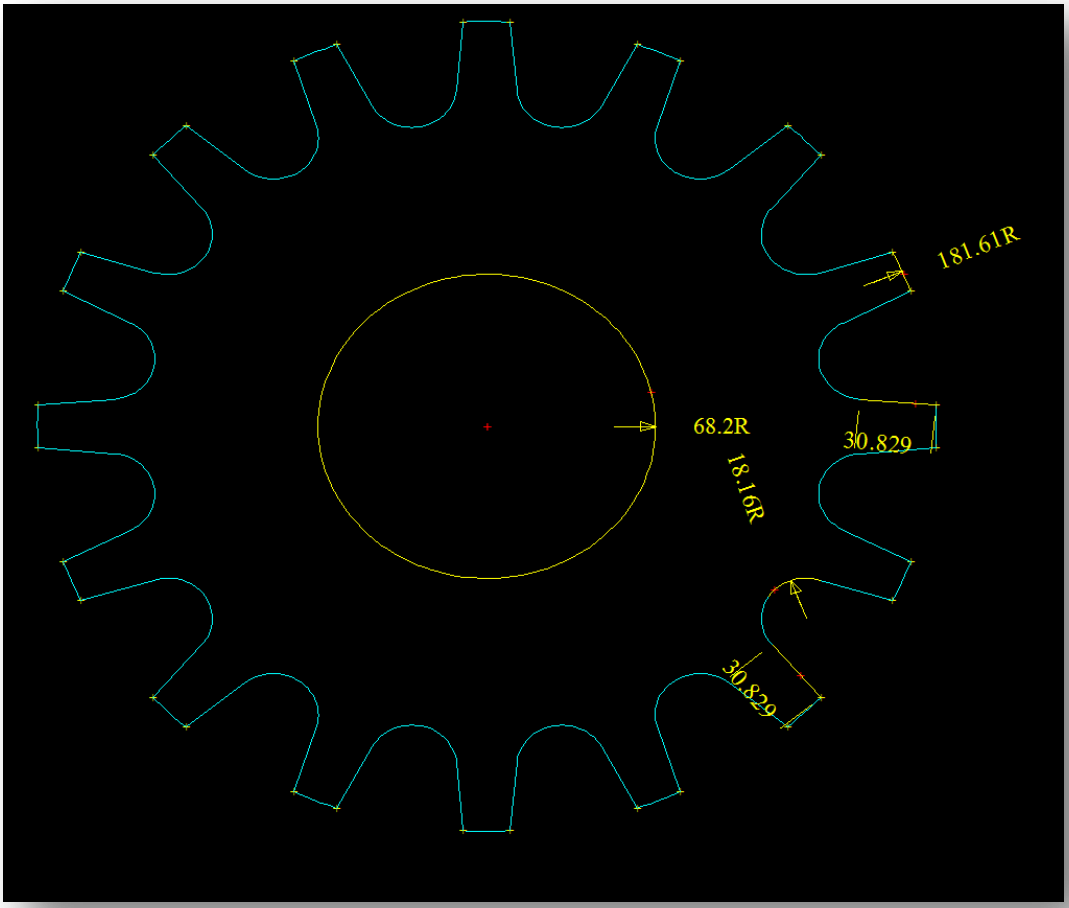


Figure 61 : The complete Sprocket

48. Now the Sprocket is complete!

Bolt-Plate

Rating: Intermediate

Time: 12 minutes

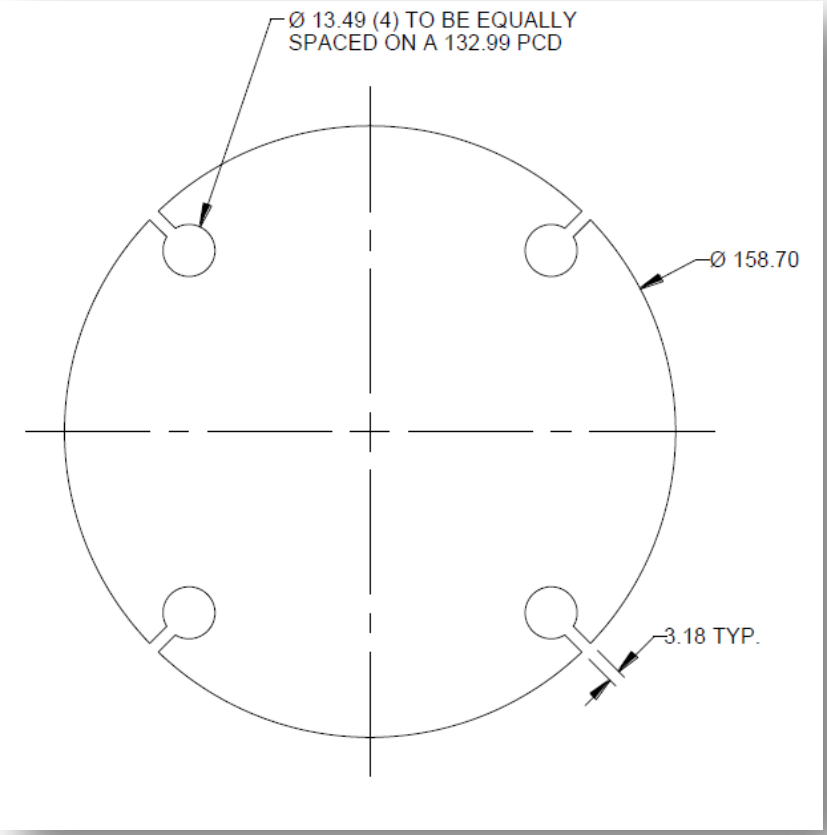


Figure 62 : The Bolt Plate Drawing

Instructions

1. First we start by selecting an origin for the drawing. Because the drawing is circular, we will select the center of the circle as our origin.
2. We will begin by creating the outer circle. Click on the **Circle** button

3. Enter the Diameter of the Bolt plate, *158.70d,* with the special 'd' character for diameter:

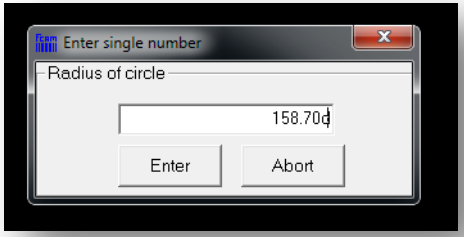


Figure 63 : The Diameter of the outer bolt plate

4. **Right Click** to bring up the points menu, and select **Absolute Co-ords**
5. Set the center of the circle as *0,0* and press **Enter**
6. **Autoscale** to get it to the right size

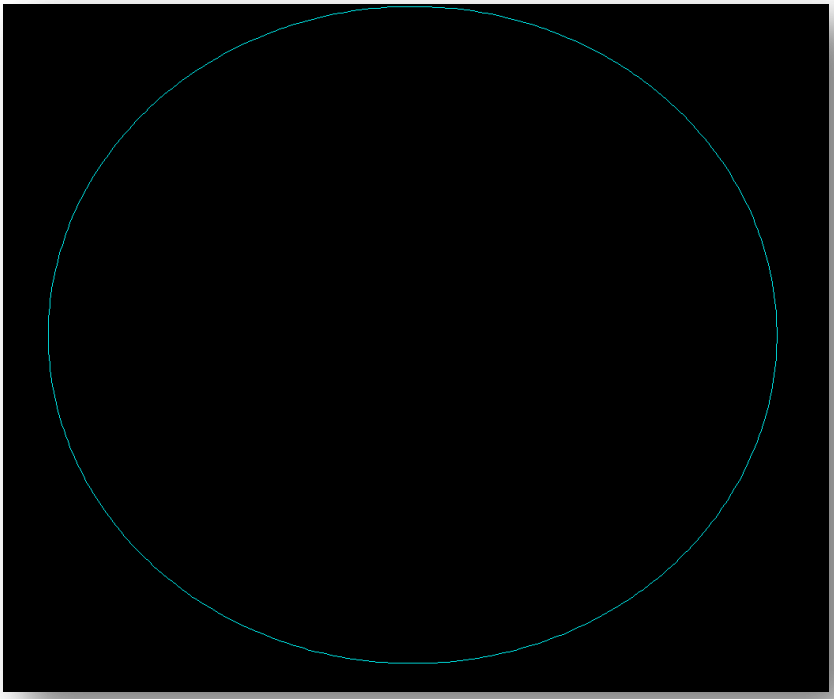


Figure 64 : The outer circle created

7. Next we need to create a circle for the inner bolt holes. **Repeat steps 2-8** with the Bolt Hole PCD of *132.99d*

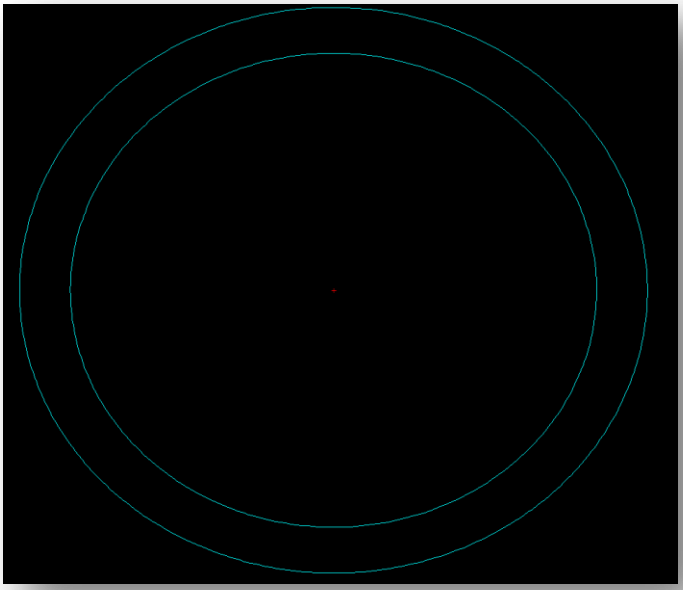
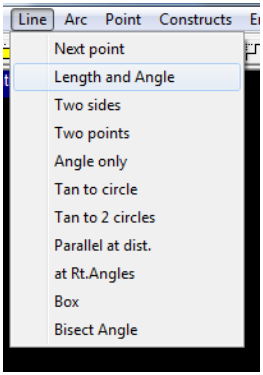
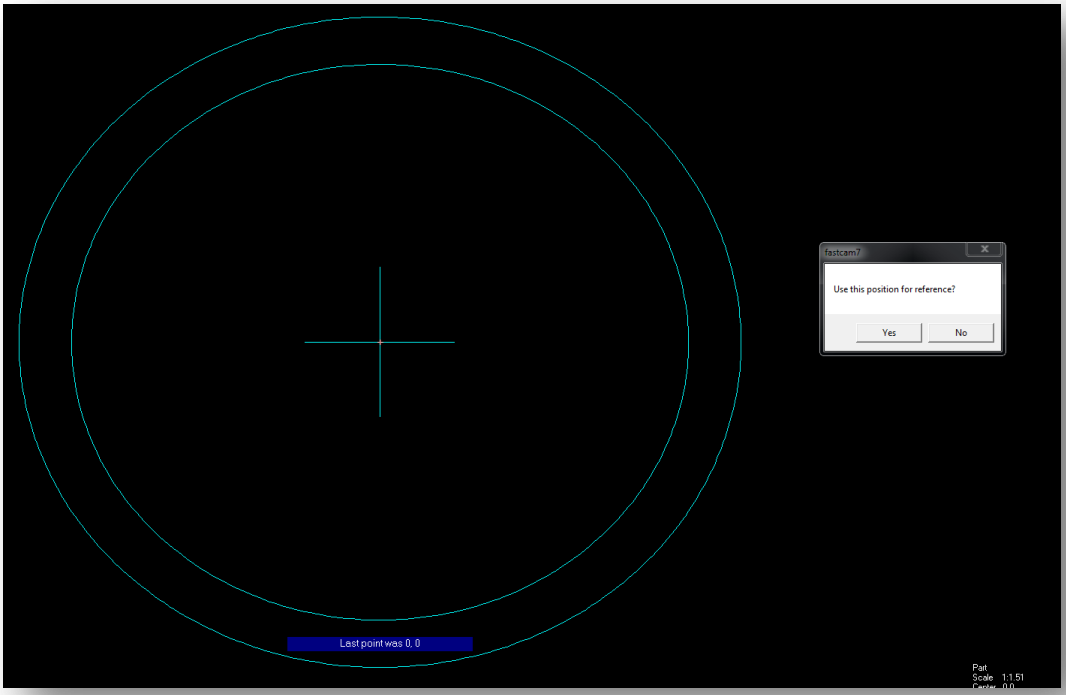


Figure 65 : The two circles

8. Now we need to create 2x construction lines for the diameter of the outer circle at *45°* and *-45°*. Click **Line > Length & Angle.** Make sure to use the ORIGIN as the reference point. The crosshairs will show your current reference point.





9. The origin as the reference for the Length & Angle

10. Set the length to larger than the outside Radius, *100mm.*Click **Enter**
11. Select **Direct Entry**
12. Set the angle to *45°* and click **Ok.**

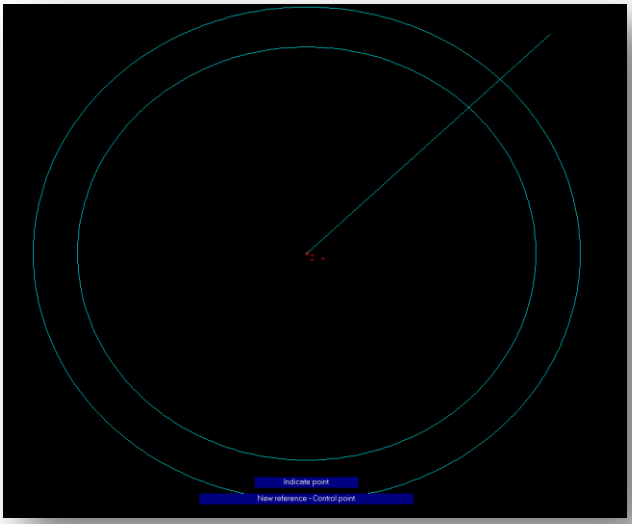
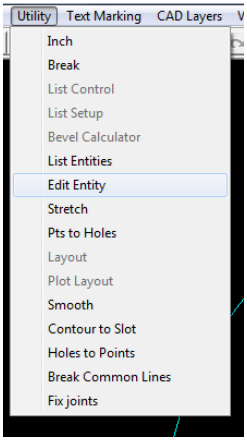


Figure 66 : The first construction line at 45°

13. Now we need to extend that line to the other side of the circle. Click **Utility > Edit Entity**



14. Select **Line**
15. **Click** on the end of the construction line, closest to the Centre point. This is important as FastCAM will deduce which end of the line you wish to alter.
16. Select **Length**
17. Change the length to *200*. Click **Enter**

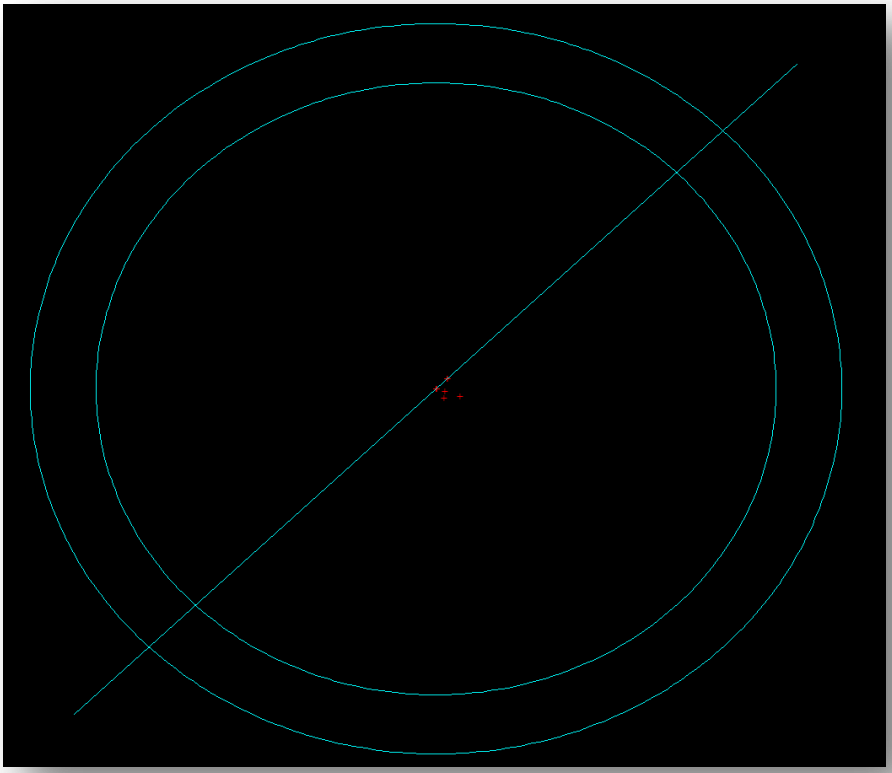


Figure 67 : The full 45 degree construction line.

18. **Repeat 8-17** for the *-45°* construction line.

