

Department of Electrical and Electronics Engineering

Computer Aided Electrical Drawing

Module-1

Winding Diagrams:

- (a) Developed Winding Diagrams of D.C. Machines: Simplex Double Layer Lap and Wave Windings.
- (b) Developed Winding Diagrams of A.C. Machines:
- (c) Integral and Fractional Slot Double Layer Three Phase Lap and Wave Windings.
- (d) Single Layer Windings – Un-Bifurcated 2 and 3 Tier Windings, Mush Windings, Bifurcated 3 Tier Windings. Single line diagrams of generating stations and substations.

Module-2:

Single Line Diagrams: Single Line Diagrams of Generating Stations and Substations Covering Incoming Circuits, Outgoing Circuits, Busbar Arrangements (Single, Sectionalised Single, Main and Transfer, Double Bus Double Breaker, Sectionalised Double Bus, One and a Half Circuit Breaker Arrangement, Ring Main), Power Transformers, Circuit Breakers, Isolators, Earthing Switches, Instrument Transformers, Surge or Lightning Arresters, Communication Devices (Power-Line Carrier) and Line Trap

Module-3:

Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:

Transformers - Sectional Views Of Single And Three Phase Core And Shell Type Transformers .

Module-4:

Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:

D.C. Machine - Sectional Views of Yoke with Poles, Armature and Commutator dealt separately.

Module-5:

Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:

Alternator – Sectional Views of Stator and Rotor dealt separately

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Module-4

DC MACHINES

Objective : To draw the sectional views of yoke, field system, armature and commutator dealt Separately

Problem 1 :

Draw the sectional end and front elevation of the pole for the given below dimensions.

Width of the pole = 14cm

Pole Arc = 20cm

Height of the pole with shoe = 19cm

Radius of the pole = 28cm

Thickness of yoke = 9.5cm.

Show clearly the method of fixing the pole core lamination and the pole core with the yoke.

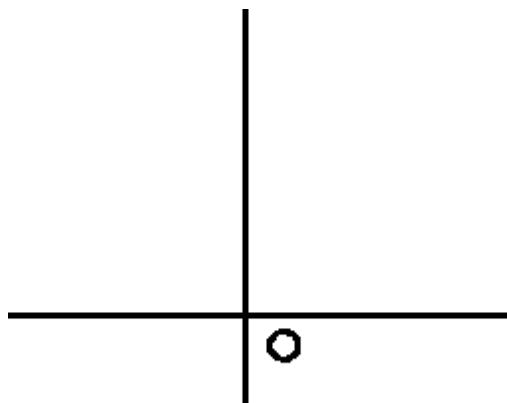
Solution:

Step1:

- Limits
- Lower corner 0,0
- Upper corner (3000,3000)
- Zoom
- All

Step2:

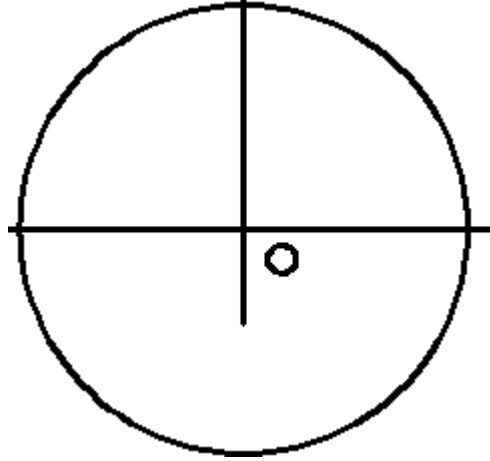
Using “LINE” command draw horizontal & vertical line



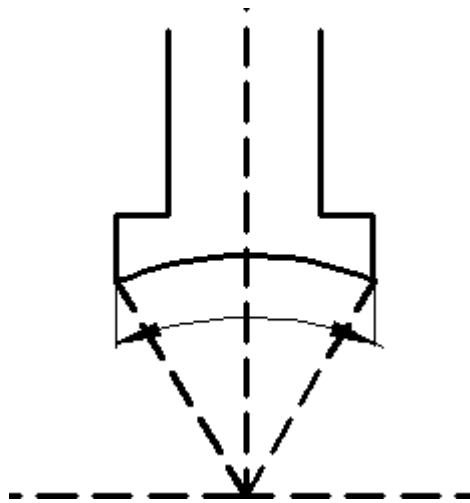
Step3:

With “O” as centre draw a circle of radius 28cm

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Step4:



Wkt: Pole arc = $R\theta$

Given: pole arc = 20

$R=28$

θ in radians = $180/\pi \times \text{pole arc}/R$

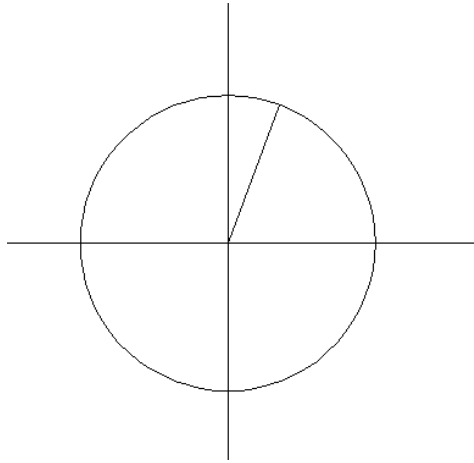
$\theta = 180/\pi \times 20/28 = 41^\circ$

Using line command draw a line of radius 28cm at 20.5°

Since Autocad take angle always wrt x-axis but we need 20.5° wrt y-axis

Type 28cm @ 69.5°

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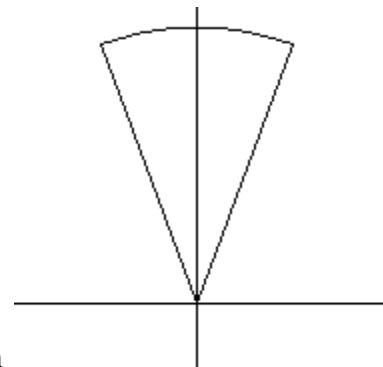
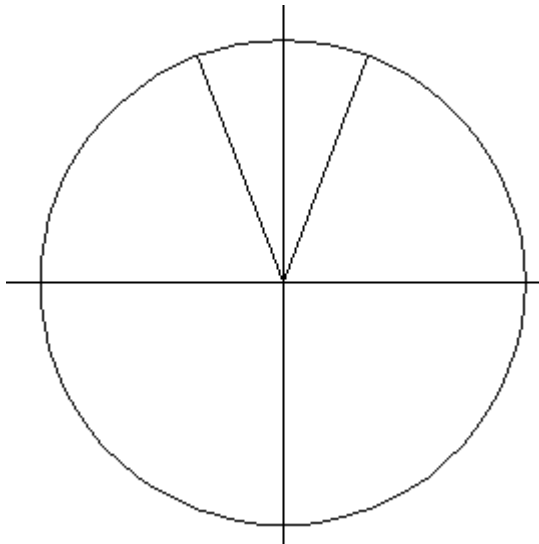


Step5:

Mirror it we get & Trim

Note:

- @280<69.5
- 280,69.5
- 280<69.5



After Trim

Step 6:

Let

1. $r=R$ =radius of pole =28cms

Given:

Height of the pole with shoe=19cms=Hp

Note: usually thickness of pole shoe=3cms

Pole body =Hp-thickness of pole shoe

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$$= 19 - 3 = 16 \text{ cms}$$

2. $r_1 = r + \text{thickness of pole shoe}$

$$r_1 = 28 + 3 = 31 \text{ cms}$$

$r_2 = r_1 + \text{height or thickness of pole body}$

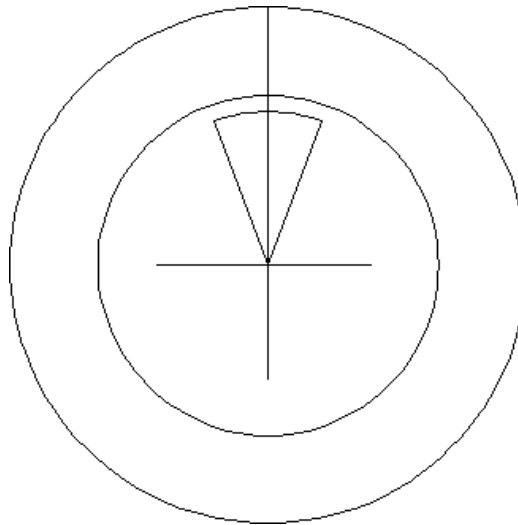
$$= 31 + 16 = 47 \text{ cms}$$

Draw two circles of radius

$$r_1 = 31 \text{ cms}$$

$$r_2 = 47 \text{ cms with 'O' as center}$$

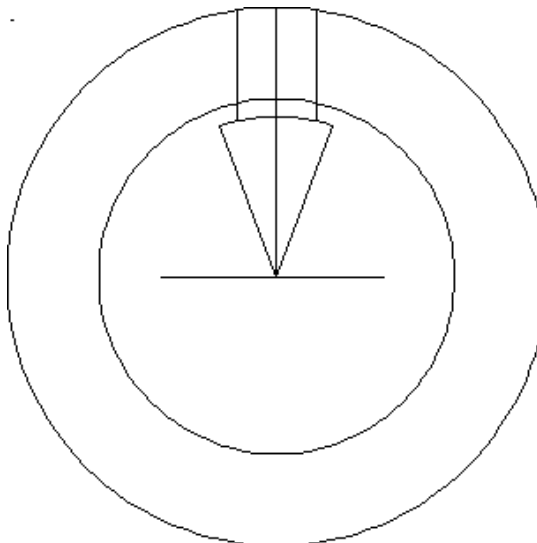
we get



Step 7:

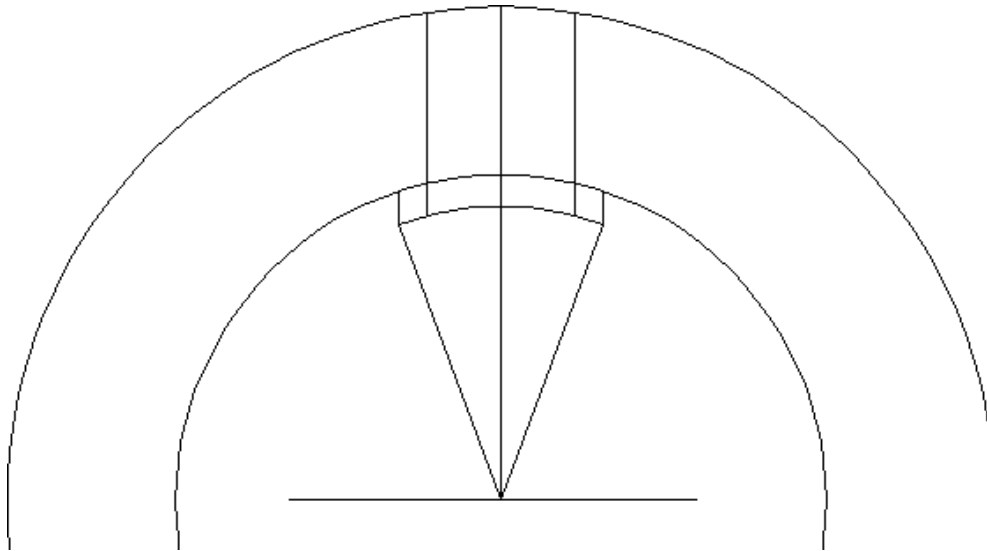
Given width of pole (W_p) = 14 cms

Offset vertically by 7 cms we get

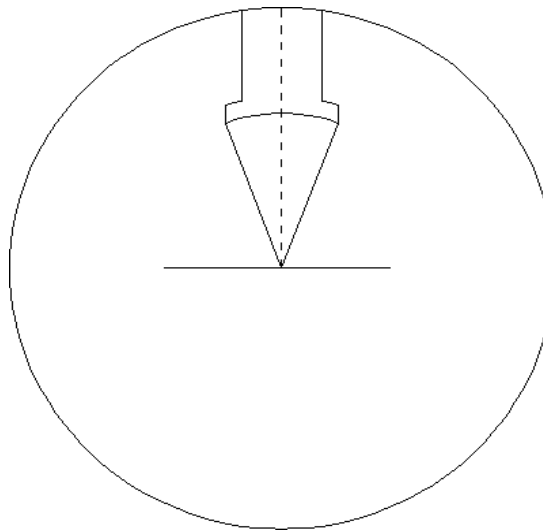


Note: Extend a line from point (a) & (b) to touch r_1

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Trim r1, we get



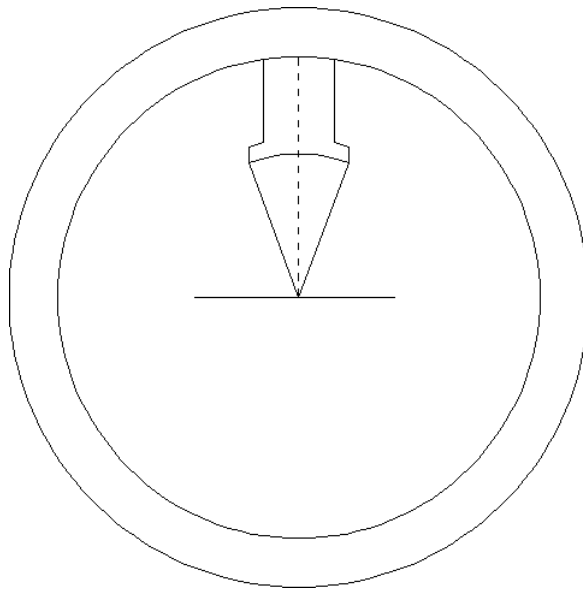
Step 8:

Given thickness of yoke = 9.5cms

$r3 = r2 + \text{thickness of yoke}$

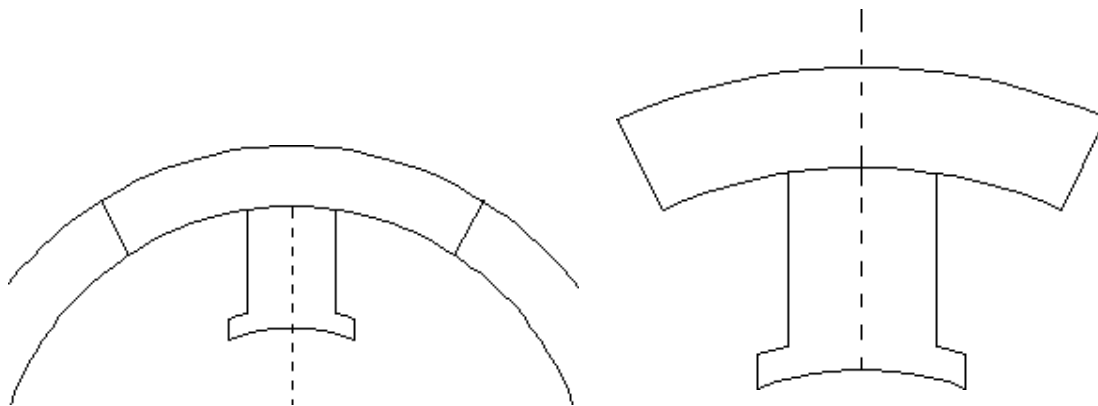
$r3 = 47 + 9.5 = 56.5\text{cms}$

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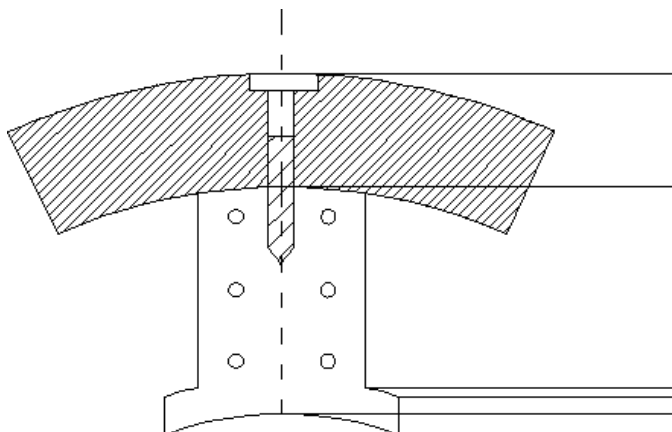


Step 9:

Draw inclined line and mirror it



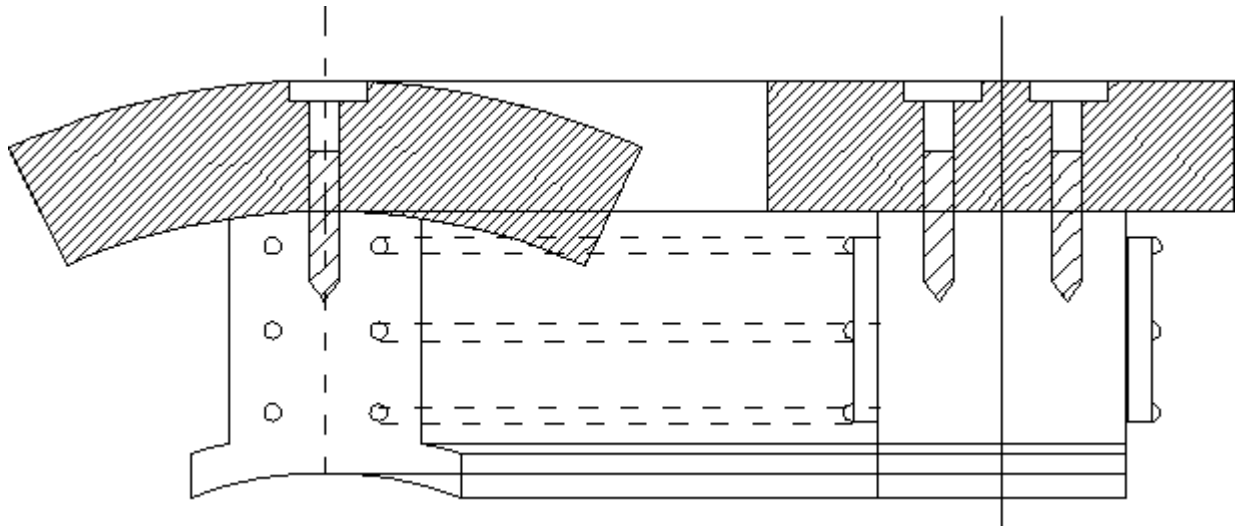
Step 10: Hatch , draw bolt and holes we get



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Step 11: Length of pole body is not given so assume as 18cms

project the line as shown above, then we get



Problem 2:

Draw the sectional end sectional elevation of the pole core made of laminated sheet steel with a pole shoe. The pole core is fixed with the yoke by means of hexagonal headed set screws.

Width of the pole = 19.6cm

Height of the pole = 27.54cm including the thickness of pole shoe

Length of the pole = 35.6cm

Thickness of yoke = 8cm

Air gap length = 0.5cm

Radius of armature = 38.25cm

Solution:

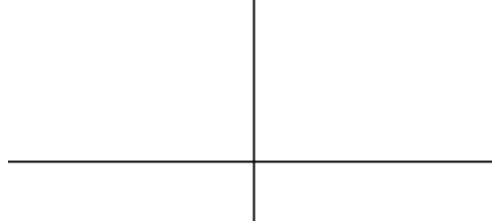
Step1:

- Limits
- Lower left corner(0,0)
- Upper corner (3000,3000)
- Zoom
- All

Step2:

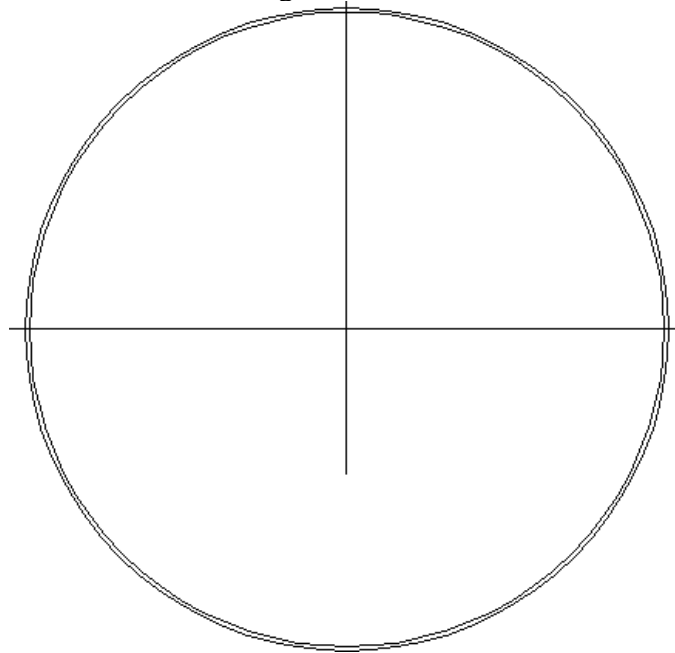
Using 'LINE' command draw horizontal & vertical line

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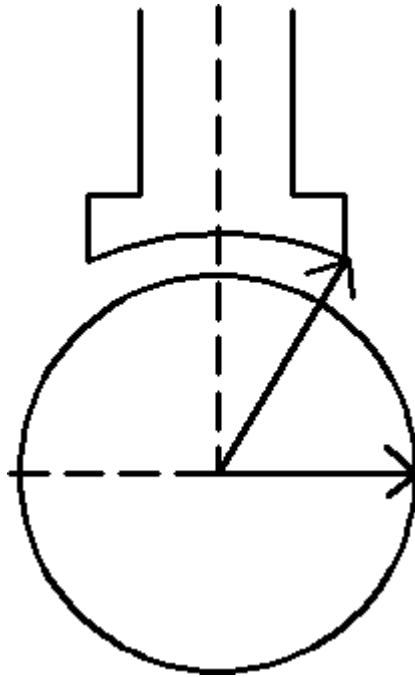
Step3:

1. With 'O' as centre draw circle of radius =38.25cm i.e radius of armature (r)
2. Given air gap =0.5
Radius $r_1 = r + 0.5$
 $= 38.25 + 0.5 = 38.75\text{cms}$
Again draw one more circle with radius $r_1=38.75\text{cm}$, we get



Step4:

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Note: In the present problem pole arc is not specified. So follow below steps

Step5:

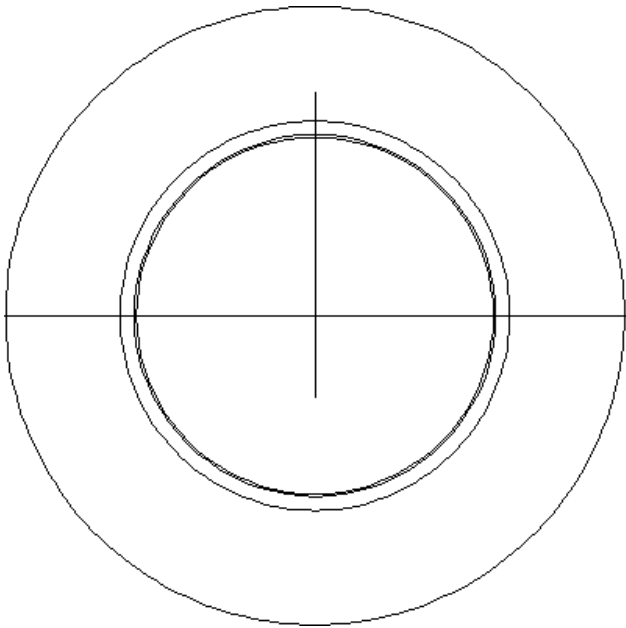
1. $r_1 = \text{radius of pole} = 38.75\text{cm}$
2. height of pole with shoe = 27.54cm
 Assume pole shoe = 3cm
 Pole height = $27.54 - 3 = 24.54\text{cm}$
 $r_2 = r_1 + \text{thickness of shoe}$
 $= 38.75 + 3 = 41.75\text{cm}$
 $r_3 = r_2 + \text{height of pole body only}$
 $= 41.75 + 24.54 = 66.29\text{cm}$

Draw 2 circles of radius

$$r_2 = 41.75\text{cm}$$

$$r_3 = 66.29\text{cm}$$

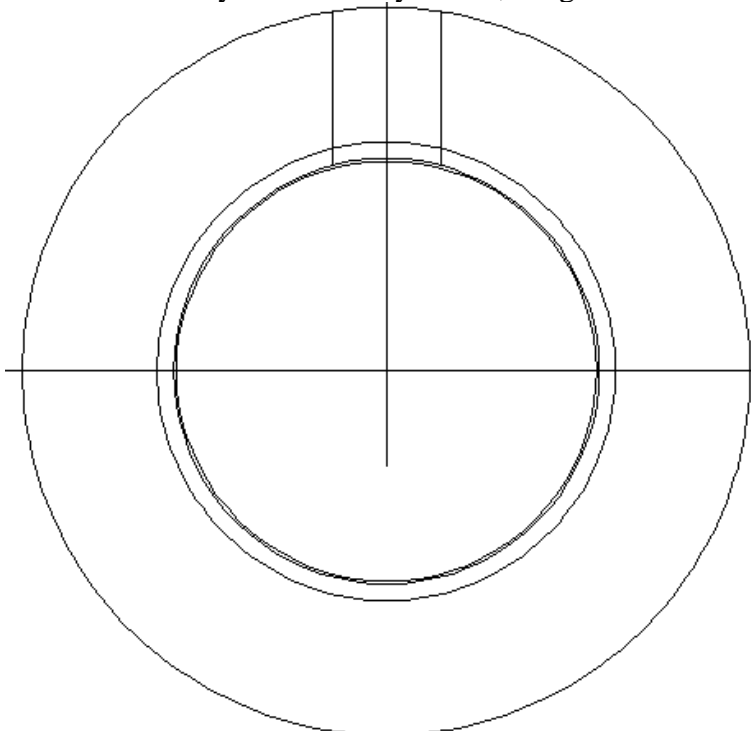
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Step 6:

Given width of pole (w_p) = 19.6cm

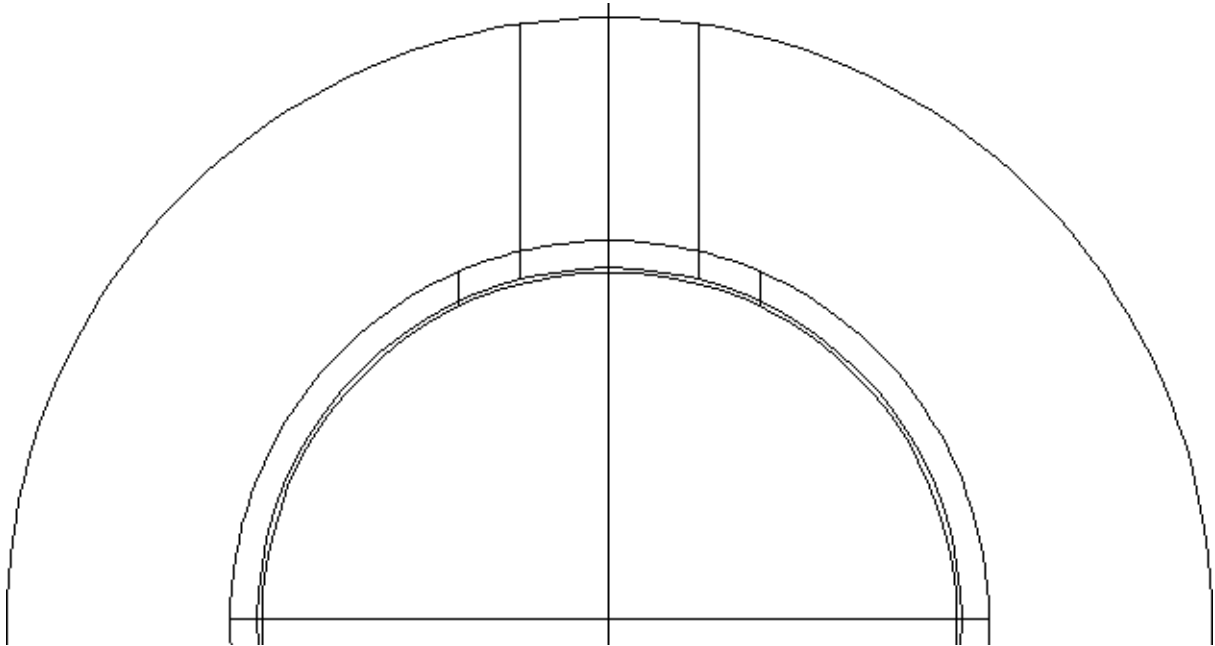
Offset vertically both sides by 9.8cm, we get



Step 7:

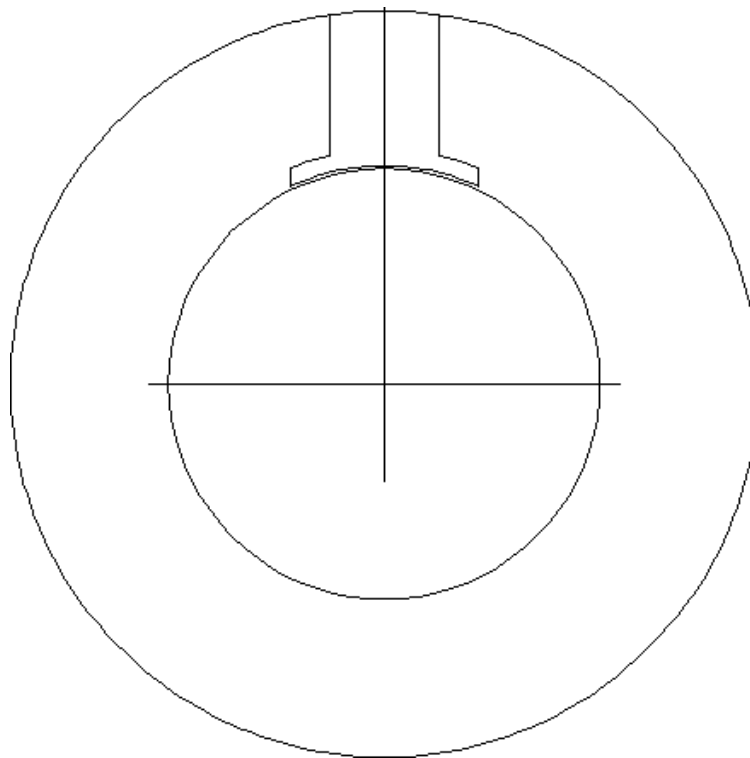
Draw a arbitrary line parallel to “ab” and mirror we get

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Step 8:

After trim, we get



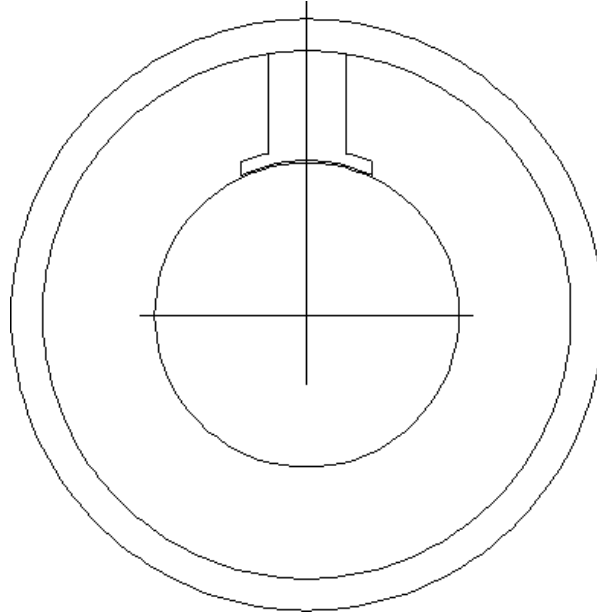
Step 9:

Given thickness of yoke = 8cm

$r_4 = r_3 + \text{thickness of yoke}$

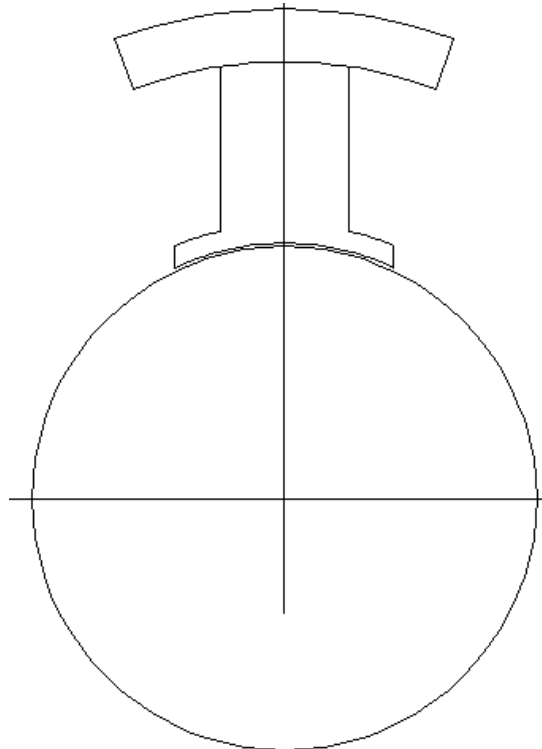
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$$= 66.29 + 8 = 74.29 \text{ cm}$$



Step 10:

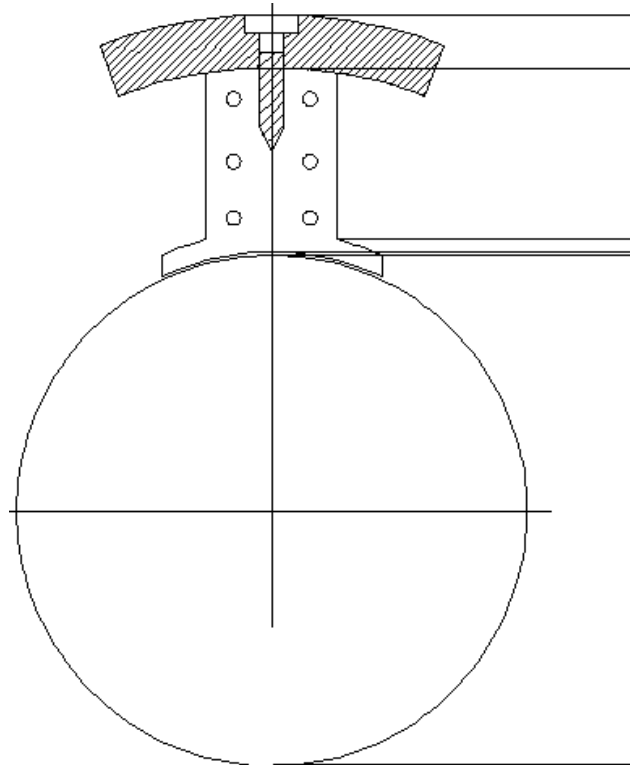
Draw a inclined line and mirror it



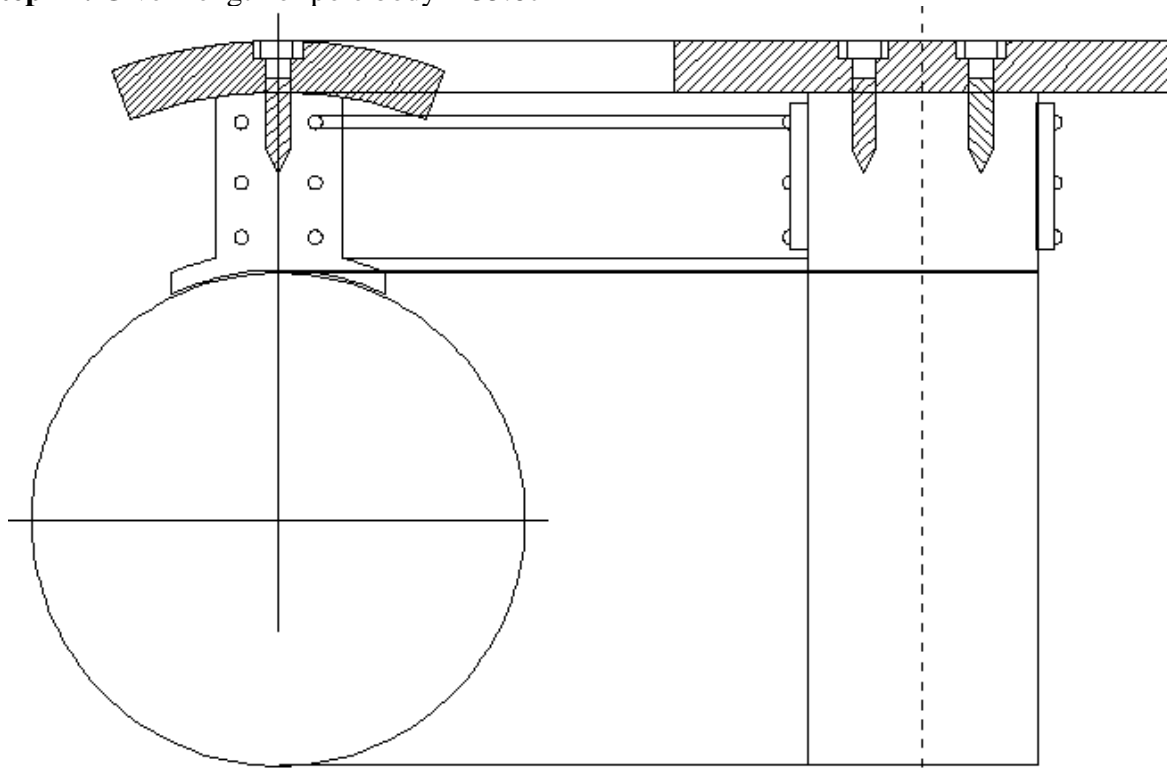
Step 11:

Hatch , draw bolts and holes we get

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Step 12: Given length of pole body = 35.6cm



Problem 3:

Draw the two views of the commutator assembly.

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1. The front elevation to be half in section.
2. The end elevation half in section for the given dimension, use any suitable scale.