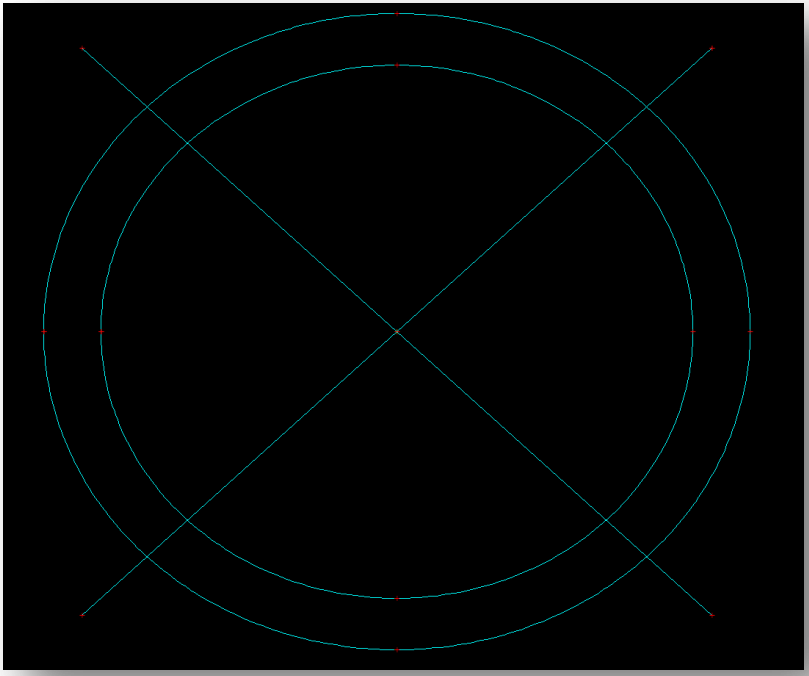
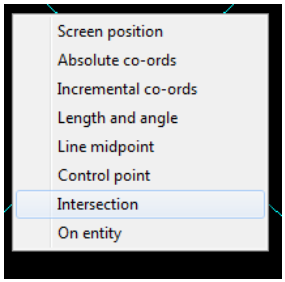


Figure 68 : Both construction lines fully built

19. Next we want to build the holes that reside on the Inner circle, and the construction lines. Click **Circles**

20. Type in the diameter of the bolt holes, with the 'd' special character, 13.49d. Click **Enter.**
21. **Right click** to bring up the point menu
22. Select **Intersection**



23. Then **click** on a **construction line** and the **inner circle**, close to where you think the circle will be centered. This will create a circle at the intersection's center point.
24. **Repeat 23** on all the construction lines and the inner arc

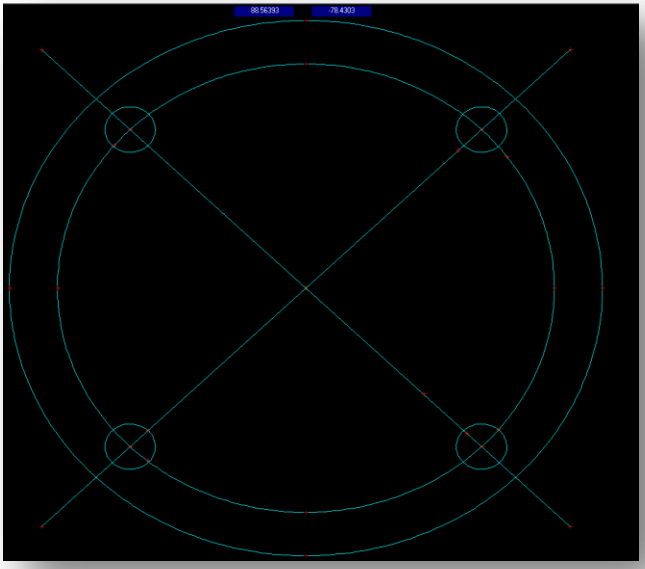
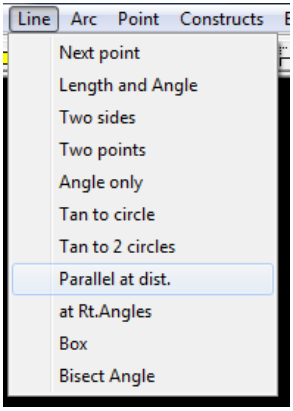


Figure 69 : All Bolt Holes created

25. Now we need to build the bridges from the bolt holes to the outside circle. Click **Line > Parallel at Dist.** *(Parallel at Distance)*



26. **Select** one of the construction lines.
27. Enter half bridge width, *1.59*. Click **Enter**
28. **Click** on one side of the construction line, as two lines are possible.
29. Click **Same Length**
30. You will now have created a parallel line from this construction line

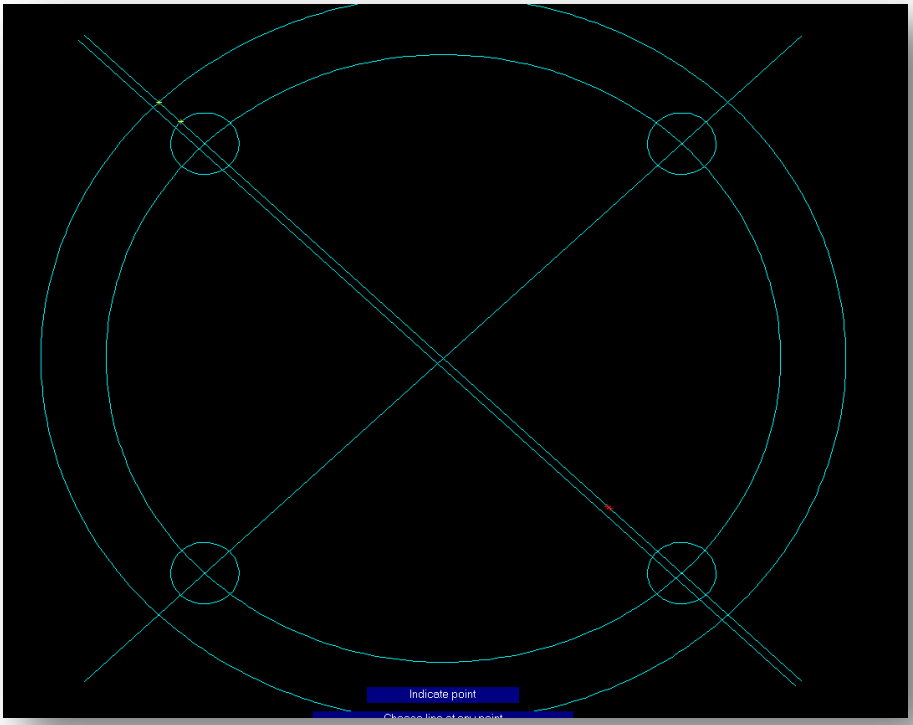


Figure 70 : **The first parallel construction line created.**

31. **Repeat** steps **25-30,** to create the other three parallel construction lines for the other bridges.

    HINT: if you do not right click out of it, you will stay in parallel at distance mode and can create the extra lines quickly

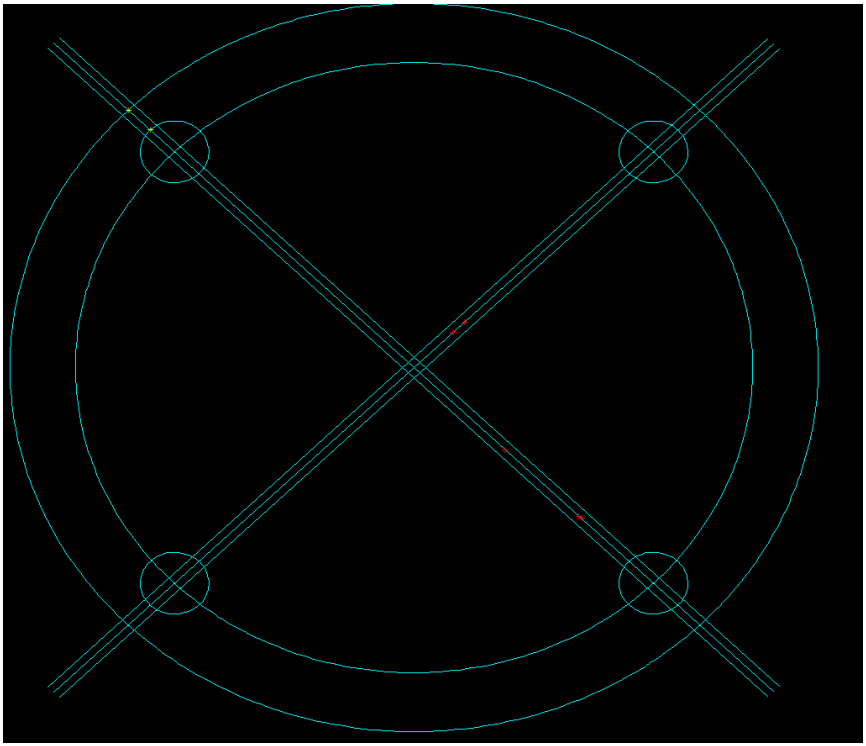


Figure 71 : **The bolt plate with all construction lines and holes present**

32. All we need to do now is trim up the drawing. Select **Trim > Smart Trim** and get rid of all the construction lines.

    HINT: If you don't want to trim all the small lines in the center, leave them until last and then use ***Erase > Window, all, inside only***

Finished Drawing

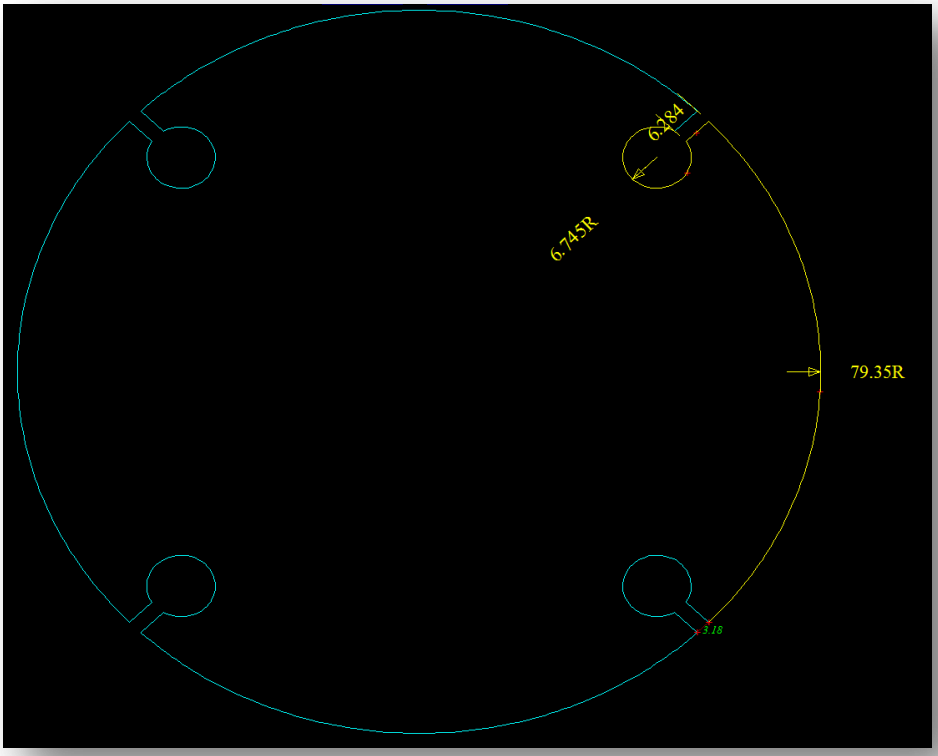


Figure 72 : The Complete Bolt Plate

33. Your Bolt Plate is complete

Gear

Rating: Intermediate

Time: 20 minutes

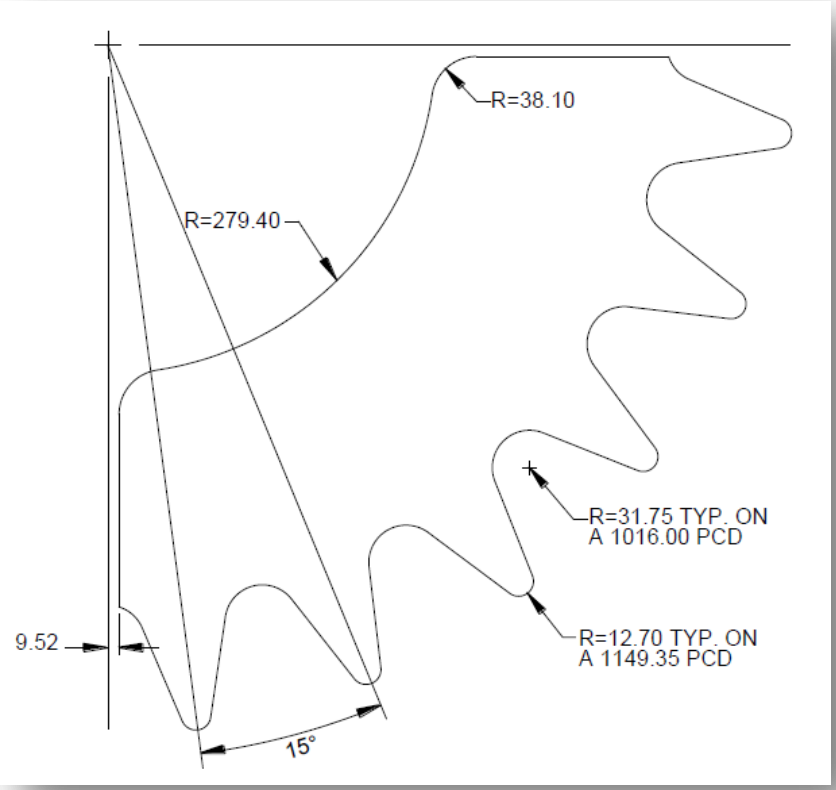


Figure 73 : The Gear Drawing

Instructions

1. Firstly select the origin point. As a lot of the dimensions for the circles and PCDs come from the same place, the top left crosshair on the image, we shall use that as our origin point.
2. Now we create the 3 interior circles. Click **Circle**

3. First we shall create the outer PCD. Type in the diameter of the circle, with the special 'd' character to designate it as a diameter, *1149.35d*. Click **Enter**
4. **Right click** to bring up the points menu
5. Select **Absolute Co-ords**
6. Set the coordinates as the center of the circle as *0,0,* and click **Enter.**
7. **Autoscale**

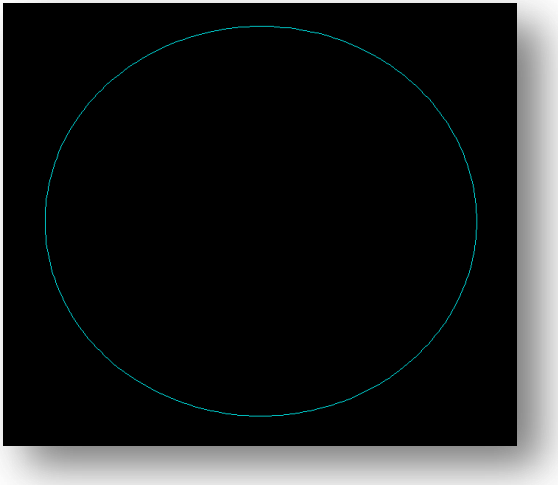


Figure 74 : The Outermost PCD circle

8. Now **repeat 2-7** with the other circles that come from the center, the *1016.00d* PCD circle and the Radius = *279.4* circle.

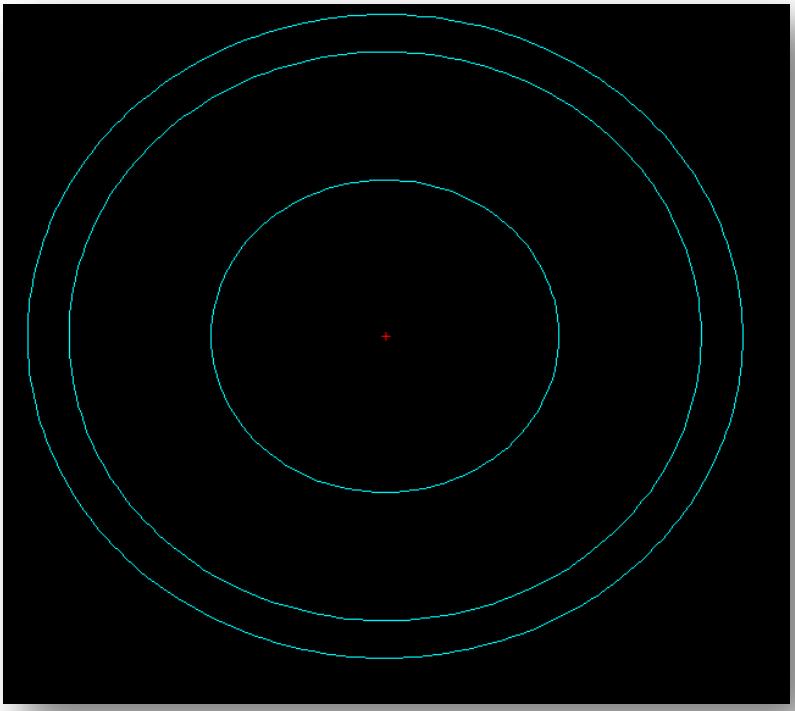


Figure 75 : The 3 circles built

9. Next we need to build the construction lines. Click **Line > Angle Only**
10. **Set** the position for reference as the center of the circles
11. Select **Direct Entry**
12. Set the angle as *97.5° (= 90° + 7.5°)* and click **Enter**

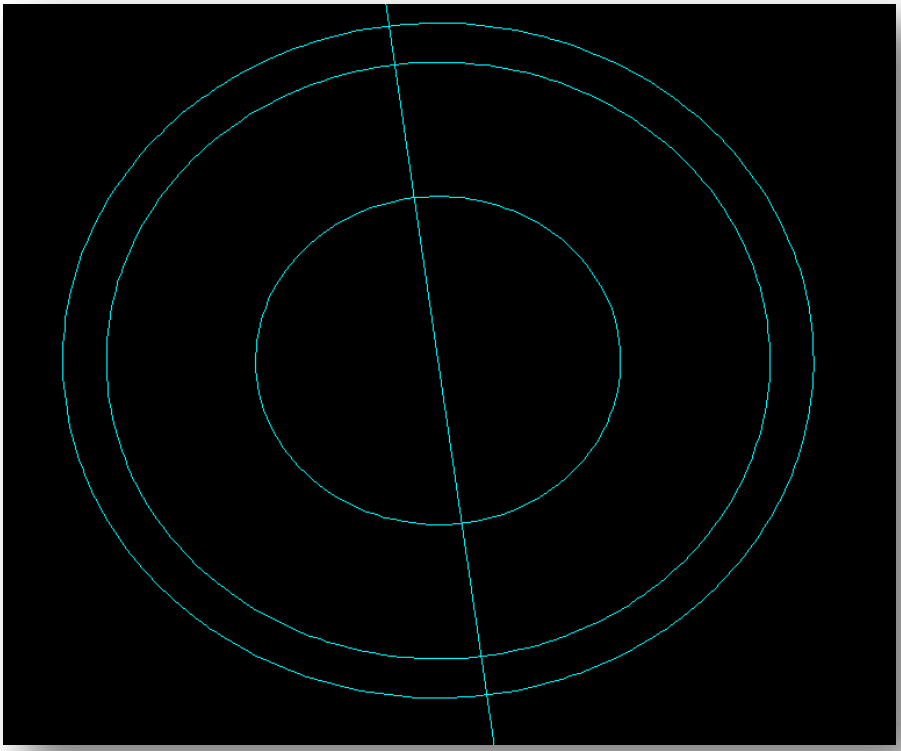


Figure 76 : **The first construction line built**

13. Now **repeat 9-12** with an angle of 112.5° (=97.*5° + 15°*)

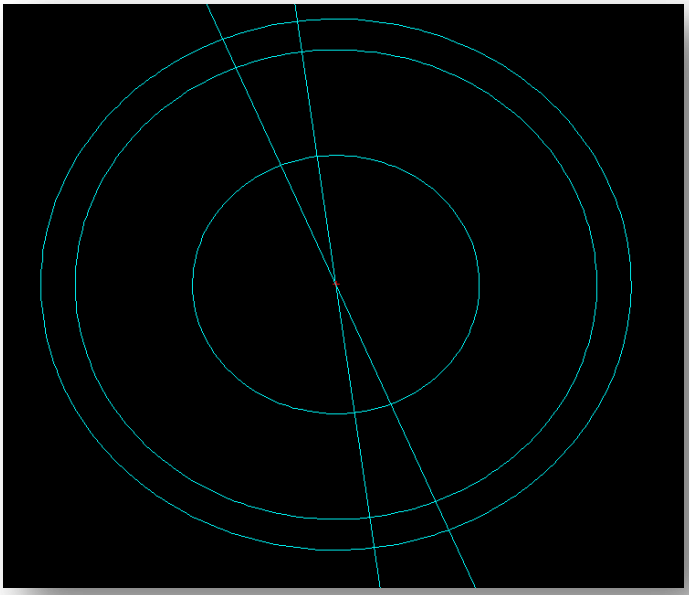
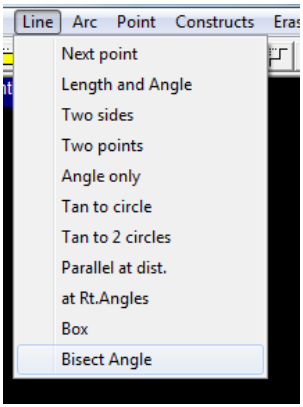


Figure 77 : **The first two construction lines created**

14. Now for the last construction line, Click **Line > Bisect Angle**



15. **Select** the two construction lines we just created. It will create a line that bisects them.