Given: Diameter of commutator = 13cm

Length of the commutator = 11.8cm

Diameter of shaft = 4cm

Segment pitch with mica = 0.6cm

Mica thickness = 0.1cm

Solution:

1. Assume copper riser = 1cm(standard value)

Formula:

$L = 0.4r$, where r = radius of the commutator

$N = \frac{1}{2} * L$

$M = \frac{1}{4} * k$ or $\frac{1}{4} * \text{length of commutator}$

Calculation:

Copper riser:

Given : dia of commutator $D = 13\text{cm}$, then $r = D/2 = 13/2 = 6.5\text{cm}$

Then $L = 0.4 * 6.5 = 2.6\text{cm}$

$N = \frac{1}{2} * L = \frac{1}{2} * 2.6 = 1.3\text{cm}$

$M = \frac{1}{4} * \text{length of commutator} = \frac{1}{4} * 11.8\text{cm} = 2.95\text{cm}.$

4. Segment pitch with mica = 0.6cm [1]

Commutator segment length (or) segment pitch with mica [1] = $R\theta$

$$\theta = l/R = 0.6/6.5 * 180 / \pi = 5^\circ$$

Step1:

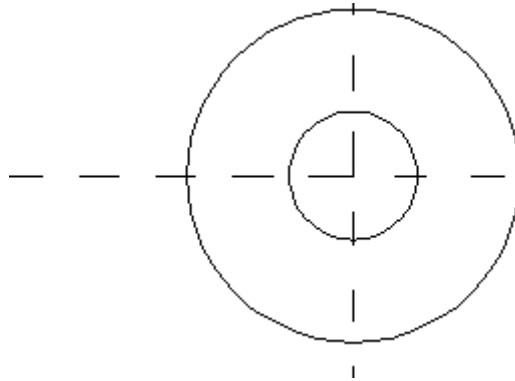
- Limits
- Lower left corner 0,0
- Upper right corner (1000,1000)
- Zoom
- All

Step 2:

Draw commutator dia ($D=130\text{mm}$, hence radius $r = 65\text{mm}$)

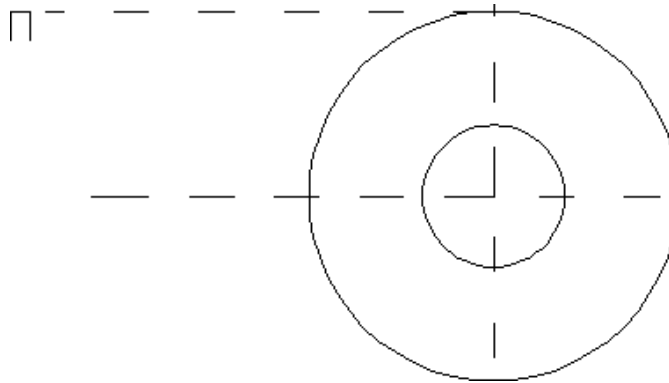
Draw shaft dia (dia = 50mm, $r = 25\text{mm}$)

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Step 3:

- Draw copper riser

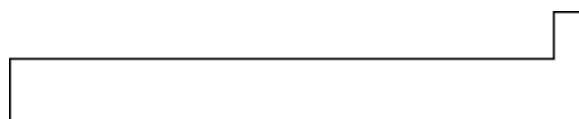


- Project the circumference of commutator
- Draw copper riser :
 - @10mm < - 90 (i.e. at point a)
 - 7mm < 180 (i.e. at point a)
 - Offset 7mm to left

Step 4:

Draw length of commutator

- At point 'c', draw a line i.e. k=11.8cm or 118mm@118<180
- At point 'e', draw a perpendicular line of distance 'N'= 13mm or 1.3cm.....@130<-90
- Repeat the same at point 'd'.

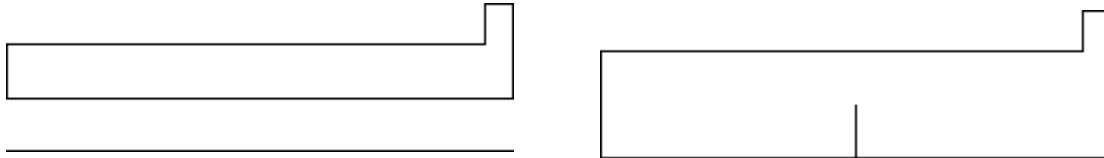


Step 5:

- Join 'fg' by a line

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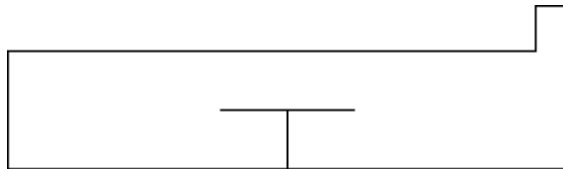
- Offset 'fg' by 13mm, we get L=26mm Or L=2N
- With Osnap ON get a midpoint 'o' & delete 'fg' we get



Calculated $M = 2.95\text{cm} = 3\text{cm}$ or 30mm

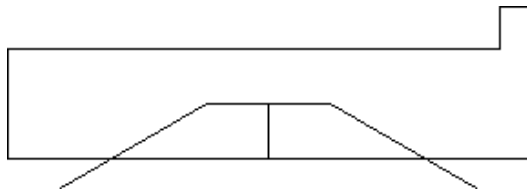
With 'o' as center a line i,e

- @15mm<0 with 'o' as centre
- @15<180 again with 'o' as center

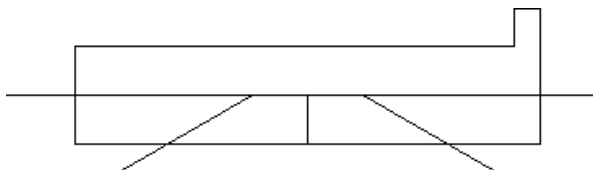


Step6:

At 'H' draw line @40<210 , where 40 is arbitrary value, At I draw a line i,e @40<-30

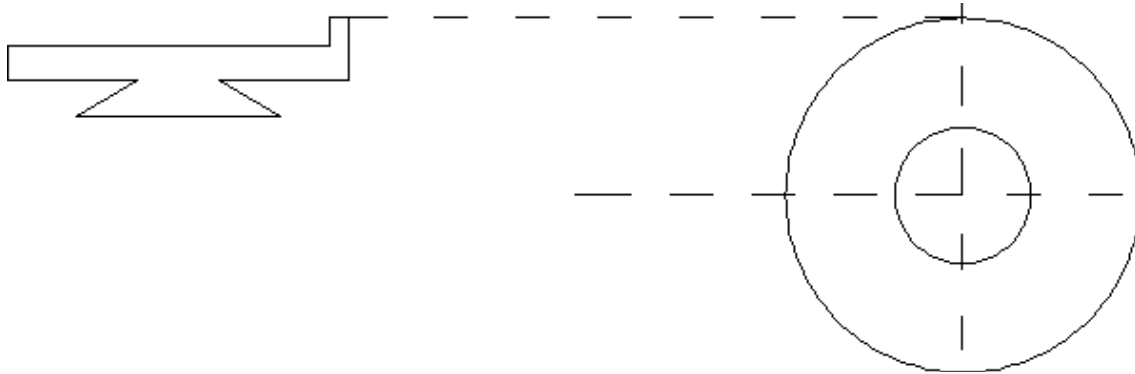


Extend a line from H & I



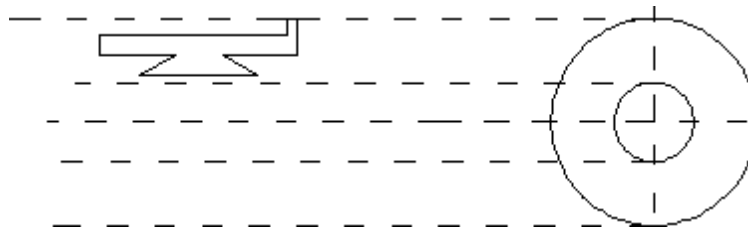
After trim and delete we get

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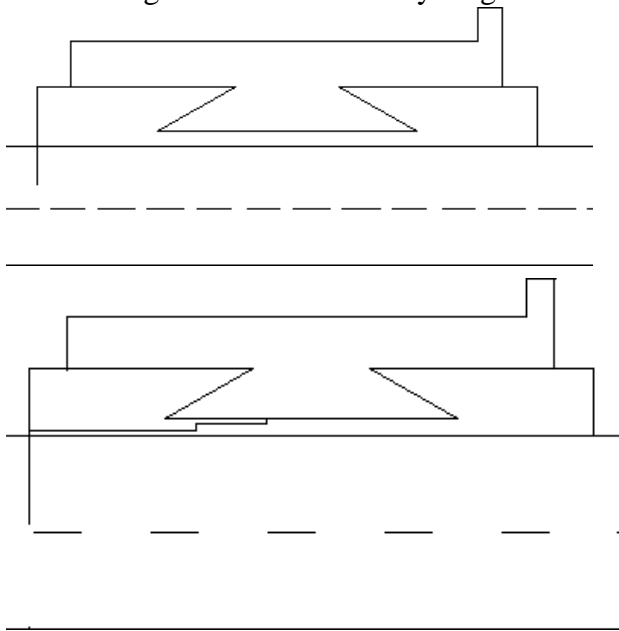
Step7:

Project shaft dia to LHS



Step 8:

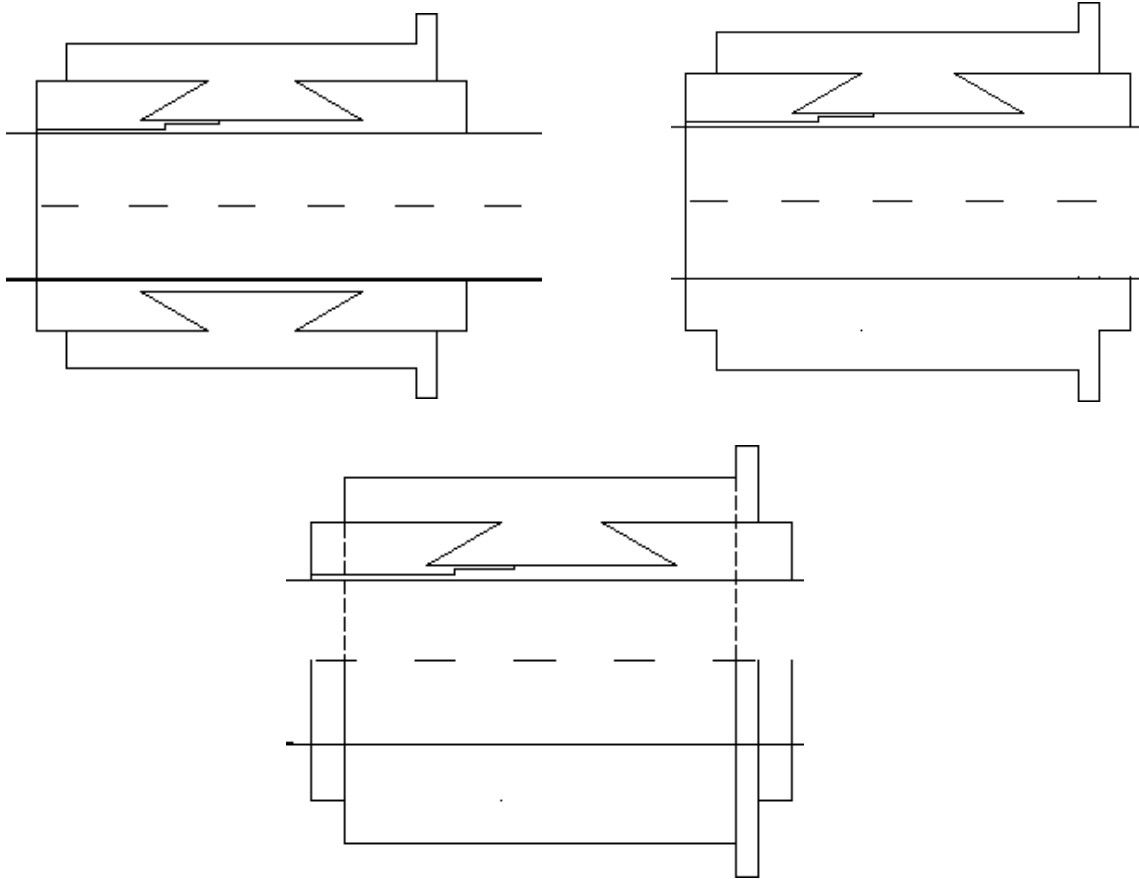
Draw v-ring on either of arbitrary length



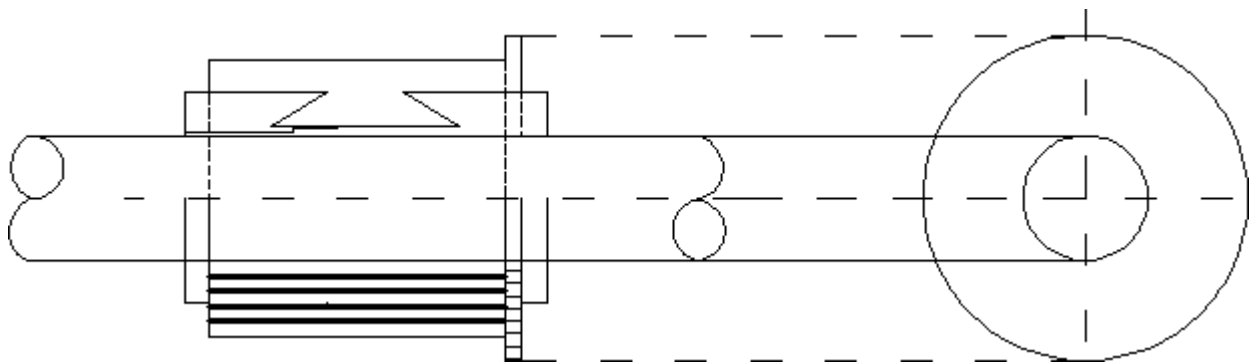
Step 9:

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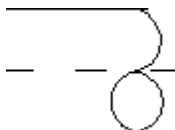
Mirror we get



Offset the line by 6mm(mica segment) and hatch



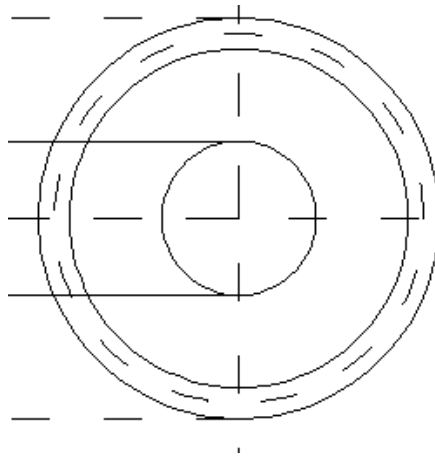
Use 3 point arc and mirror



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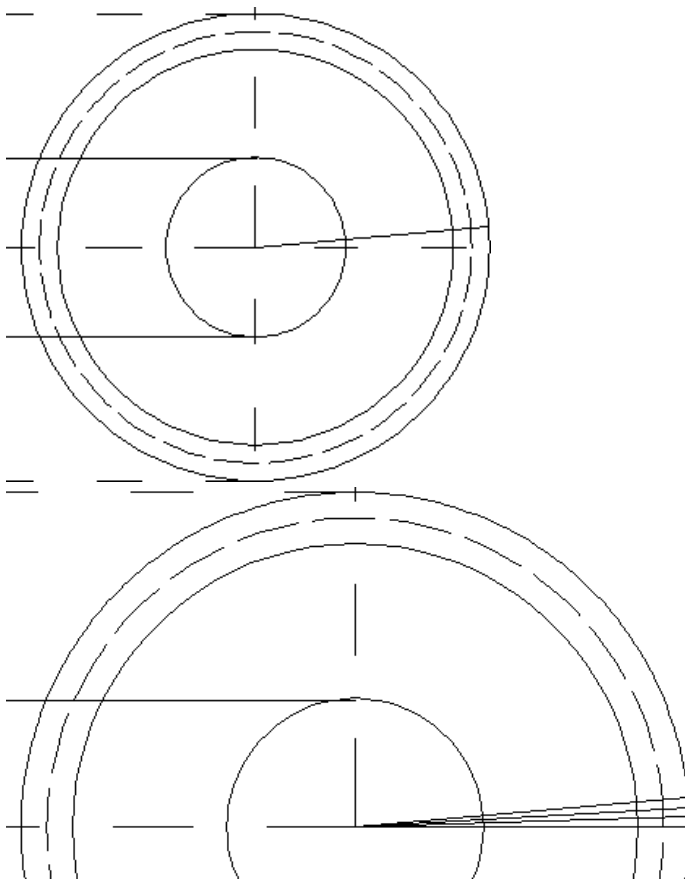
Step 10:

- Offset the circle by height of copper riser, 10mm
- Again 50% height of copper riser i.e 5mm



Step 11:

Draw inclined line @ 65° , then we get



Again draw 2 inclined line within 5° shown

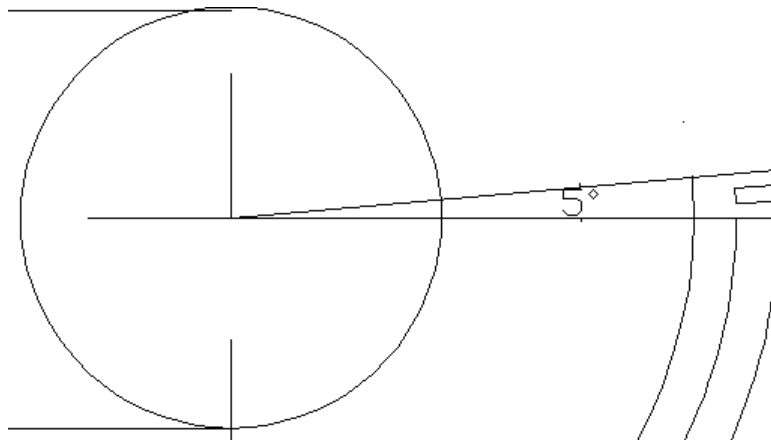
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i.e $5/3=1.667$

- @65<1.667
- @65<3.334 ; where angle 3.334 is $1.667*2=3.334$

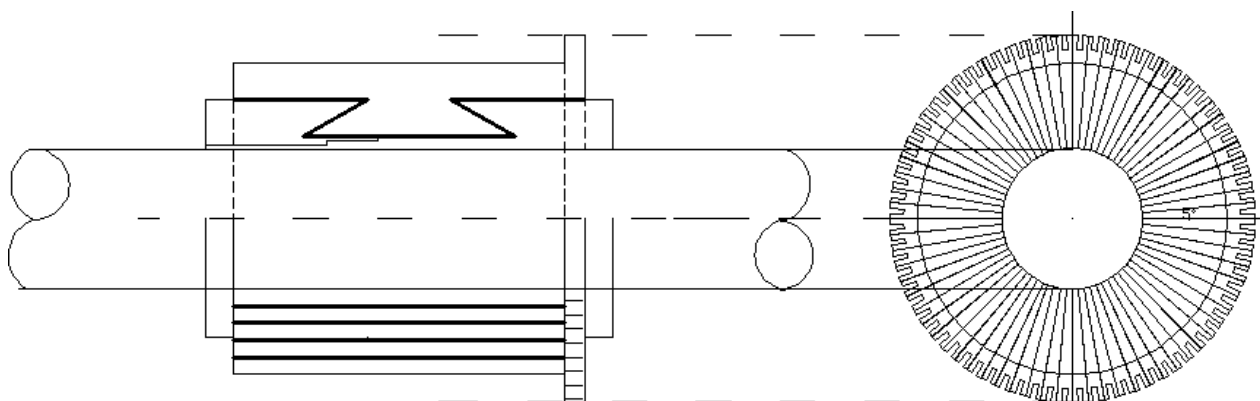
Step 12:

Trim we get



Array :

1. Polar
2. Center point (select)
3. Total no. of item: 72
4. Angle to fill : 360
5. Select object
6. OK



Problem 4:

Draw to quarter scale a half – sectional end elevation looking from the shaft end of a 100kW D.C. Generator with the main dimensions as given below

No. of poles = 4

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External Diameter of arm stamping = 41.5cm

Inside diameter of armature stamping = 21cm

No of slots = 39

Size of slot = 3.5cm*1.2cm

Main poles:

Height = 16cm

Width = 12cm

Pole arc/pole pitch = 62%

Inter poles = 4.4cm*15cm

Air gap at main pole = 0.5cm

Thickness of yoke = 60cm

Shaft diameter at coupling end = 8cm

The machine has end shield bearing. The armature stampings are mounted on a cast iron spider keyed to the shaft and clamped between the plates.