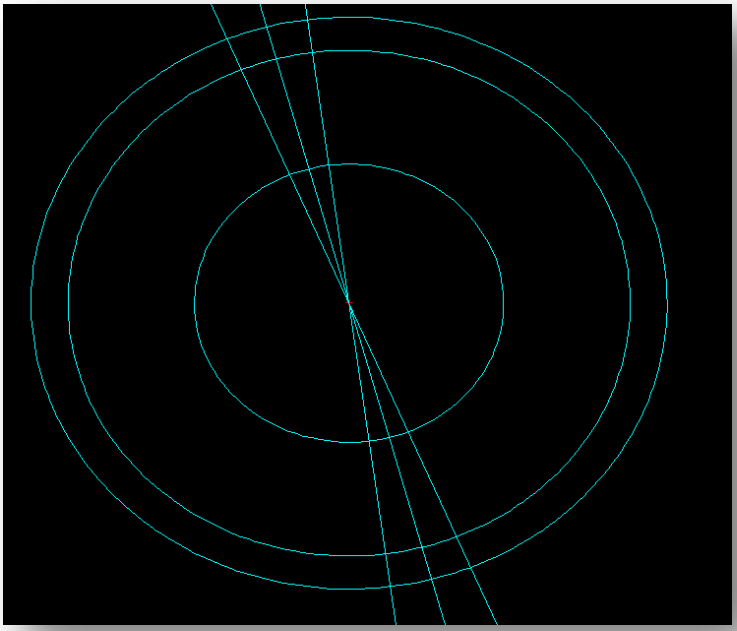


Figure 78 : The Drawing with the bisecting line between the two construction lines

16. Now we need to create circles for the top and the bottom of the tooth of the gear. Click **Circle**

17. Set the radius as the radius for the top of the gear, *12.70.* Click **Enter**
18. **Right Click** to bring up the points menu

19. Select **Intersection**
20. **Click** on the outer circle and then one of the two outer construction lines.
21. **Repeat** 20 for the other construction line and the outer circle.

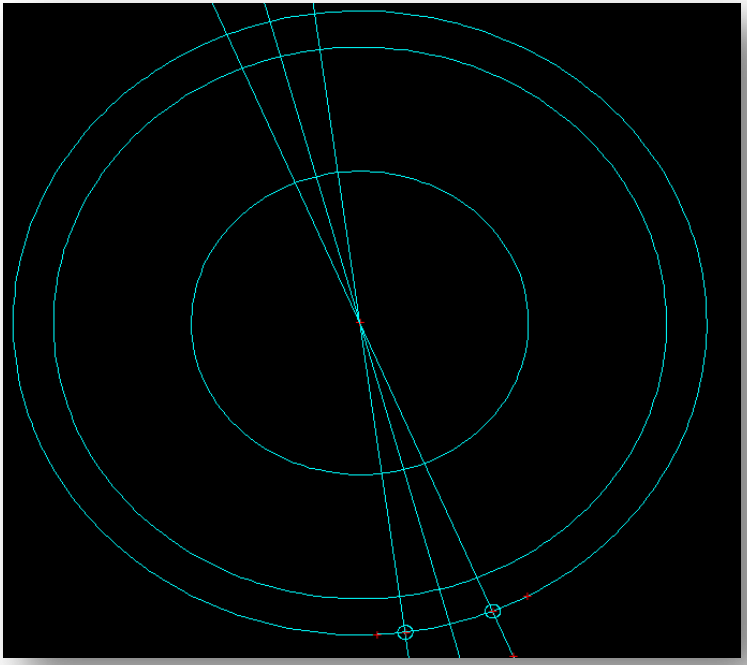


Figure 79 : The two of the gear's circles outer circles created

22. **Repeat 16-19,** with the inner gear circle radius of *31.75*
23. **Click** the Middle Circle & the Bisecting construction line

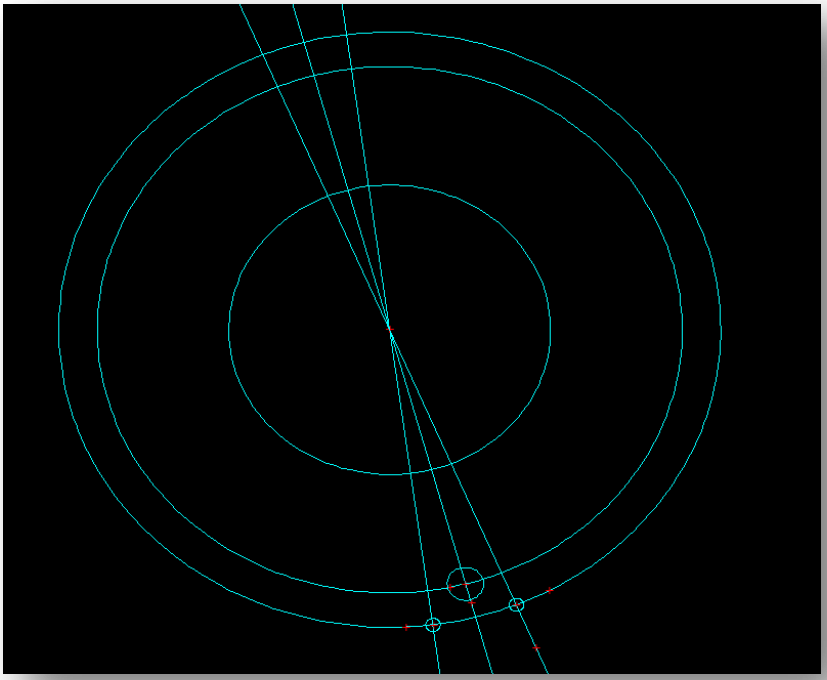


Figure 80 : The 3 circles for the gear tooth created

24. To create the tangential lines between the circles. First zoom into the 3 circles we built on the construction lines. Click **View Indicate Corners**

25. **Left Click** on one corner for your zoomed window, and then create the zoom window you want by moving the mouse, and **left click** again. A window will show you the area you are zooming into.

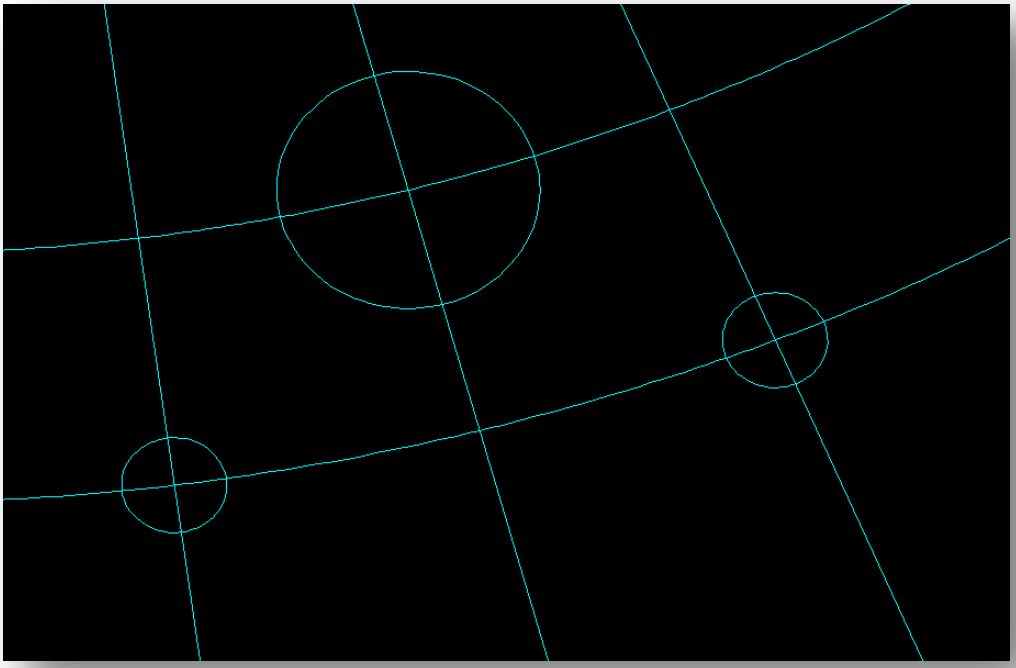


Figure 81 : **After zooming into our 3 gear circles**

26. Click **Line > Tan to 2 circles** *(Tangent to two circles)*
27. We want to build the **inner** tangent, relative to the gear, of these two circles *(there are multiple tangents able to be built between these two circles)*.To do this Click on the **Right side** of the **Left Circle**, then on the **Left Side,** of the **Centre Circle**

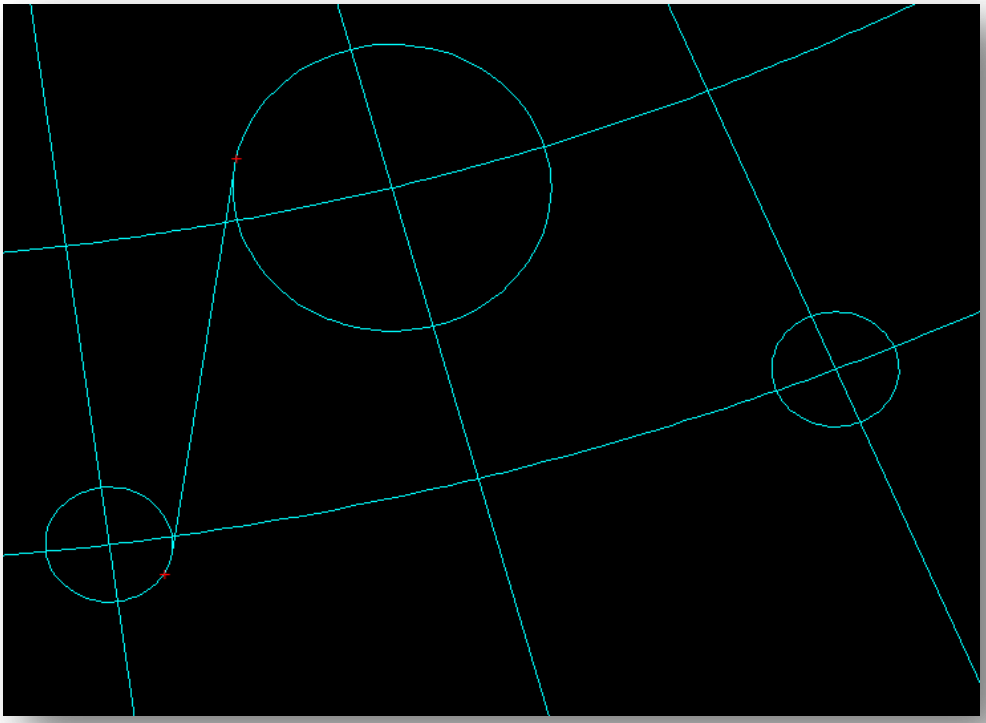


Figure 82 : After adding the tangential line between the circles

28. **Repeat 26 & 27** for the right circle and the center circle, being sure to build the inner tangent for these two circles.

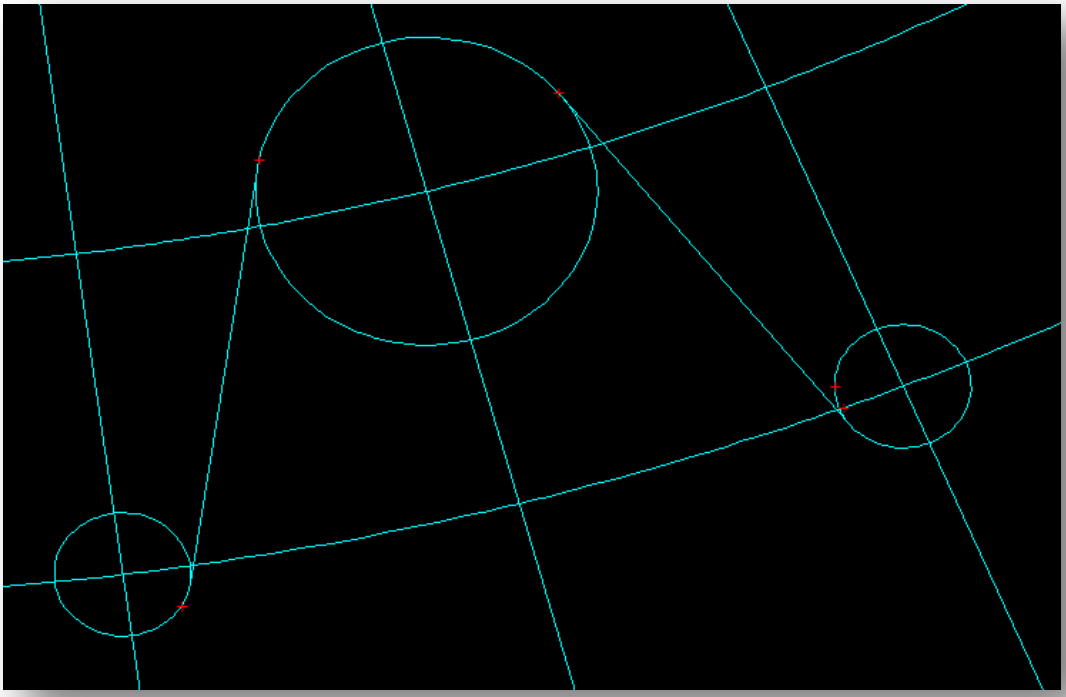


Figure 83 : **After building the two tangents**

29. We now need to trim the drawing until only the gear tooth profile, and the inner circle of the gear are still available. Use **Trim > Smart Trim** to reduce the drawing to the following. *(Be sure to trim the Little entities around the tangent lines and the small outer gear circles)*

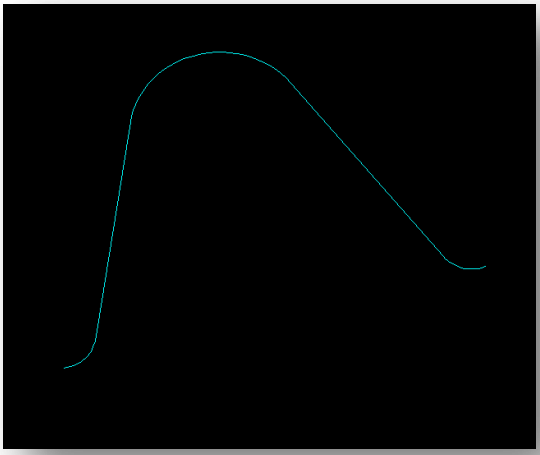
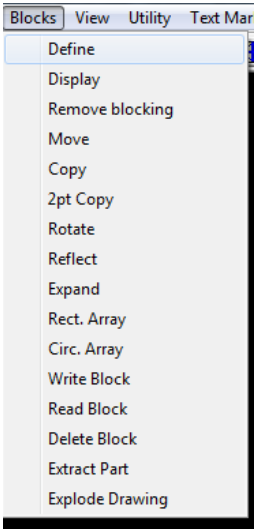
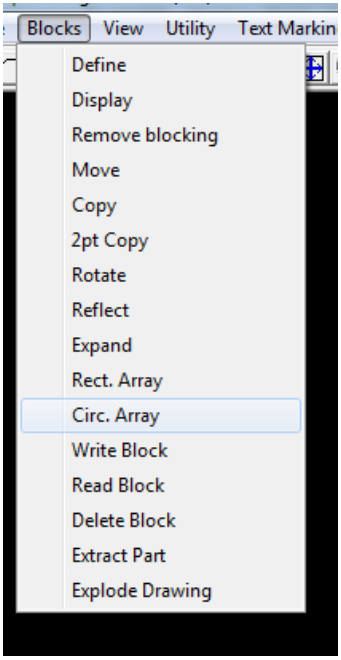


Figure 84 : **The trimmed drawing, showing a single tooth of the gear.**

30. Now we can set up our block, so we can array it. Click **Blocks > Define**



31. Select **Window**
32. Select **All,**
33. **Highlight** the Gear tooth
34. Name the Block, and click **Enter**
35. **Set** a center for the part, chose the *0,0* origin.
36. You can check if it has been set correctly by clicking **Blocks > Display**
37. Next use **Blocks > Circ. Array** *(Circular Array)*



38. Select the rotation center as being the *0,0* point. *You may need to **Right Click** to bring up the points menu, and select **Control Point***
39. Set the Total number of items as *6*. click **Enter**
40. Set the angle Step as *15°*. Click **Enter**

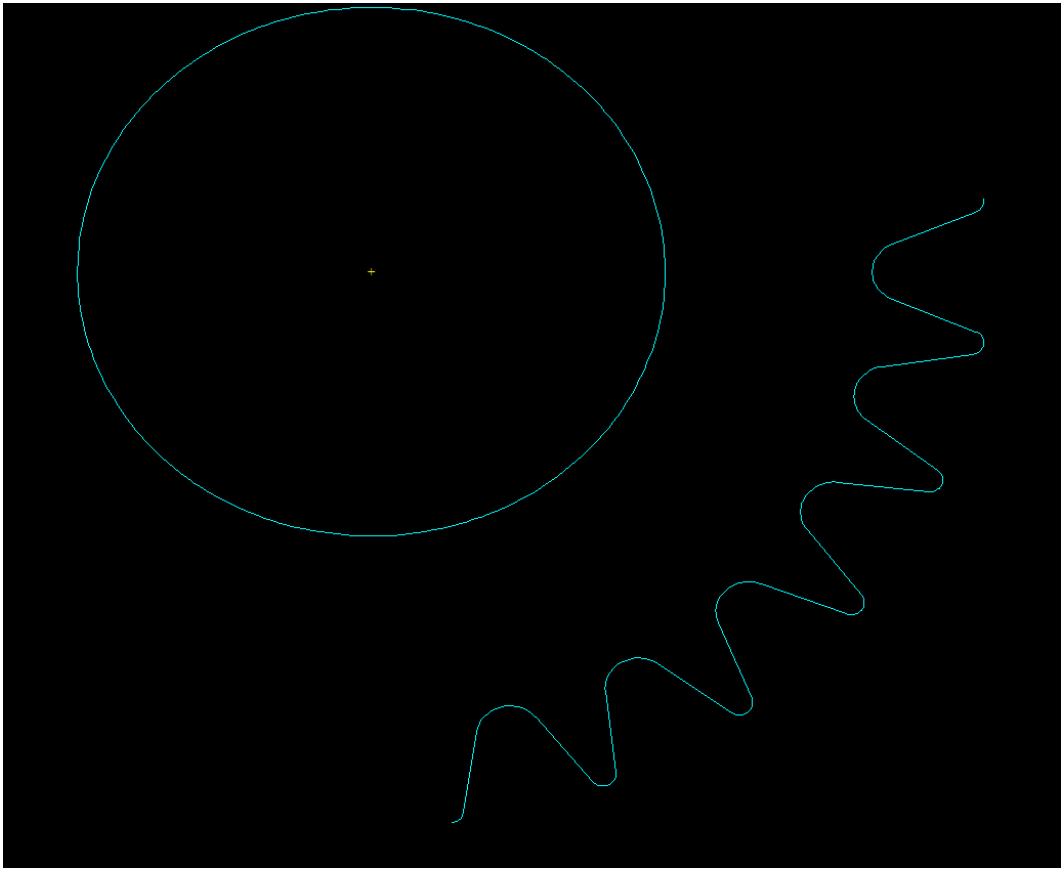


Figure 85 : The array tooth for the gear, and the inner circle

41. We need another part however, the other half Tooth at the bottom of the gear. **Repeat steps 37-40**, this time with total number as *2*, and a step angle as -15°.

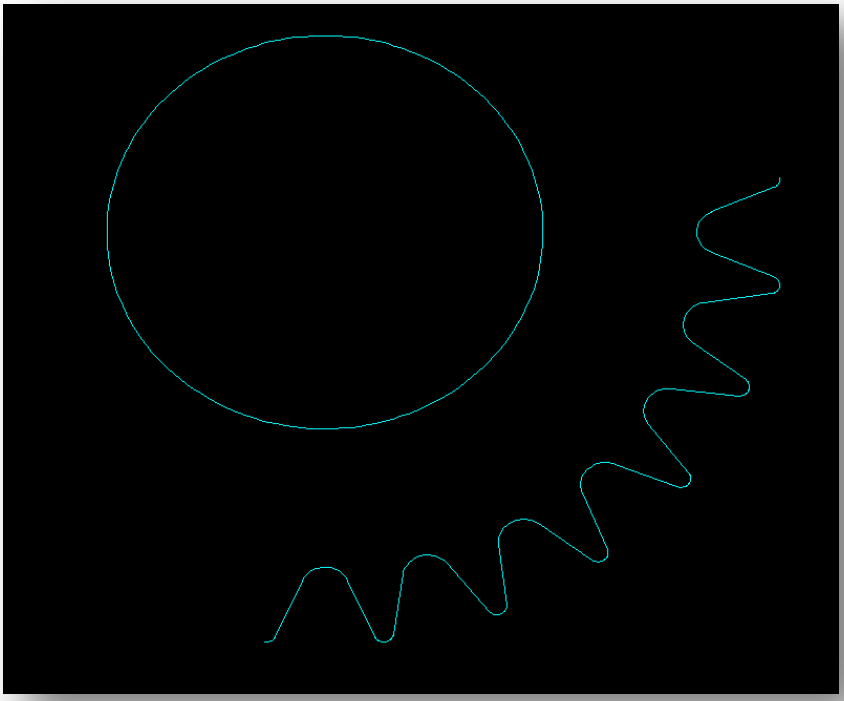


Figure 86 : The gear with the full tooth profile developed

42. Now we need to build the lines from the inner circle to the outer gear. Click the **Line to two points button.**

43. Turn on **Control Points**

44. **Click** the *0,0* control point, and control point on outer ring of the gear that is vertically below it.
45. **Repeat 42-44** for the horizontal line

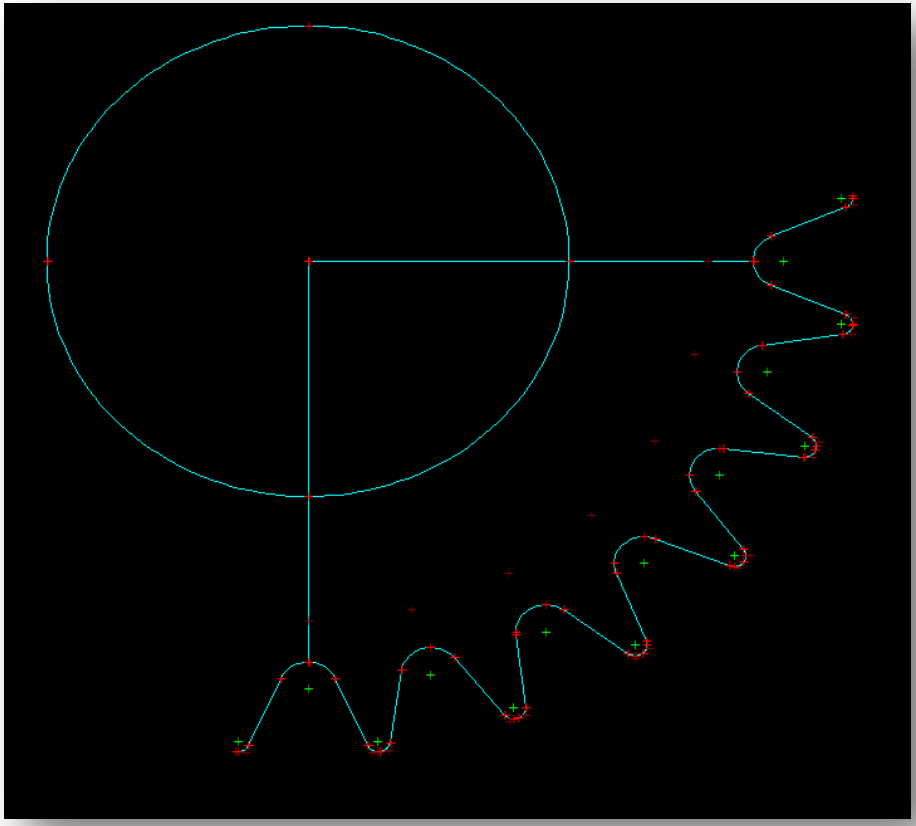


Figure 87 : **The gear with both lines built**

46. These are not the final lines however; Click **Line > Parallel at dist.** *(Parallel at Distance)*
47. **Click** on the vertical straight line

48. Set the distance as *9.52,* Click **Enter.**
49. Click on the right side of the line, as there are two sides it can go on
50. Select **Infinite length**
51. **Repeat 46-50** for the Horizontal Line.

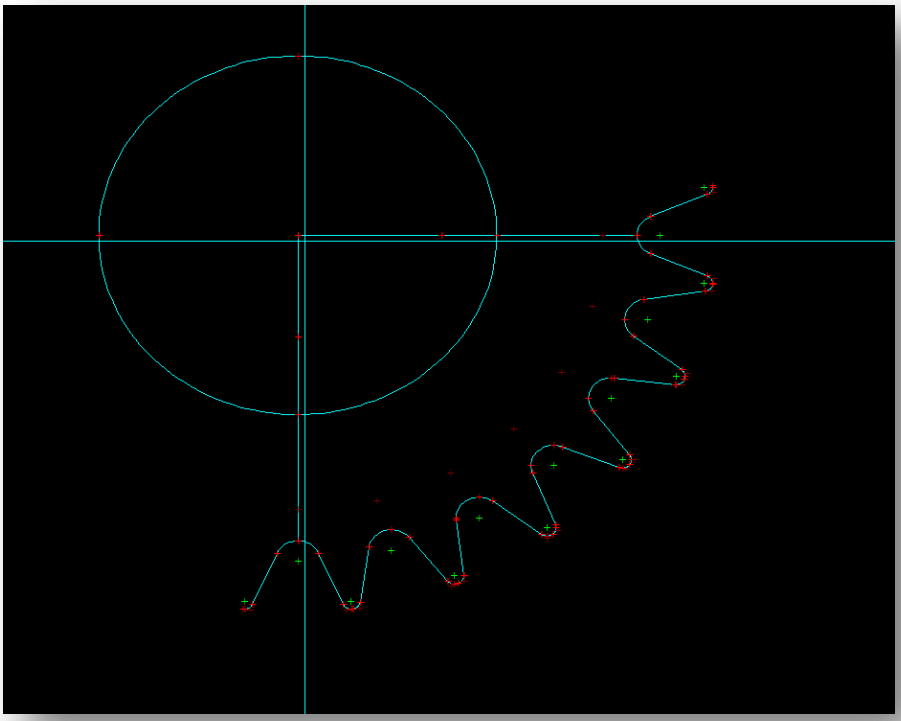
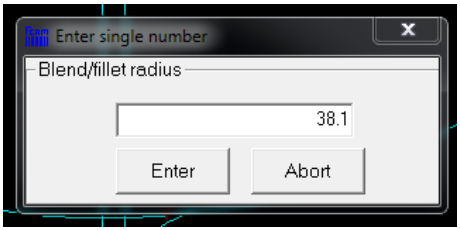


Figure 88 : The Gear with the vertical and horizontal lines built

52. Click **Fillet Blend**

53. Enter the Radius of the inner corners as *38.1,* click **Enter.**



54. **Click** the vertical line, and the inner circle, on the side that will create the fillet, as per the drawing.
55. You should be able to just **repeat 54** to create the fillet from the horizontal line. If not, **repeat 52-54.**

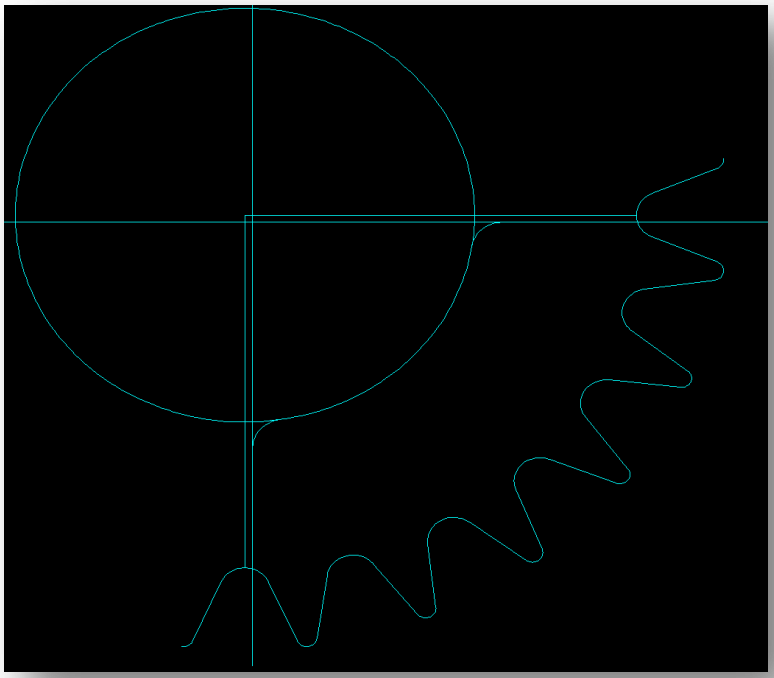


Figure 89 : The part with the fillets in place

56. Now use the **Trim > Smart Trim** to strip out all the excess lines & arcs that aren't apart of the final drawing.

Finished Drawing

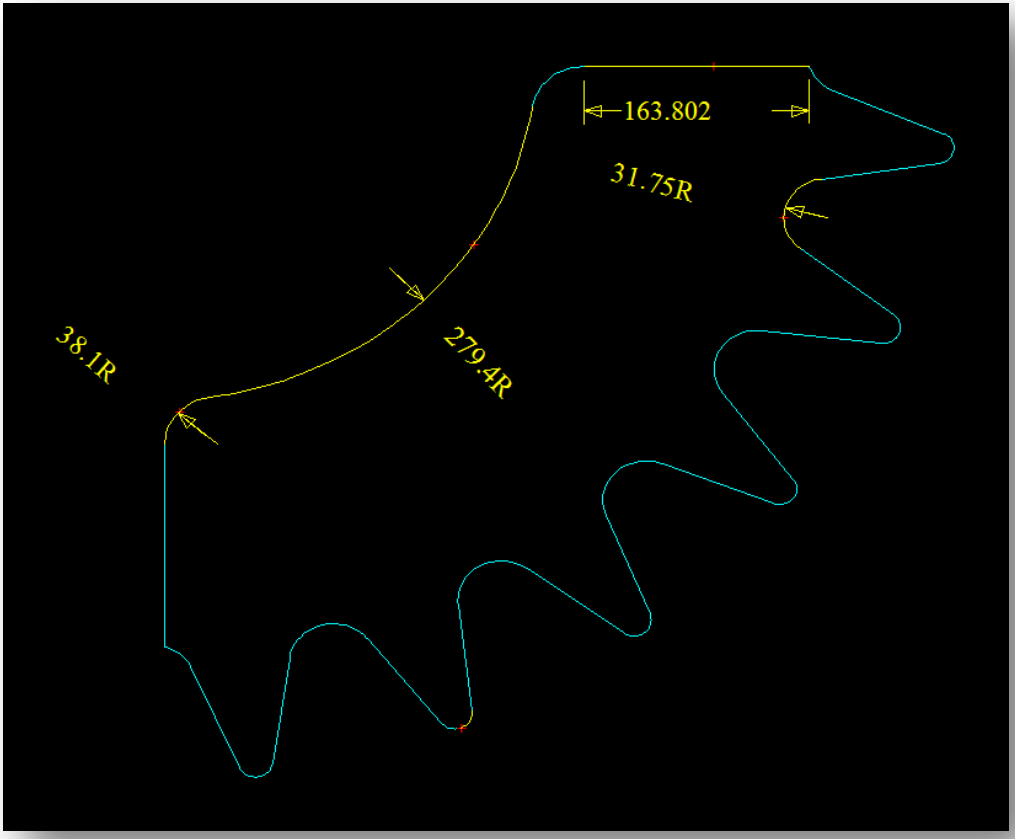


Figure 90 : The Final Drawing

57. You have completed the Gear!

Spricket

Rating: Intermediate

Time: 15 minutes

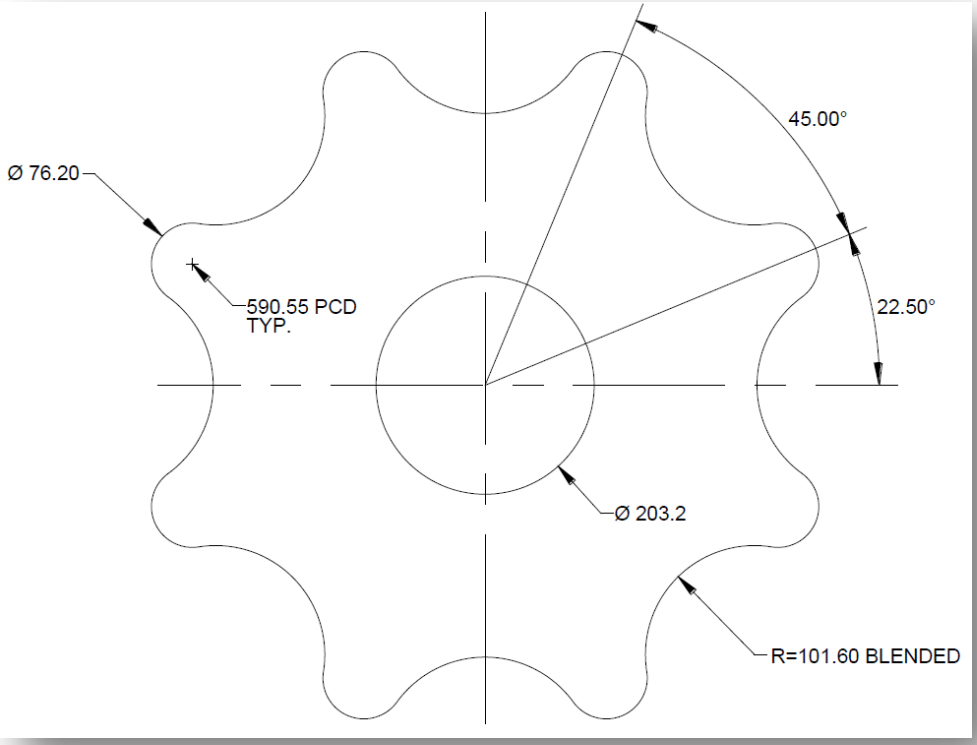
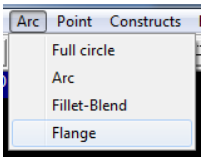


Figure 91 : The Spricket Drawing

Instructions

1. We will first define our origin point to be the center of the Spricket.
2. First we will build the PCD Diameter and the inner circle diameter. Click **Arc > Flange**



3. Enter the Interior Diameter of *203.2*, and the exterior PCD of *590.55.* Click **Enter**
   NOTE you don't need the 'd' character here because diameters are expected
4. Using **Absolute Coordinates** Set the origin of the two circles as the origin of the drawing, *(0,0)*.

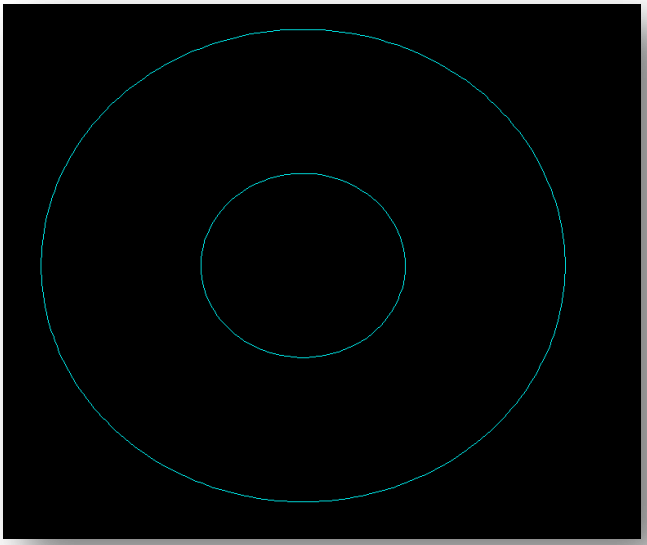


Figure 92 : The 2 circles built

5. Next we need to build the construction lines. Click **Line > Angle Only**
6. Set the position for reference as the center of the circles

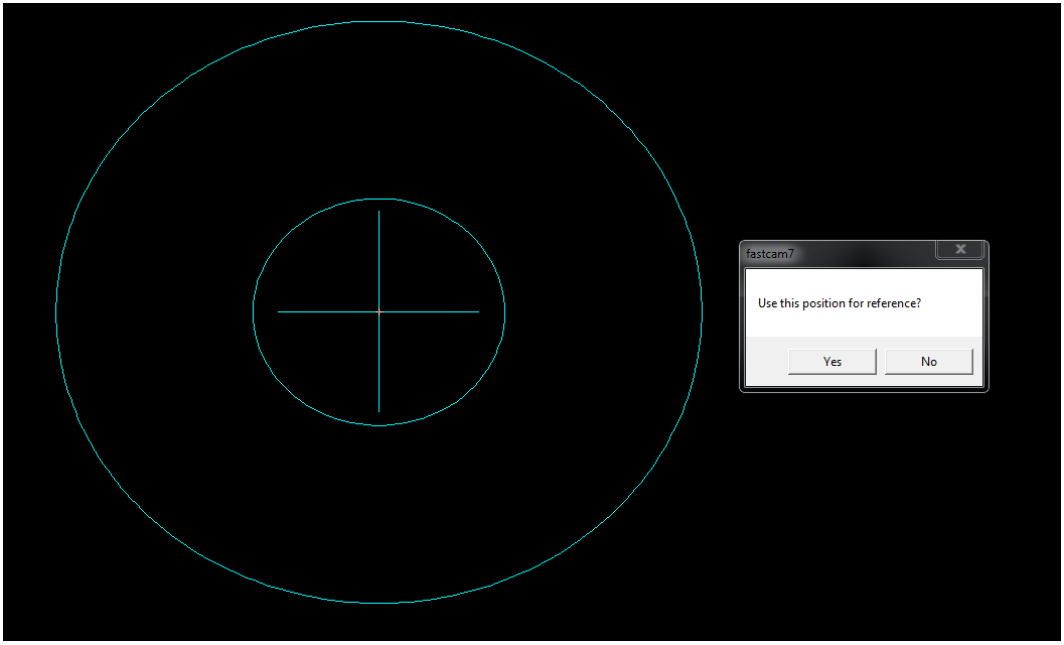


Figure 93 : The Reference point for the construction line

7. Select **Direct Entry**
8. Set the angle as *22.5°* and click **Enter**

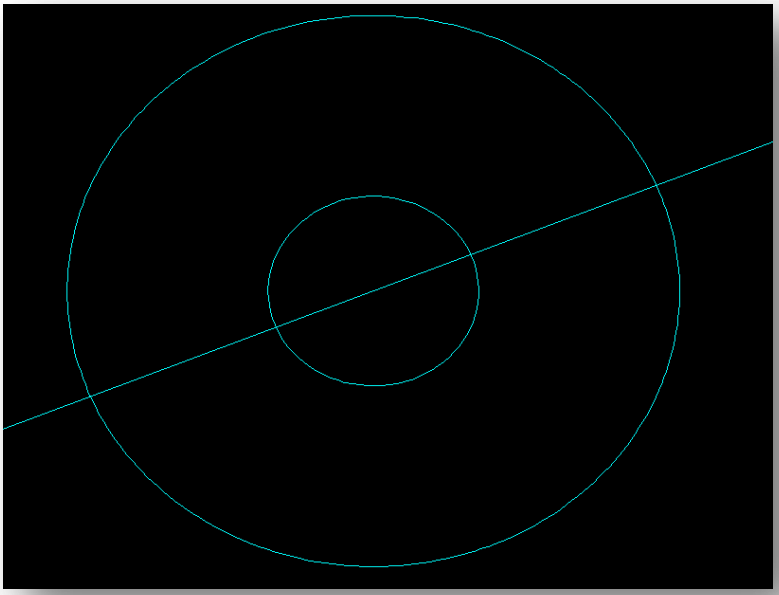


Figure 94 : **The first construction line built**

9. Now **repeat 5-8** with an angle of *-22.5°*

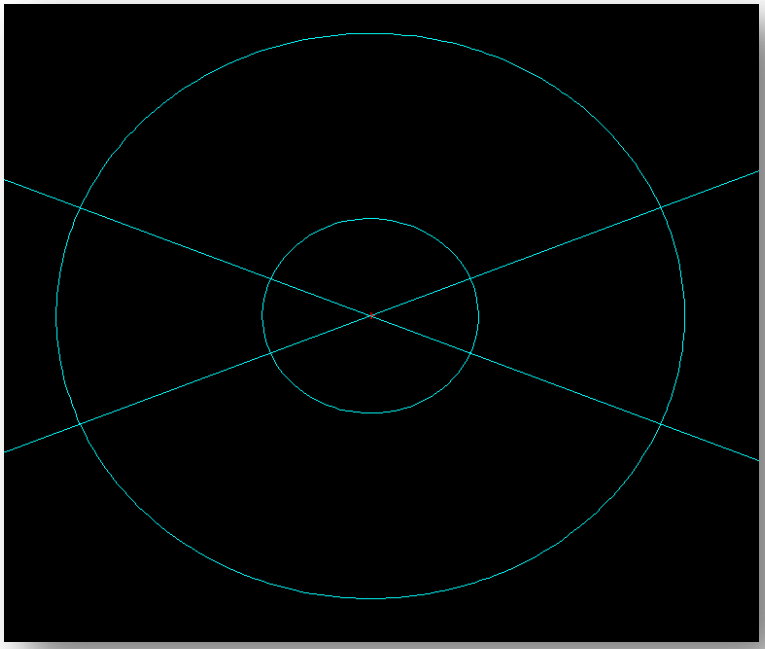


Figure 95 : Both construction lines built

10. Now we need to create circles for the top and the bottom of the tooth of the gear. Click **Circle**

11. Set the diameter as for a circle on the PCD of the Spricket, *76.20d.* Click **Enter**
12. **Right Click** to bring up the points menu
13. Select **Intersection**
14. **Click** on the outer circle and then one of the two outer construction lines.
15. **Repeat 14** for the other construction line and the outer circle.