Solution:

1. **Shaft:** Diameter of shaft = 8cm

2. **Armature or Rotor:**

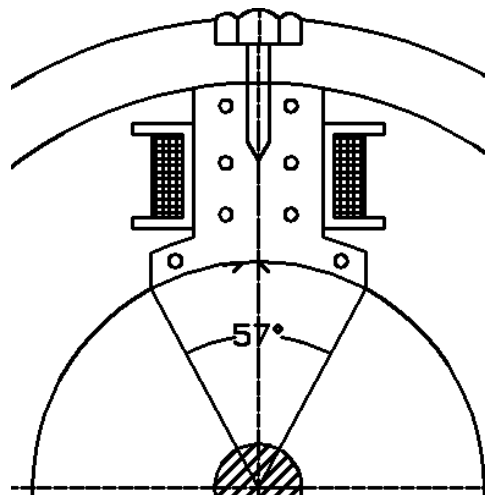
1. Inside diameter of Armature stamping = 21cm
2. Outside diameter of Armature stamping = 41.5cm
3. No of slots = 39
4. Size of slot = 3.5cm*1.2cm

3. **Main poles:**

Given: - pole arc/pole pitch = 62%

Pole pitch = $360/\text{No. of poles} = 360/4 = 90$

Then pole arc = $0.62 * \text{pole pitch} = 0.62 * 90 = 56.7^\circ = 57^\circ$



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4. Stator:

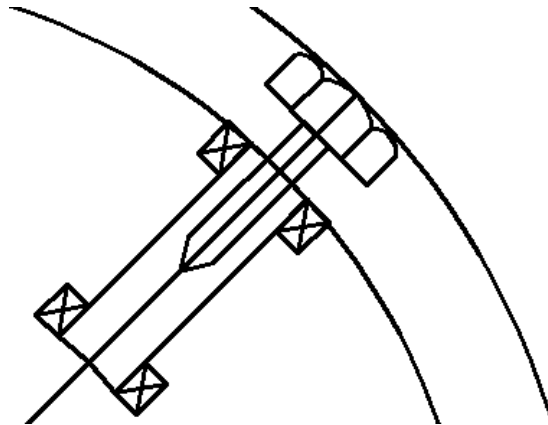
Outer diameter of stator stamping = outer diameter of Armature stamping + 2*air gap +
2*height of the main pole.

$$= 41.5\text{cm} + 2*0.5\text{cm} + 2*16\text{cm} = 74.5\text{cm} = 75\text{cm}$$

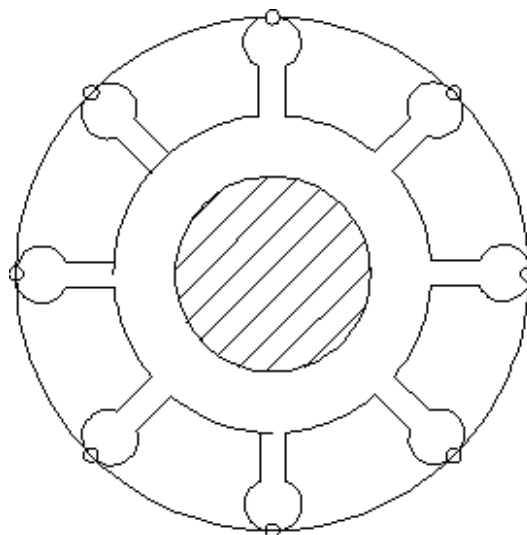
5. Overall diameter of the machine = Outer diameter of stator + 2*thickness of the yoke stamping

$$= 75.5\text{cm} + 2*6 = 86.5\text{cm}$$

5. Interpole:



Spider:



Step1:

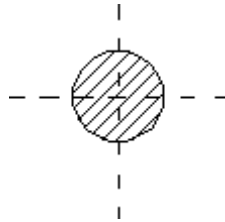
- Limits
- Lower left corner 0,0
- Upper right corner (1000,1000)

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- Zoom
- All

Step2: (shaft detail)

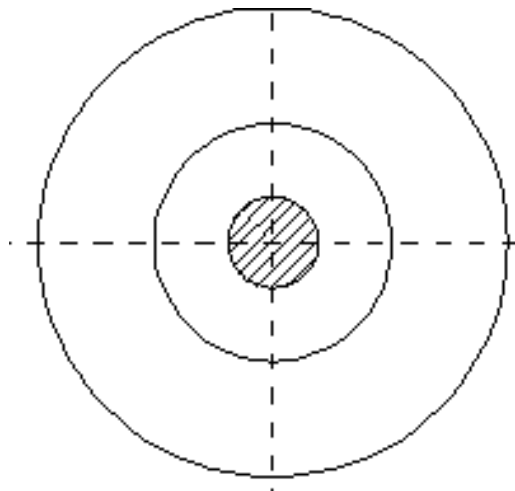
Draw a circle of dia 80mm, hatch the shaft



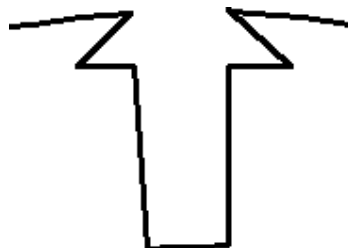
Step3:

Armature details:

- Draw armature of dia : Inner dia = 210mm & outer dia = 415mm

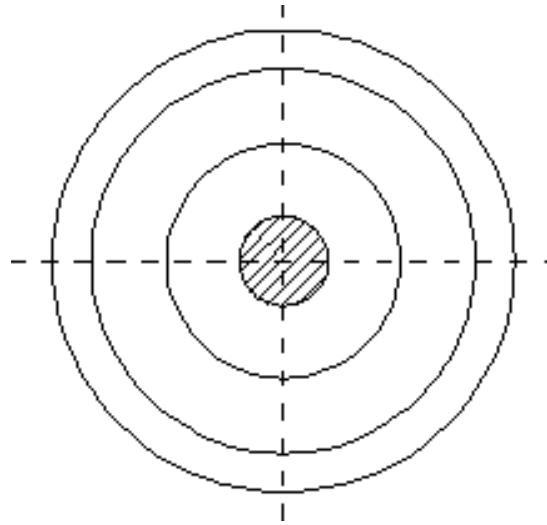


- To draw armature slot



Offset , outer dia of armature by 35mm

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Wkt: Pole arc = $R \Theta$; where R = outer dia of arm – 3.5cm

$$= 41.5\text{cm}/2 - 3.5\text{cm}$$

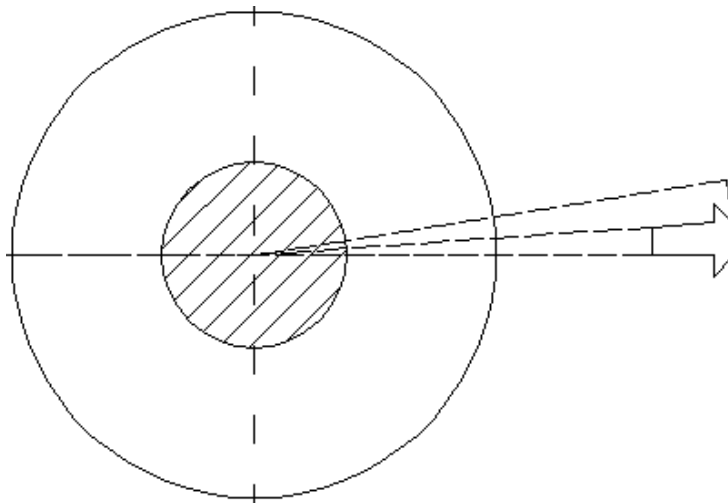
$$= 17.25\text{cm}$$

Hence $\Theta = \text{pole arc}/R * 180/\pi$

$$= 1.2\text{cm}/17.25\text{cm} * 180/\pi = 4^\circ$$

Given no. of slots = 39, Take 40 so that slot angle is a whole no.

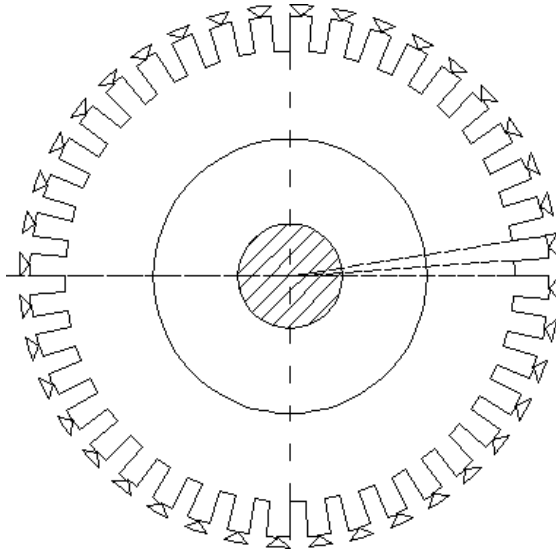
$$\text{Slot angle} = 360/\text{no. of slots} = 360/40 = 9^\circ$$