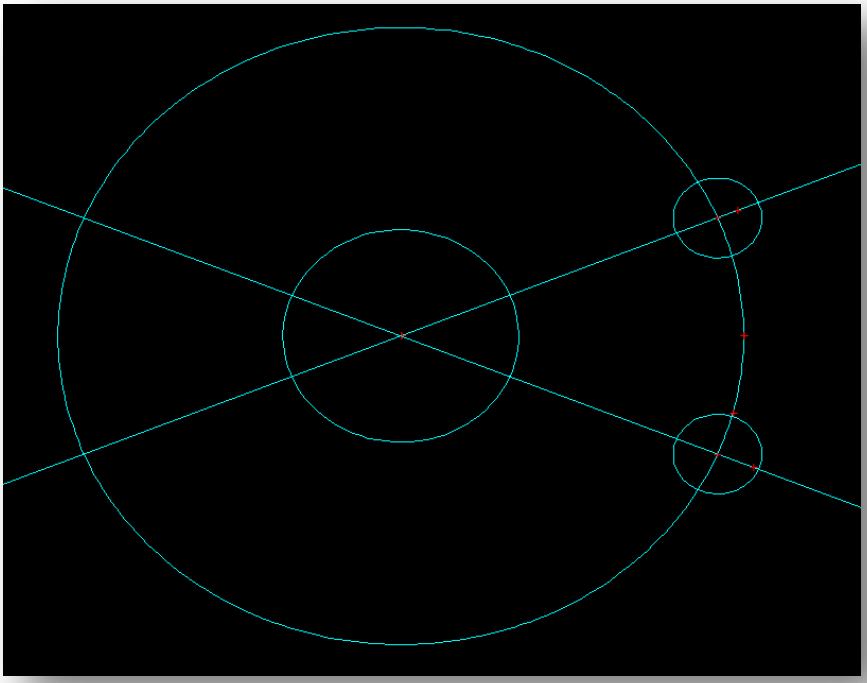


Figure 96 : **The two Spricket teeth circles built**

16. Next we need to blend in the arc between the Spricket's teeth. Click **Arc > Fillet-Blend**
17. Set the blend radius as *101.6*. Click **Enter**.
18. On each of the circles, **click** where the blend will approximately be originating from. *This is important because there are multiple arcs possible between the circles.*

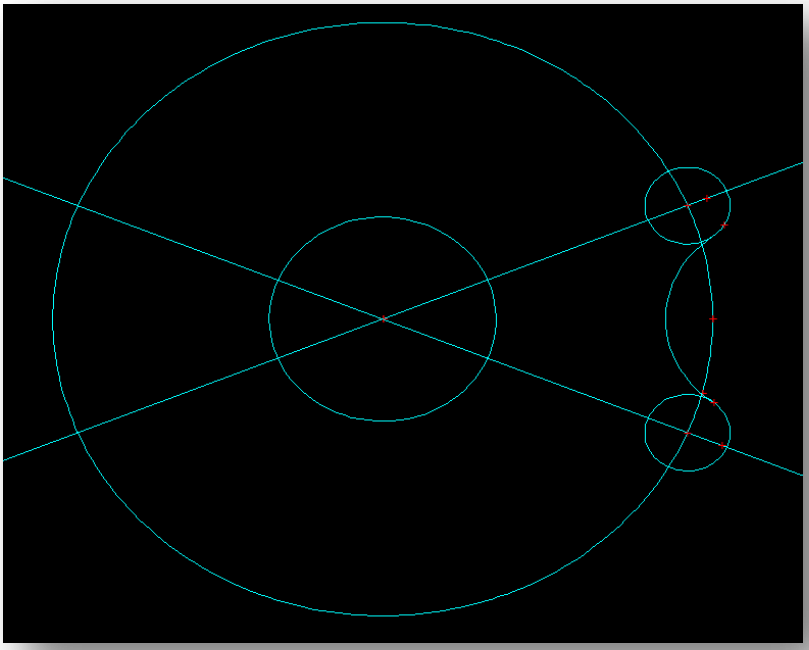
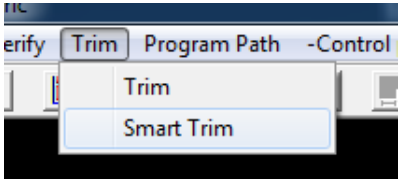


Figure 97 : The Spricket's teeth and the fillet-blend line created

19. Now we need to trim this drawing down until only the outer teeth shape, and the inner circle remain. User **Trim > Smart Time** to do this*. Be sure to get all the small arcs near the blend line and the circle, as well as the half circles on either side of the teeth, this is so when we array we are not doubling up lines*



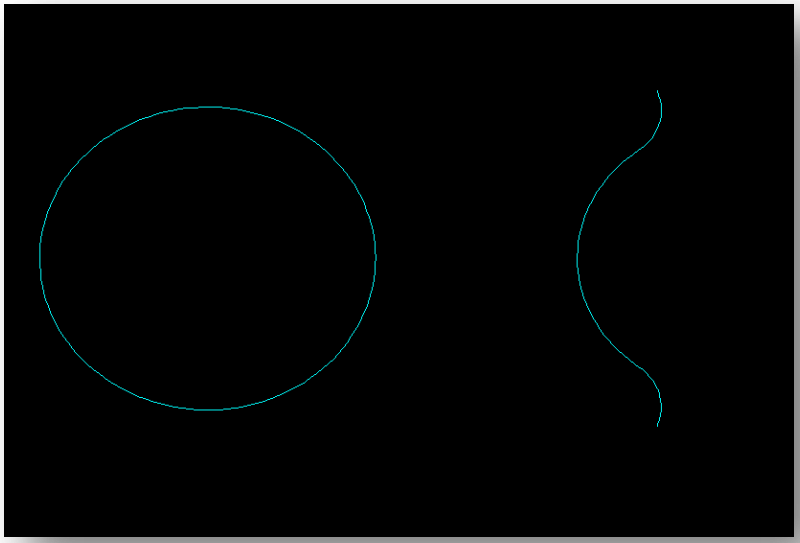
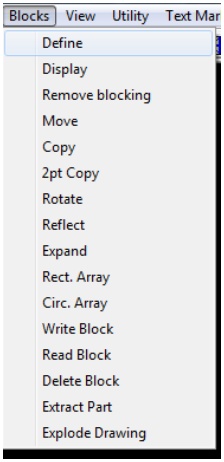
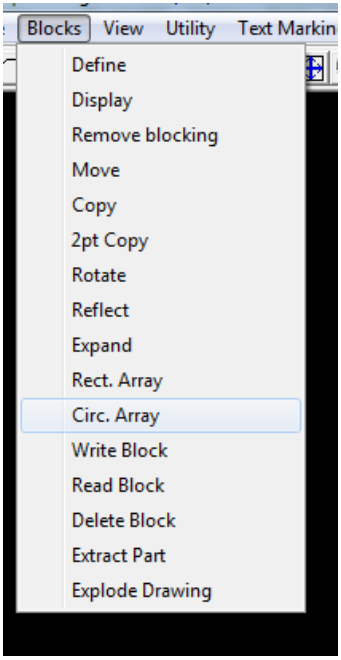


Figure 98 : The Reduced Drawing

20. Now we need to block the outer arc of the Spricket, so we can array it. Click **Blocks > Define**



21. Select **Window**
22. Select **All,**
23. **Highlight** the Spricket outer arc portion
24. Name the Block, and click **Enter**
25. Set a center for the part, chose the *0,0* origin.
26. You can check if it has been set correctly by clicking **Blocks > Display**
27. Next use **Blocks > Circ. Array** *(Circular Array)*



28. Select the rotation center as being the *0,0* point. *You may need to **Right Click** to bring up the points menu, and select **Control Point***
29. Set the Total number of items as *8*. click **Enter**
30. Set the angle Step as *45°*. Click **Enter**

Finished Drawing

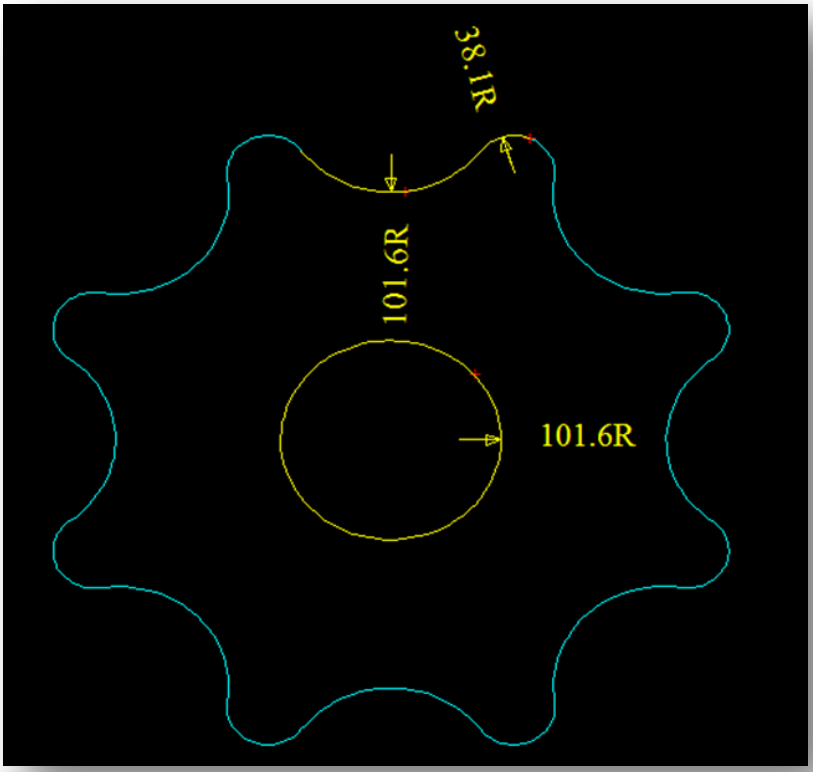


Figure 99 : The Complete Spricket

31. You have completed the Spricket!

Dog-Bone

Rating: Intermediate

Time: 20 minutes

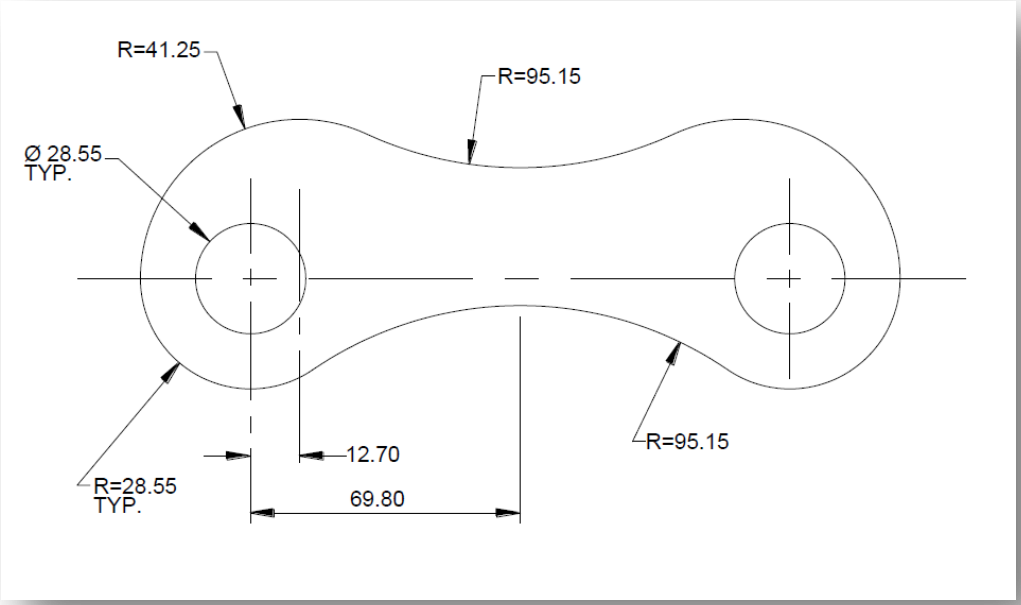


Figure 100 : The Dog Bone Drawing

Instructions

1. We will pick the origin as the left hand side inner circle's center. This is because we can see a few dimensions coming from this point.
2. First we will create all the circles on the left hand side, there are 3. Click the **Circle** button

3. First we shall create the outer PCD. Type in the diameter of the circle, with the special ‘d’ character to designate it as a diameter, *28.55d*. Click **Enter**
4. **Right click** to bring up the points menu
5. Select **Absolute Co-ords**
6. Set the coordinates as the center of the circle as *0,0*, and click **Enter.**
7. **Autoscale**

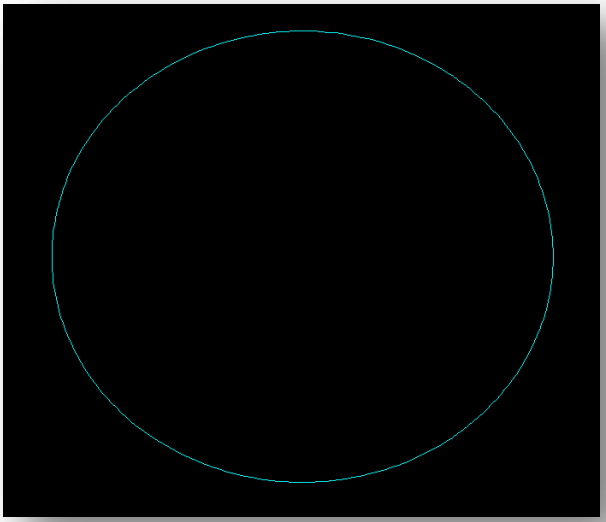


Figure 101 : The Inner left circle of the dog-bone

8. Now **repeat 2-6** with the inner circle of the both the outer circles of the side of the dogbone. *28.55* radius circle, centered on the same point as the inner hole. And a *41.25* mm radius circle centered at coordinates*, (12.7,0)*

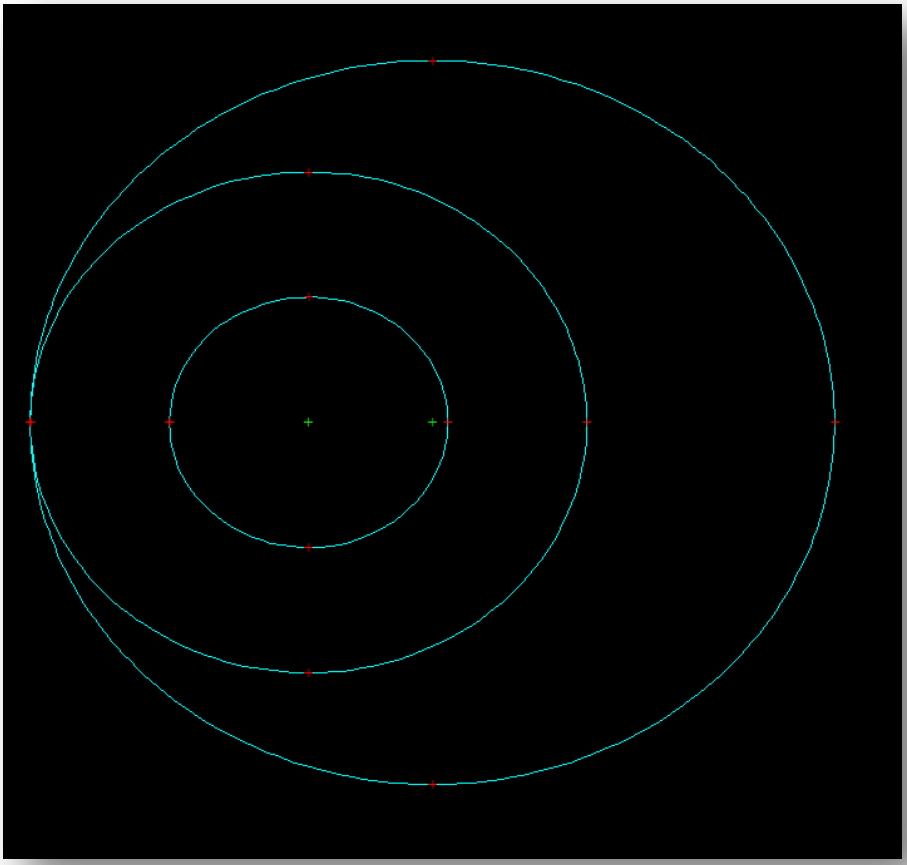


Figure 102 : The three circles for one side built

9. Now we must build the three circles for the other side. You can **repeat steps 2-8** above, and reflect the piece manually. OR you can block the part and reflect directly. This is the method I will describe. First click **Control Point**

10. Now **place** the point, using the points menu and **absolute coordinates**, at *(69.8,0)*

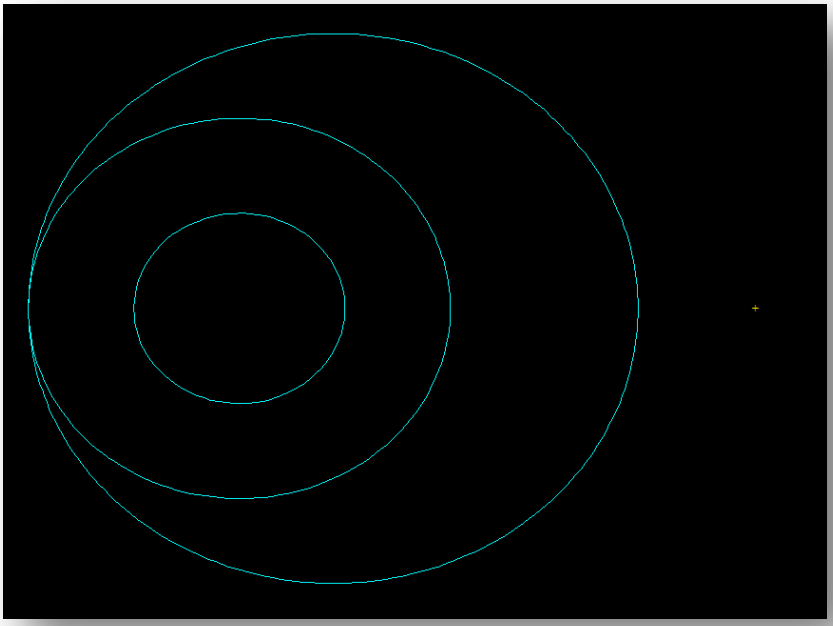
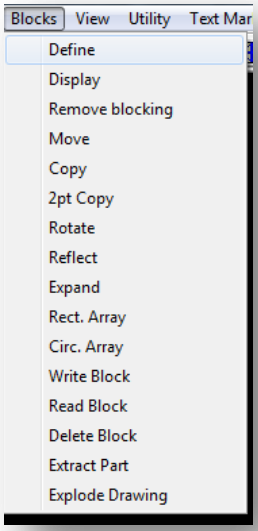


Figure 103 : The drawing with the point created

11. Next we need to block our three circles. Click **Blocks -> Define**



12. Select **Window**
13. Select **All,**
14. **Highlight** the three circles
15. Name the Block, and click **Enter**
16. Set a center for the part, **chose** the *0,0* origin.
17. You can check if it has been set correctly by clicking **Blocks > Display**
18. Now to reflect this, click **Blocks > Reflect**.
19. Select **X Movements**
20. **Click** the control point we created step **10,** to the right of the circles.
21. **Autoscale**

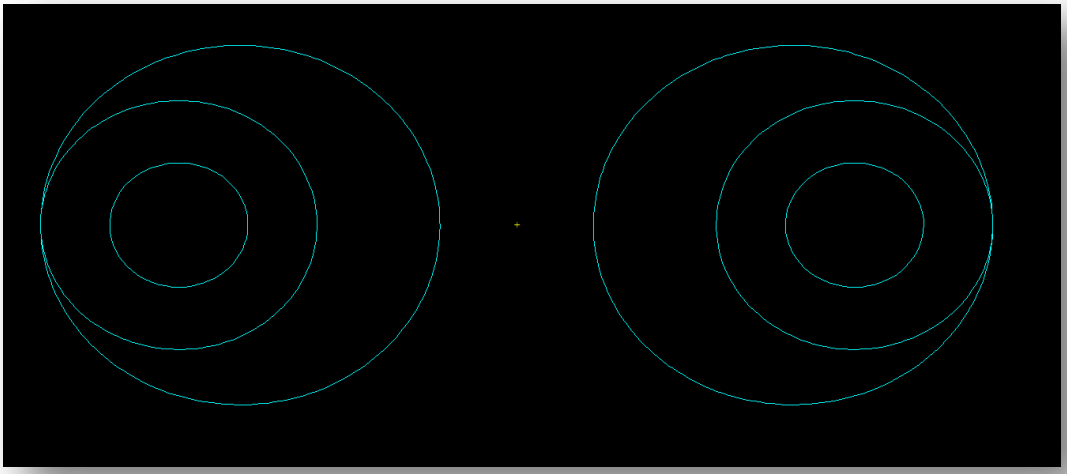
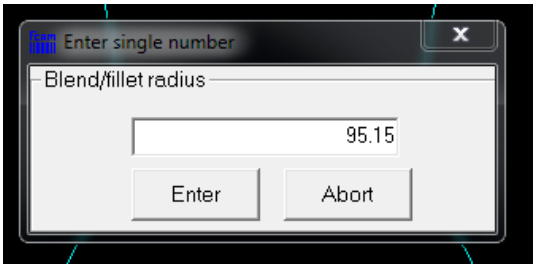


Figure 104 : **The circles reflected, so now both sides of the dog bone's circles are created**

22. Next we need to create the Blends between the two sides. For the top blend, click **Fillet-Blend**.

23. Set the blend to *95.15*. Click **Enter**



24. **Click** on the top half of the circle, close to where you expect the fillet to begin and end. *Important because multiple fillets are possible.*

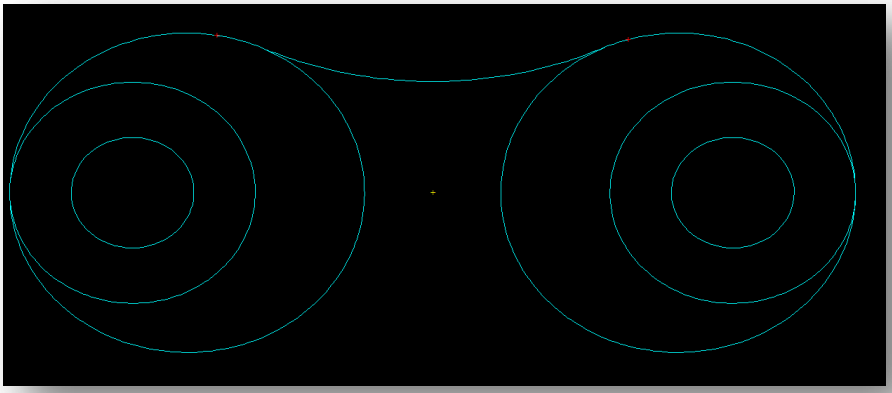


Figure 105 : The top fillet Created

25. Next **Repeat steps 22-24** this time for the same radius fillet, coming from the left and right middle circles.

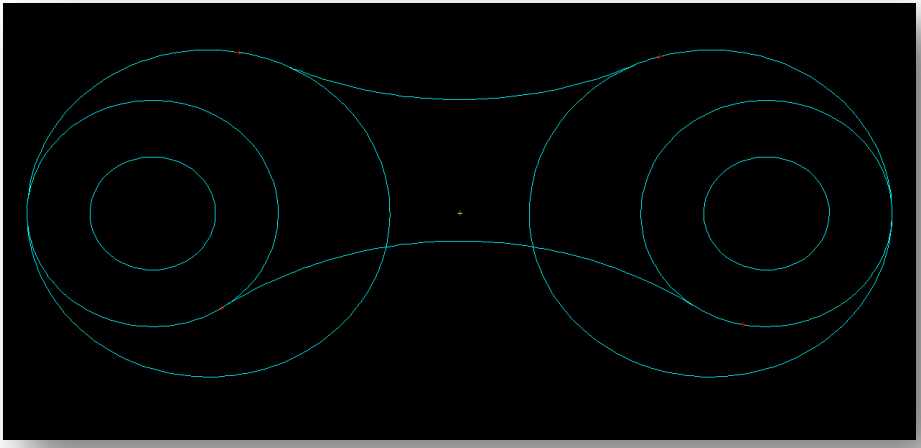
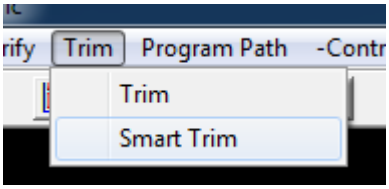


Figure 106 : All the fillets created.

26. Lastly we need to trim the image up. Use **Trim > Smart Trim**, and get rid of all the lines that are not in the drawing. *You will have to remove the blocking we did before with* ***Blocks > Remove Blocking***



Finished Drawing

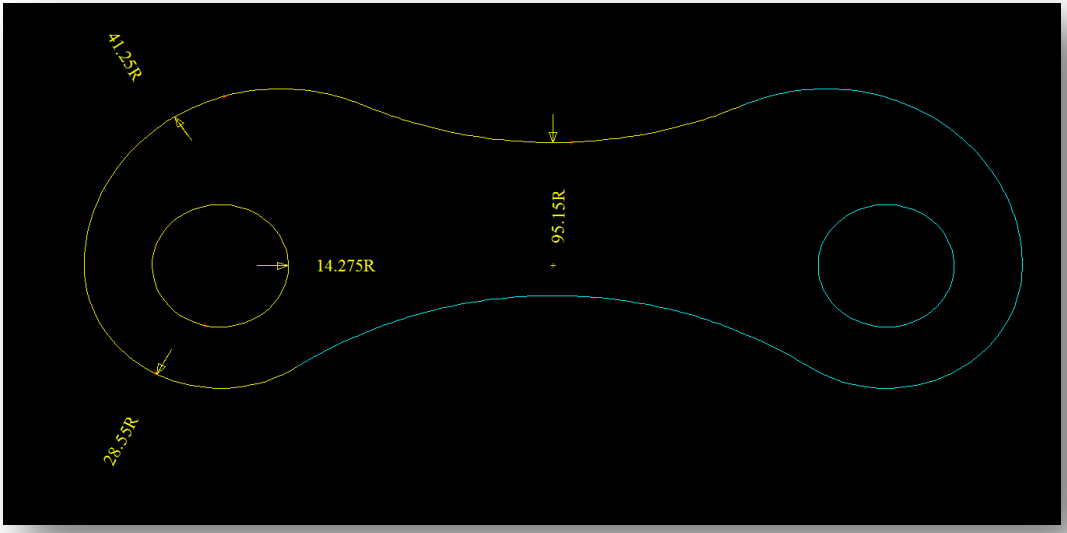


Figure 107 : The finished Drawing of the Dog-Bone

27. The Dog-Bone is complete!

Advanced Drawings

Misc.

Rating: Advanced

Time: 15 minutes

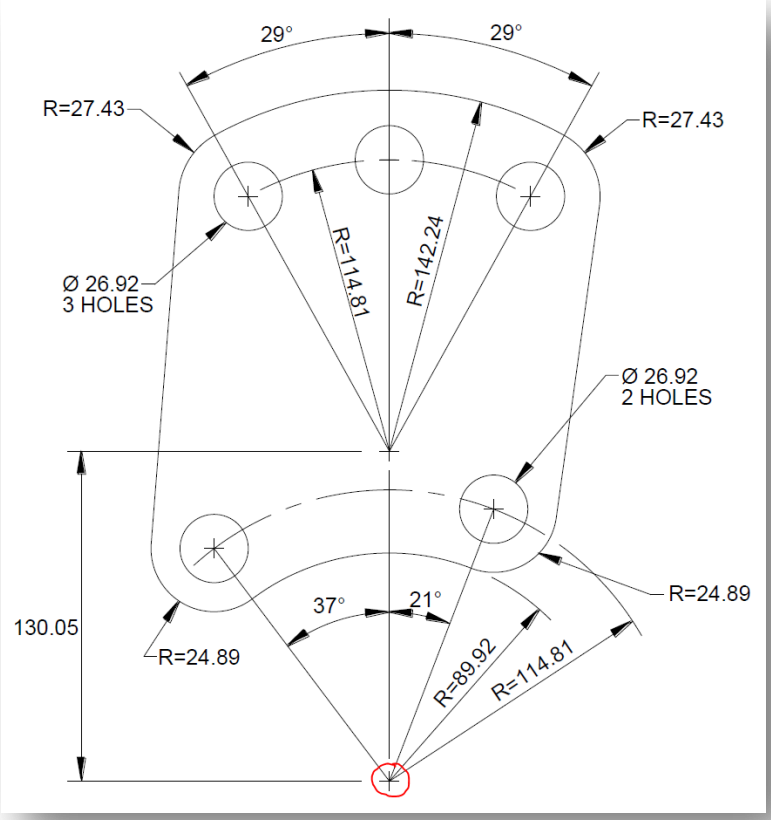


Figure 108 : The Misc. Drawing

Instructions

1. We will pick the origin as the bottom point where all the radius lines are originating from. Indicated on the drawing with the red circle.
2. Create a **point** at the origin, as *0,0* in absolute coordinates

3. Create a **circle** at the origin of Radius *89.92*. This will be the lower arc of the part.

4. Next create a **point** for the bottom right circles center, using the option **Point > Length & Angle.** It will be at length *114.81,* and angle of *69°* (=90-21)

5. **Repeat 4** for the bottom left circle origin of the part, again length will be *114.81,* but angle will be *127°* (=90+37)
6. **Autoscale**

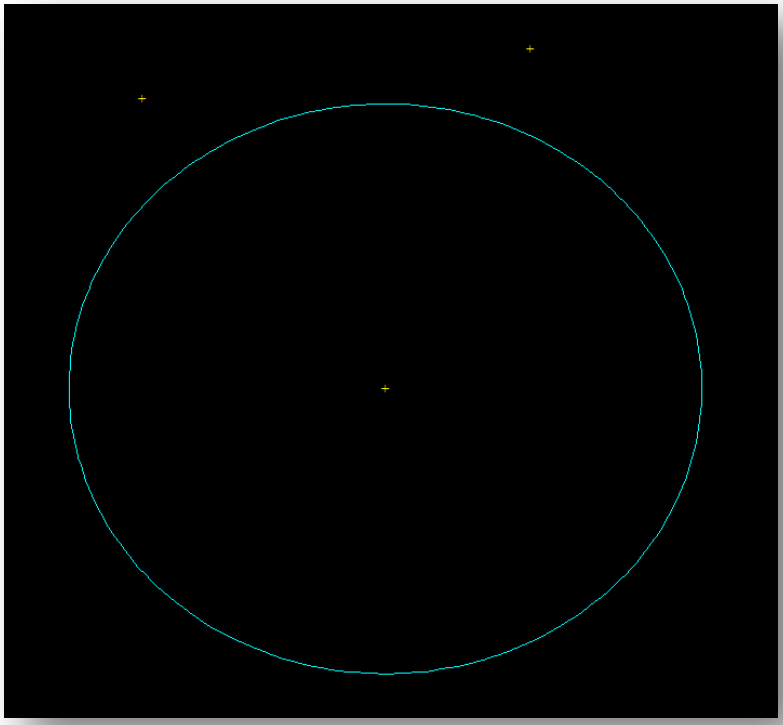


Figure 109 : The first circle and the 3 control points built.

7. Next we will build the 2 circles at each of the sides along the bottom of the part. Click **Circle**, set diameter as *26.92d.* Use the **Control Points** option to quickly place the circles at both the centers

8. **Repeat 7** with the outer arcs of the part, with circles of radius *24.89*.

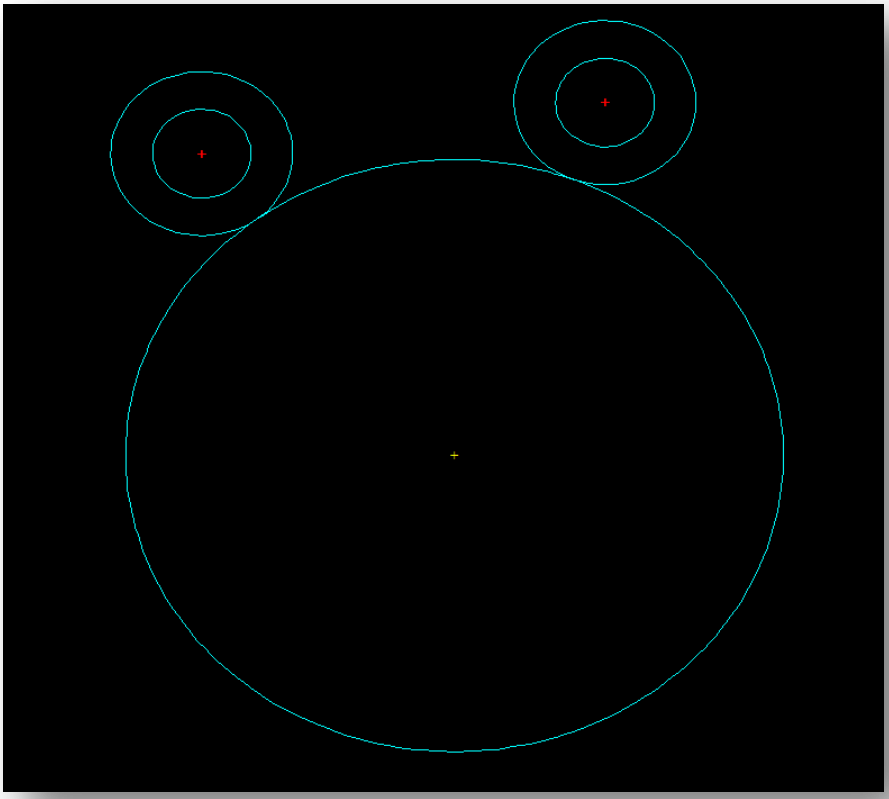


Figure 110 : **The lower circles created**

9. Now that the lower half is complete we need to create the top half of the drawing. For this, create a **point** at the origin of all the construction lines in the top half, at *0,130.05. NOTE: This point will be referred to as the* ***Top Origin***

10. Create a **circle** for the top arc of the drawing, with radius *142.24*, centered at the **top origin**.

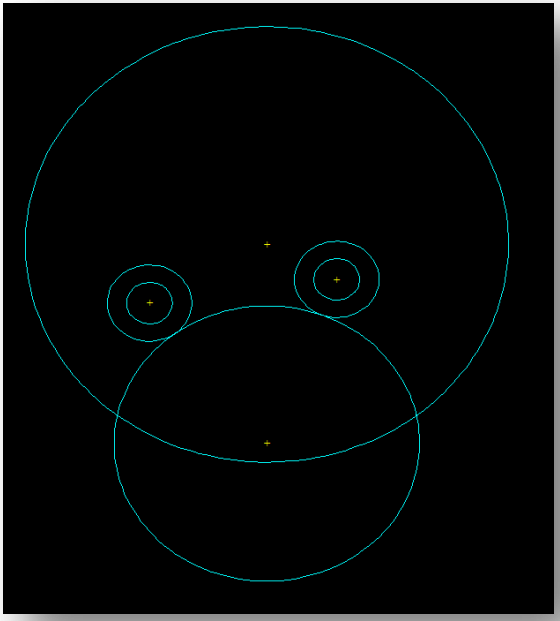


Figure 111 : The top arc circle built

11. Now create the 3 interior circles for the top half using **Length and Angle**, all of which have diameter *26.92d*, and length *114.81.* The angles for the 3 will be:
    - *61° (=90°-29°)*
    - *90°*
    - *119° (=90°+29°)*

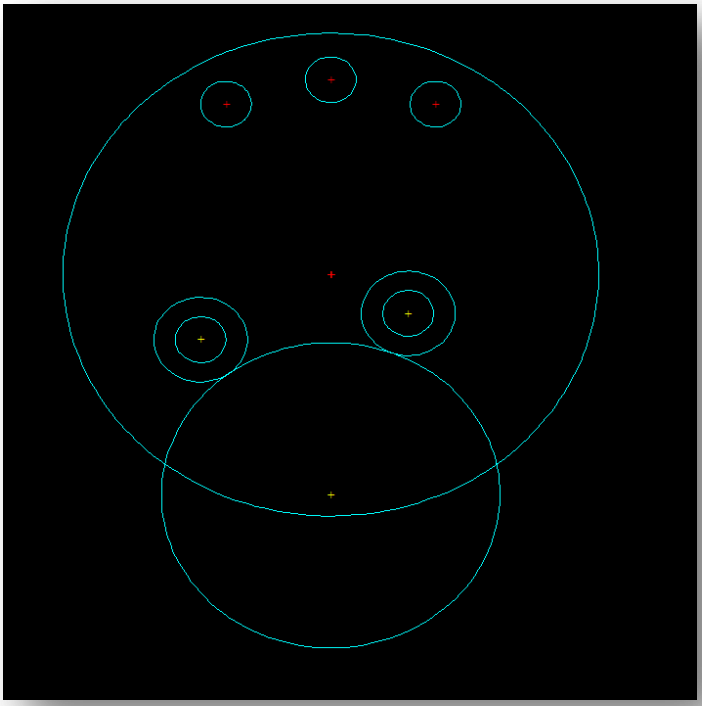
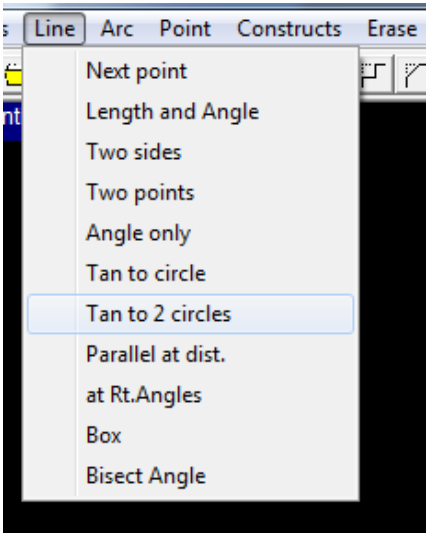


Figure 112 : **The top arc and the top 3 hole circles built**

12. Now create the outer circles which will form the part's exterior contour. Create the circles, centered at the top left and right circle's origins, and set them with a radius of *27.43*

Figure 113 : **The top circles completed**

13. Lastly, we need to create a tangential arc for each side of the Misc. part, one on the left and one on the right. Use the **Line > Tan to 2 circles** option to complete this. The lines should go from the bottom left outer hole circle to the top left outer hole circle, and the reciprocal holes on the right side of the part.



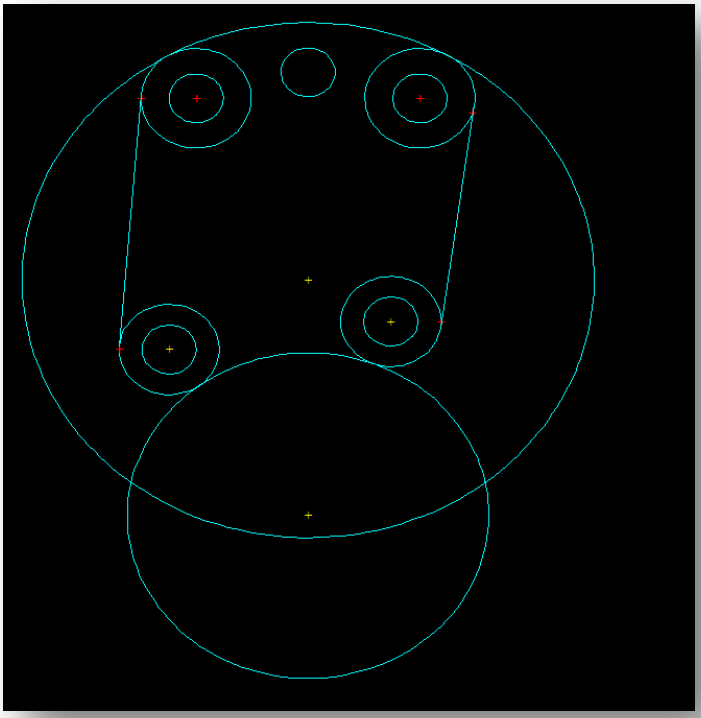
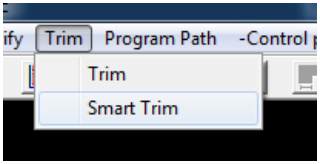


Figure 114 : The shape with all the lines completed

14. Lastly use the **Trim > Smart Trim** feature to remove all the extra lines



15. **Autoscale**

Finished Drawing

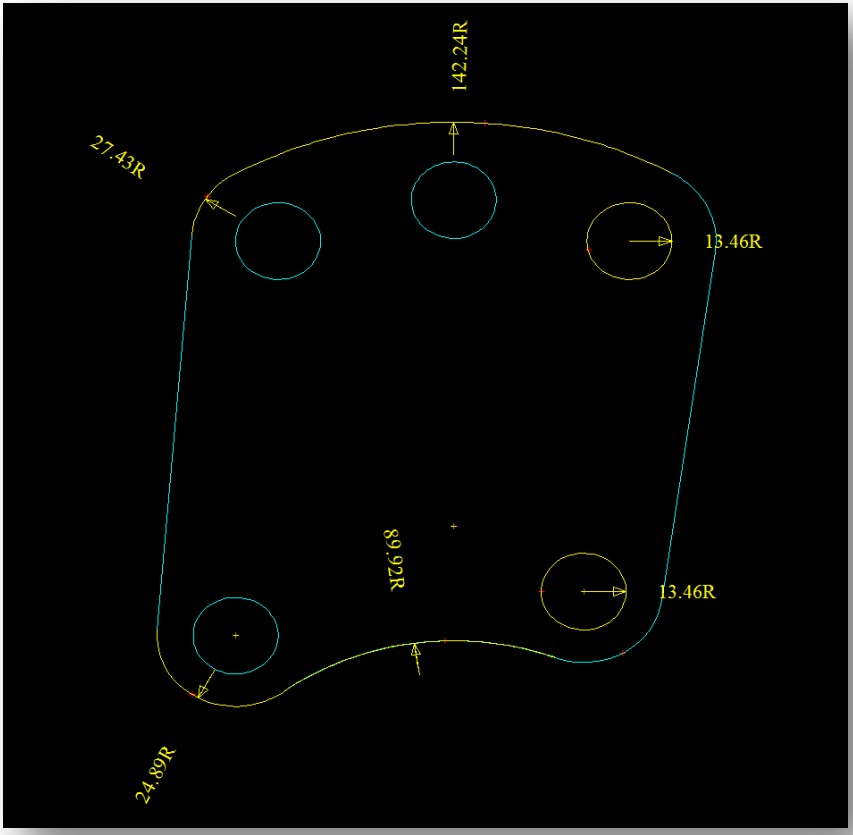


Figure 115 : The completed Drawing

16. **You have finished the drawing!**

Lever

Rating: Advanced

Time: 20 minutes

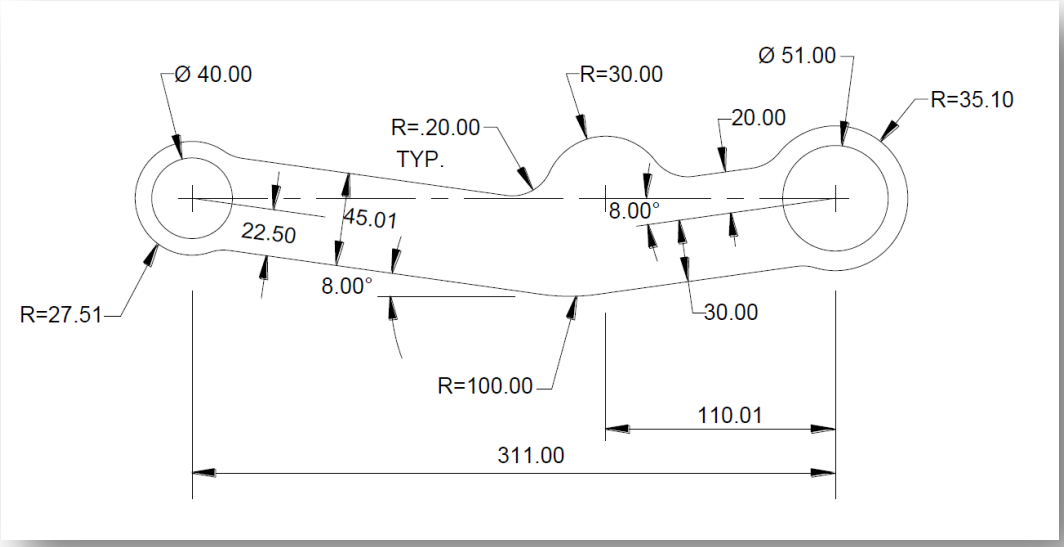


Figure 116 : The Lever Diagram

Instructions

1. We start by selecting an origin for the drawing. In this case we will choose interior circle on the left's center as our Origin. This will be our **Left Origin**.
2. Next we will create a circle at the left origin, click **Circle**, and create it with diameter *40d* centered at *0,0.* The center for the circle will serve as our **Left Origin**.

3. Create the outer arc of the left end of the lever, by creating another **circle** centered at *0,0*. With Radius *27.51*

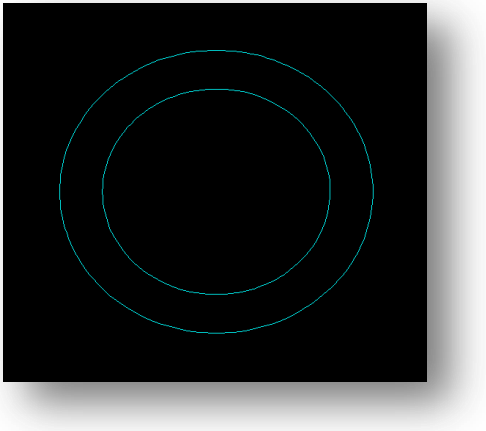
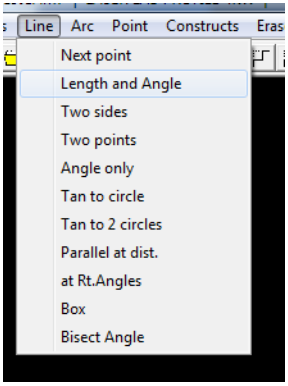


Figure 117 : The two left side circles created

4. Now we need to create a construction line for the left angle of the lever. Click **Line > Length and Angle**. Center it at the **Left Origin**, give it a length of *100*, and an angle of *-8°*



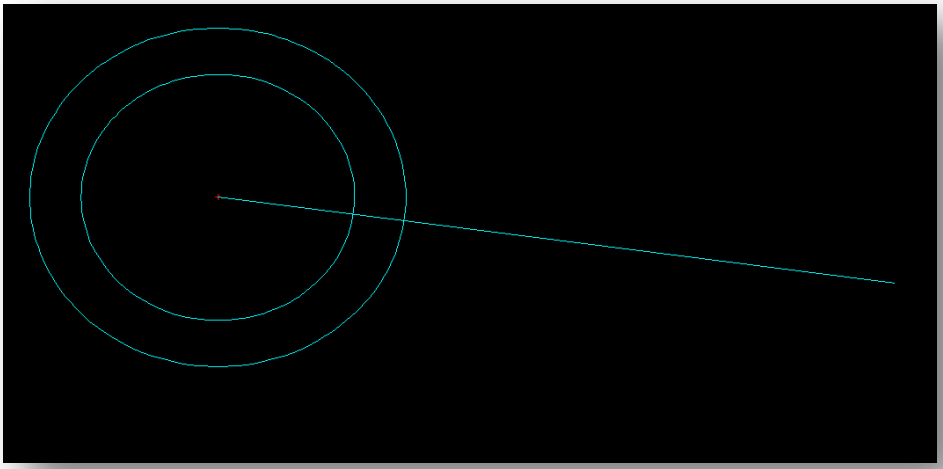
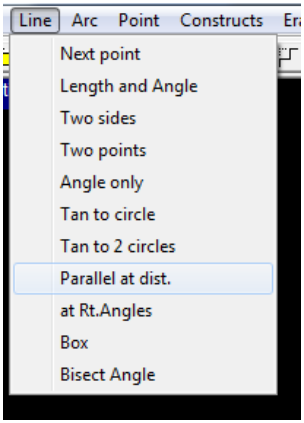


Figure 118 : The left side construction line

5. Now we need to the left bottom line of the lever's profile. Click **Line > Parallel at Dist.** *(Parallel at Distance)*. Select our construction line, and set the offset as *22.5,* then click on the underside of the construction line, and select **infinite length.**



6. **Repeat 5.** For the top side. This time work from the bottom line, as the top line is dimensioned in relation to that. Your offset will be *45.01.*

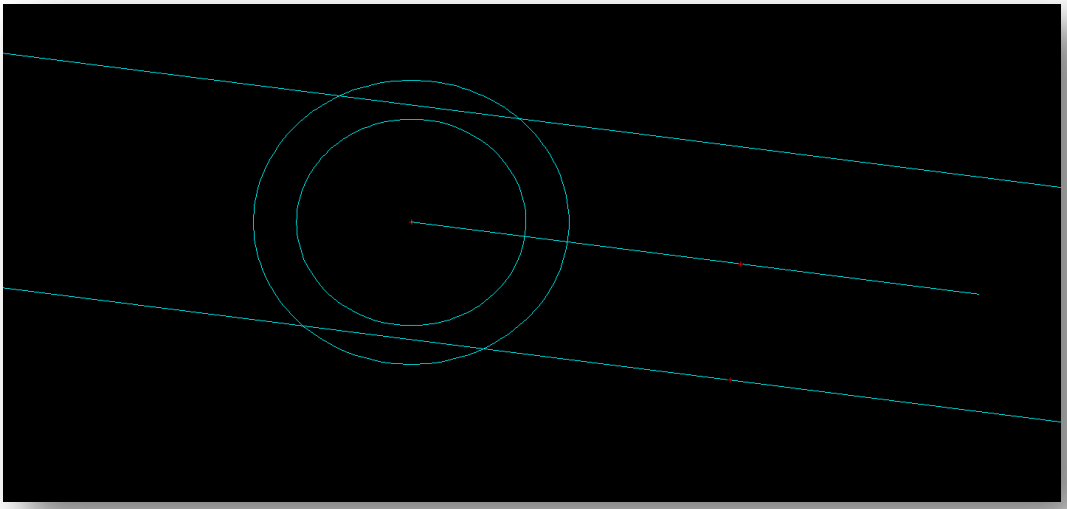


Figure 119 : The Lever with the left side built

7. Now we will build the **Right Origin** for the part. This will be at the center of the right hole in the lever. Create a **circle**, with diameter *51.0d* and center it at *311,0*.

8. Create another **circle** centered at the Right Origin, for the exterior of the part, with radius *35.1*
9. **Autoscale**

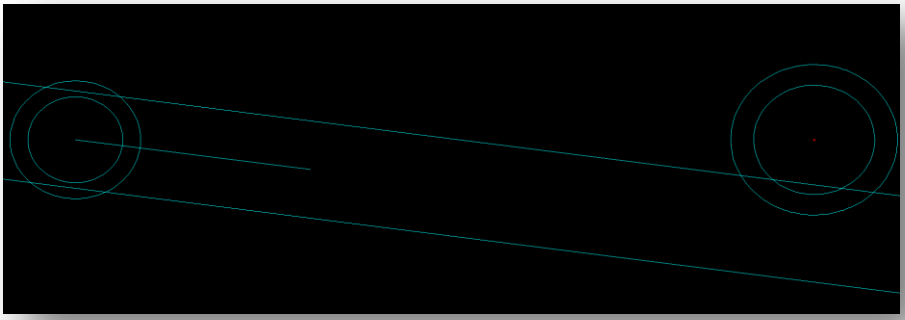


Figure 120 : **The two ends of the lever created**

10. Now create a construction line from the **Right origin**, using **Length and Angle,** of length *100*, and angle *188°(=180°+8°)*

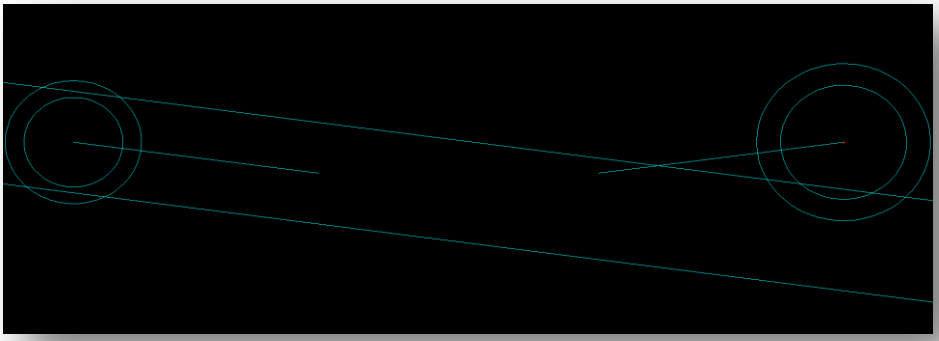


Figure 121 : **The construction line from the Right Origin**

11. Again use **Line > Parallel at Dist.** And create the lines on both sides of the right construction line
    - The bottom line is *30* below the construction line
    - The top line is *20* above the construction line.
    - Create them with **infinite length**.

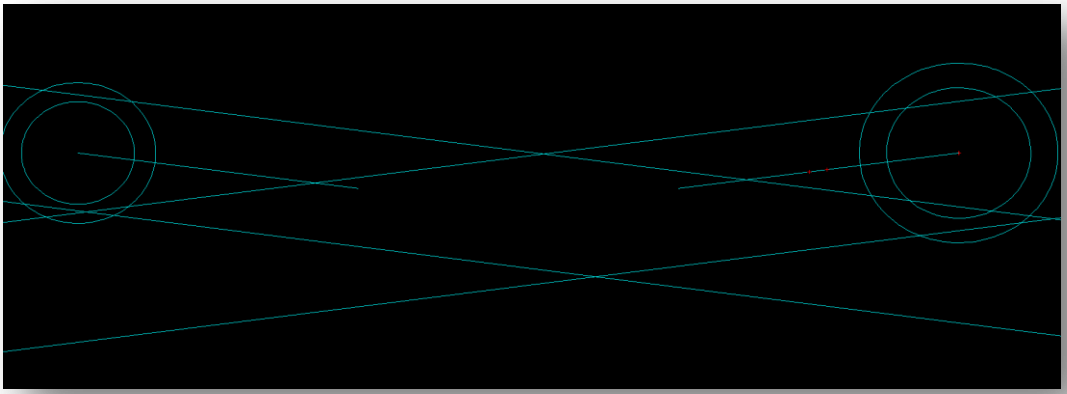


Figure 122 : The lines built from each end of the lever

12. Next we will create a **circle** for middle of the lever. Use Incremental coordinates from the **Right Origin**, and set its center as *-110.01, 0*. Radius of *30*.

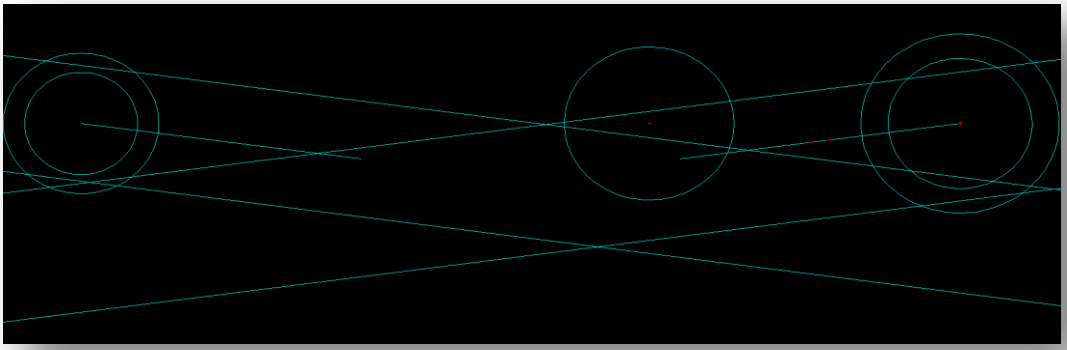


Figure 123 : The middle circle created

13. Now we need to create the two fillet blends on both sides of the middle circle. Use **Fillet-Blend** to place the fillets, with a radius of *20.00*

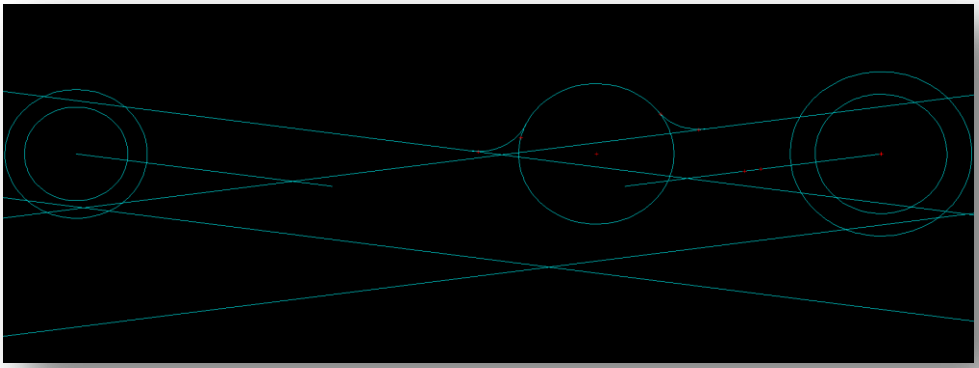


Figure 124 : The middle circle with fillet blends on either side

14. Next we need to build the bottom **Fillet Blend.** Use a radius of *100*

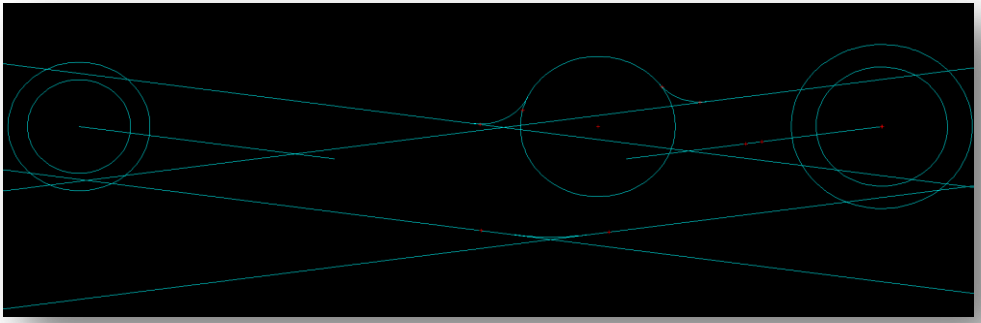
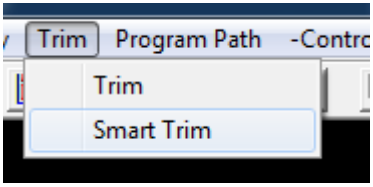


Figure 125 : The Drawing with all the fillets and circles in place.

15. Lastly we need to trim the drawing down of all construction lines. Use **Trim > Smart Trim** to get rid of all lines that aren't in the final drawing. Be sure to trim the small lines near the fillets.



Finished Drawing

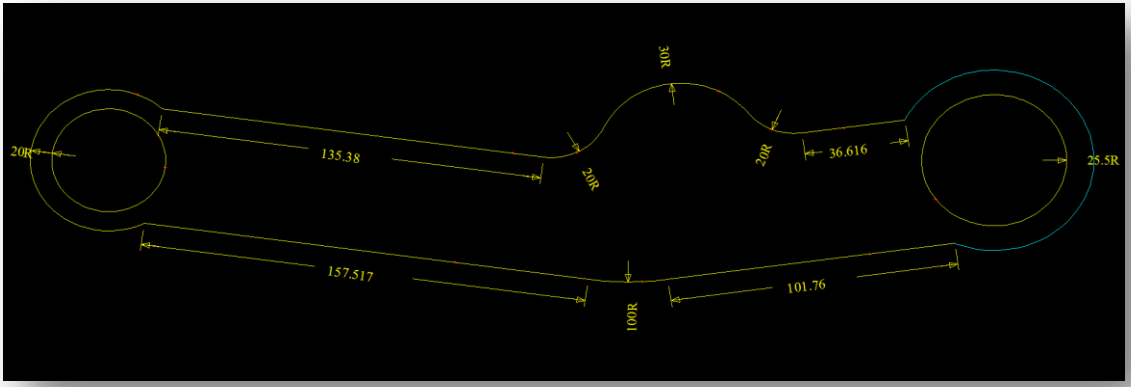


Figure 126 : The Completed Lever Drawing

16. The Lever is complete!

Lift-Arm

Rating: Advanced

Time: 25 minutes

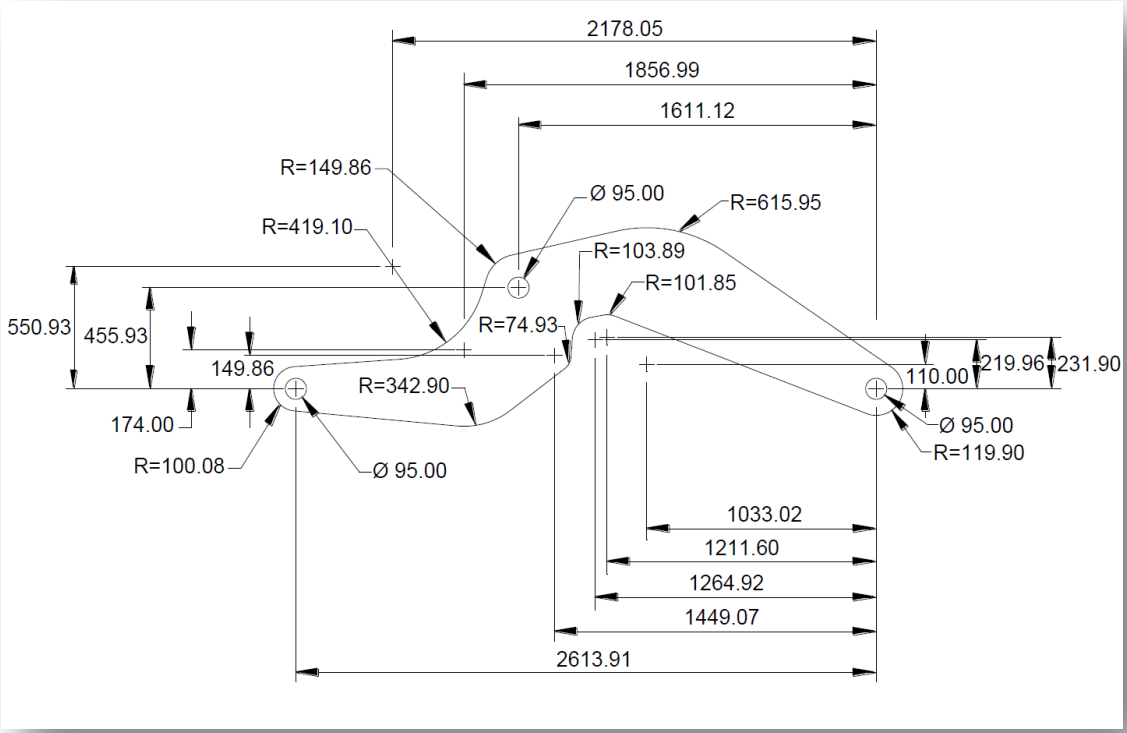


Figure 127 : The Lift Arm Drawing

Instructions

1. We will start by choosing our origin point. Because the dimensions in this drawing are referenced from two origins, we will select two.
    - The **Right Origin** will be the center of the Lift Arm's right hole. This will also be the Origin (0,0)
    - The **Left Origin** will be the center of the Lift Arm's left hole.
2. Begin by creating the right internal circle, click **Circle,** set the diameter of the hole as *95.00d* and place it at *0,0.*

3. Create a second circle at the **Right Origin**, this time radius of *119.90*, for the outside of the lever arm
4. The next step is to create all the circles for the small arcs in the middle of the diagram using our **Circle** button. For this use absolute coordinates and assume the **Right Origin,** is horizontally level with the **Left Origin**. So you can add all of the following points:

Radius	X position	Y position
615.95	*-1033.02*	*110.00*
101.85	*-1211.60*	*231.90*
103.89	*-1264.92*	*219.9*
74.93	*-1449.07*	*149.86*
342.90	*-1856.99*	*174.00*
419.10	*-2178.05*	*550.93*

5. **Autoscale**

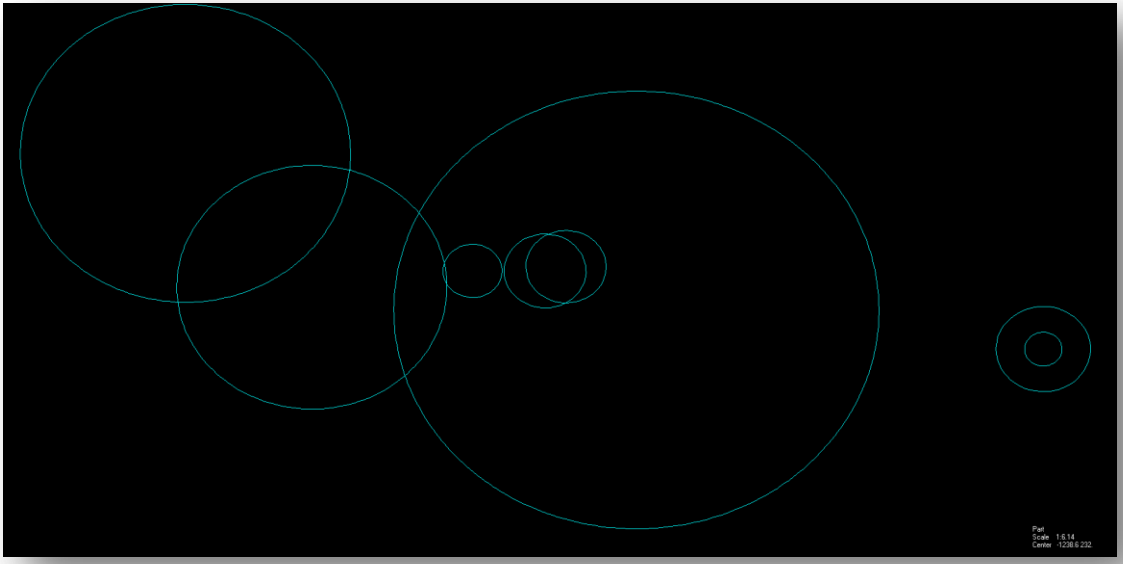


Figure 128 : The lever with all 6 small arc circles added and the two right side circles

6. Next we need to create the circles around the **Left Origin**, or the hole on the left side of the lever. Create a **Circle** with diameter *95d* centered at *-2613.91, 0*.

7. Create a second **circle** around the left origin, with Radius *100.08*, for the outside arc at that point.

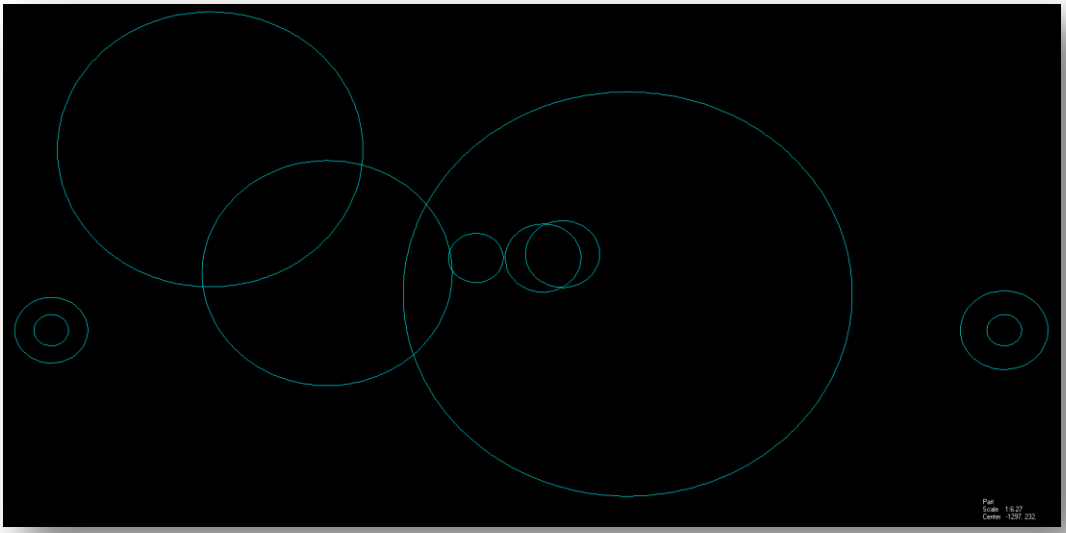


Figure 129 : **The left interior and exterior circles created**

8. Create a **circle** *95d* in diameter, at *-1611.1, 455.93,* for the center hole in the Lift-arm

9. Then create the external contour **circle**, radius *149.86*, centered on the center hole as well.

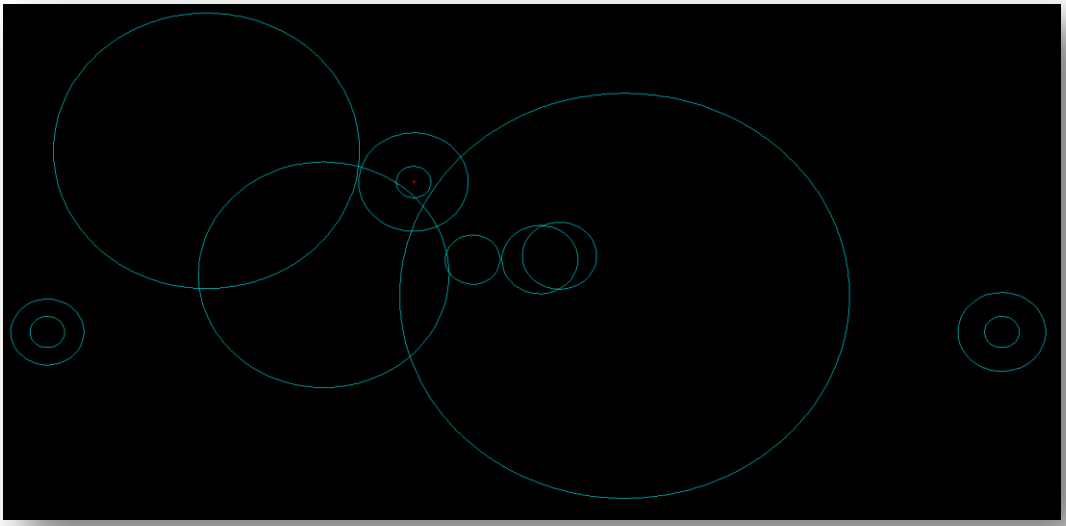
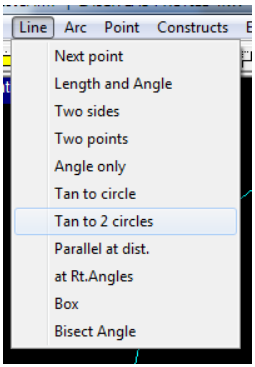


Figure 130 : The Lift arm with all the circles drawn

10. Now we need to use the **Line > Tan to 2 Circles** *(Tangent to 2 Circles)* to join up all the external contours. This can be tricky, so be sure to get the correct contours, and click where the tangents should be coming from. There are a lot of small tangents present, and no circles actually touch so all need to be joined.



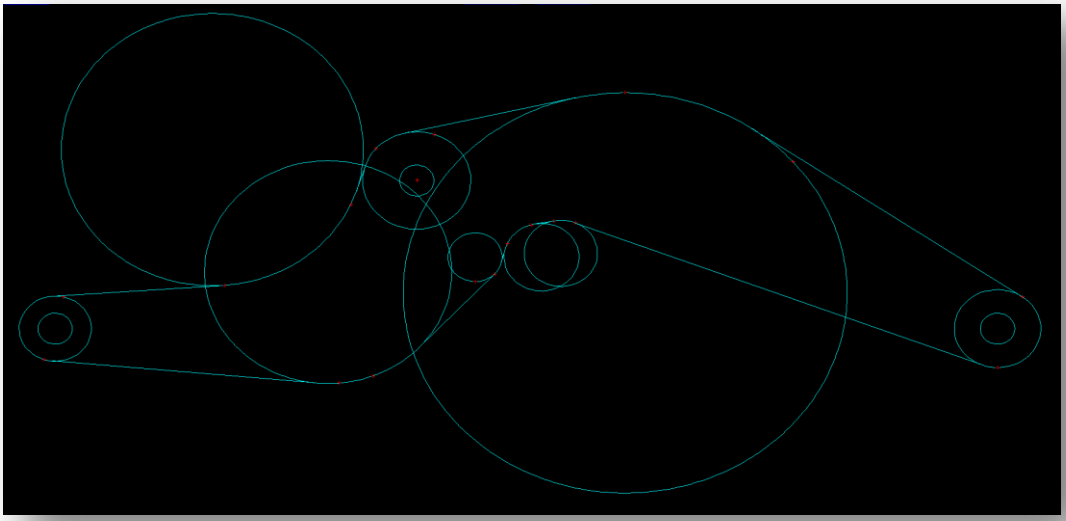
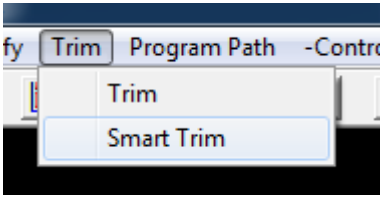


Figure 131 : The drawing with all the external contours created

11. Lastly we need to clean up all the extra circle lines using **Trim > Smart Trim.** *Be sure to trim all the little lines where the tangents meet the circles.*



Finished Drawing

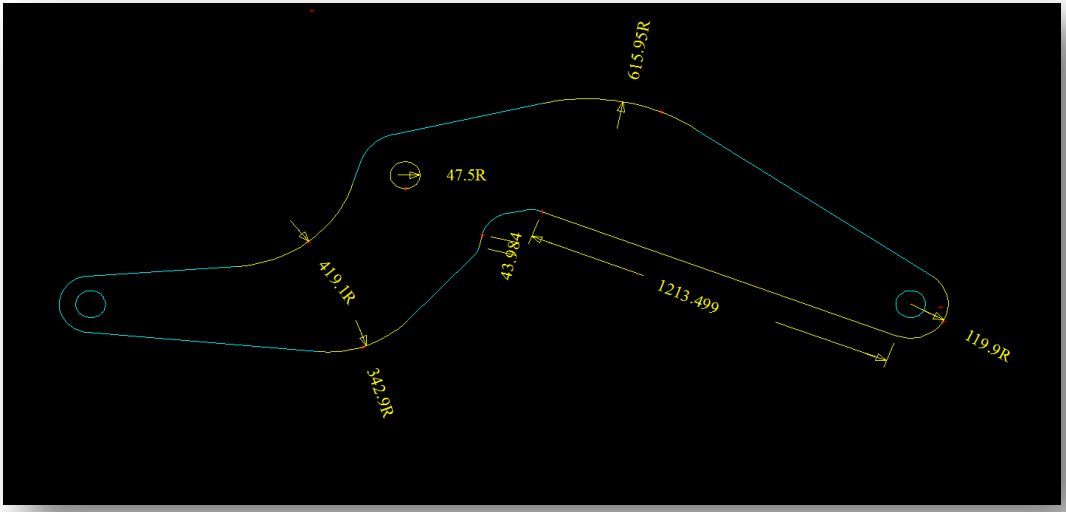


Figure 132 : The finished Lift Arm

12. The Lift-Arm is complete!