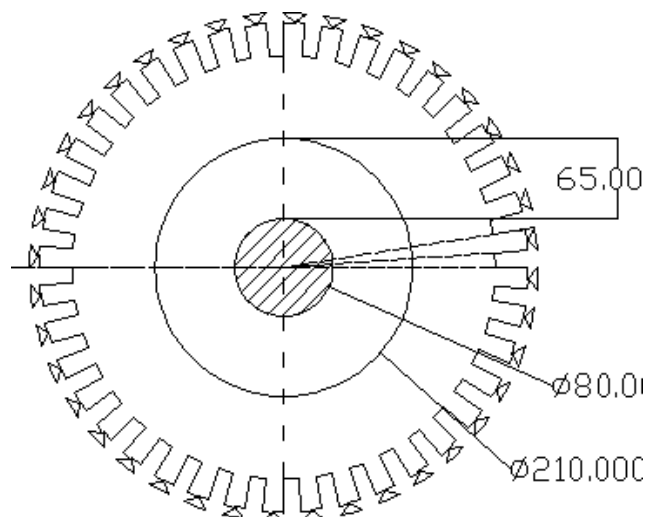
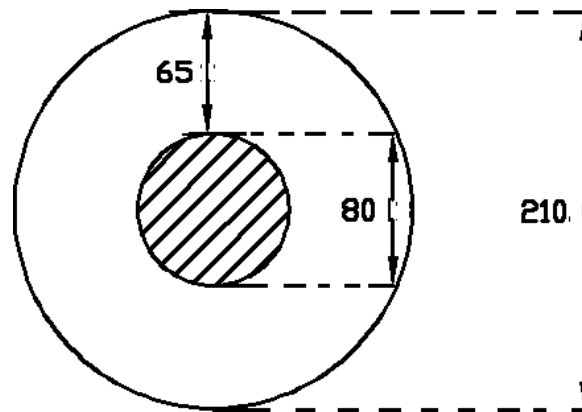
- ❖ Draw a inclined line
 - @415/2<4
 - @415/2<9
- ❖ Polar array, we get:
 - Select polar array
 - Select the object

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- Total no. of item = 40
- Angle to fill = 360
- OK



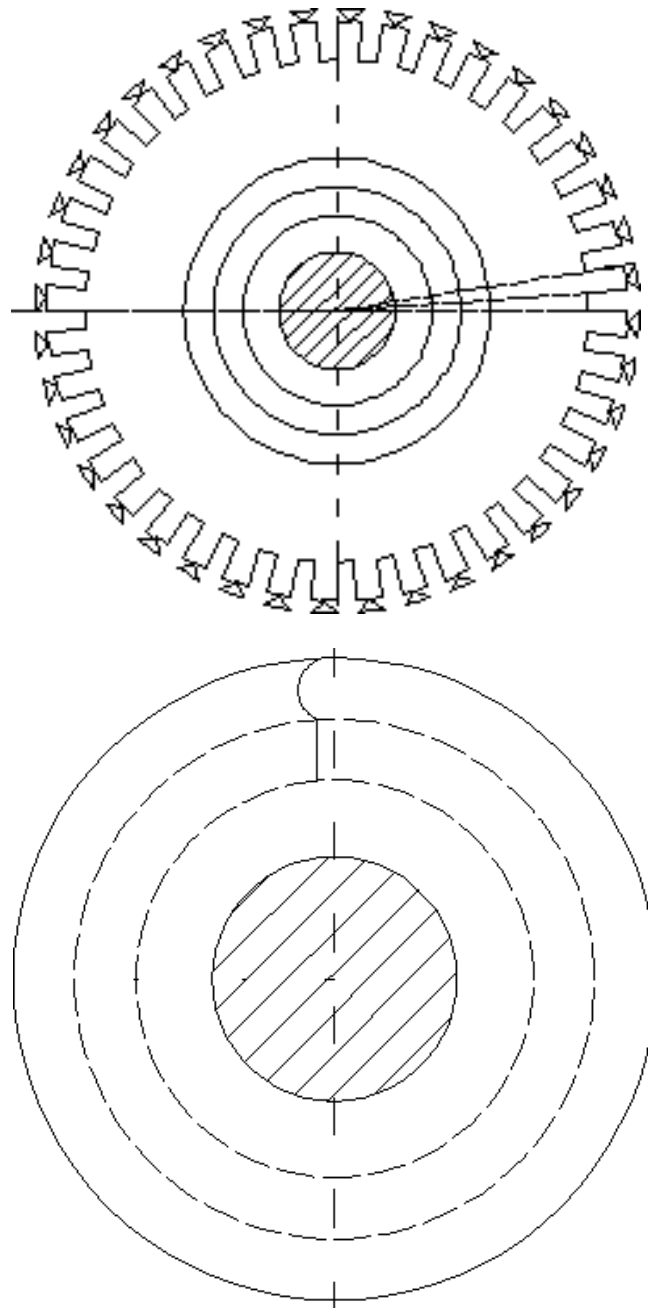
Step4 (spider):



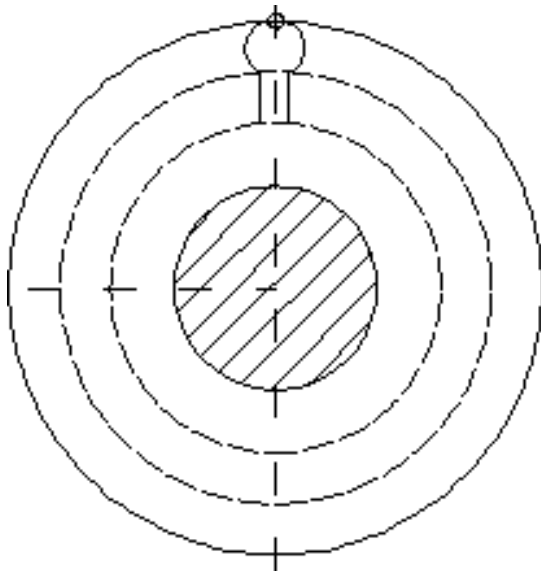
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Divide gap 65mm into 3 parts

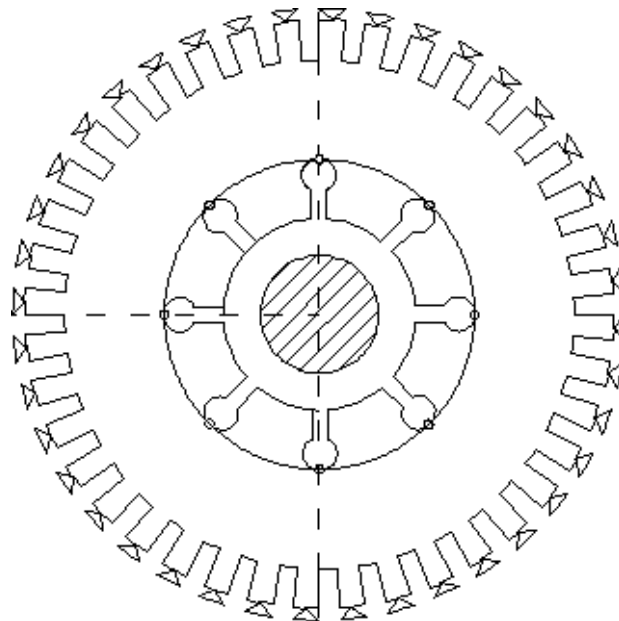
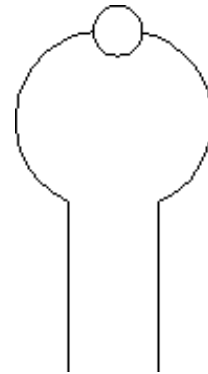
- ❖ Offset inner dia of arm by 20mm & again by 40mm, we get



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After mirror



After array we get the above fig:

- Polar array
- Select the object
- Total no. of item = 08
- Angle to fill = 360
- Ok, we get

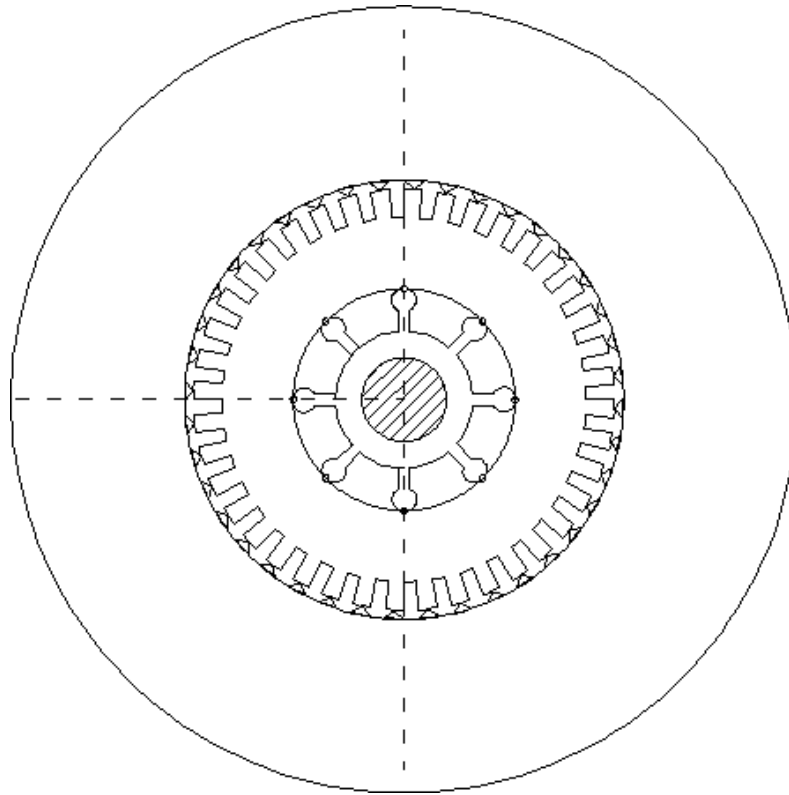
Step 5:

Draw outer dia of stator = 745mm

Inner dia of stator

$$\begin{aligned}
 &= \text{outer dia of arm} + 2 * \text{thickness of airgap} \\
 &= 41.5 + 2 * (0.5\text{mm assumed}) \\
 &= 42.5
 \end{aligned}$$

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Draw a line:

- @425/2<61.5
- @212.5<118.5

Step 6: Main pole

Height of pole with shoe = 16cm, assume shoe = 3cm

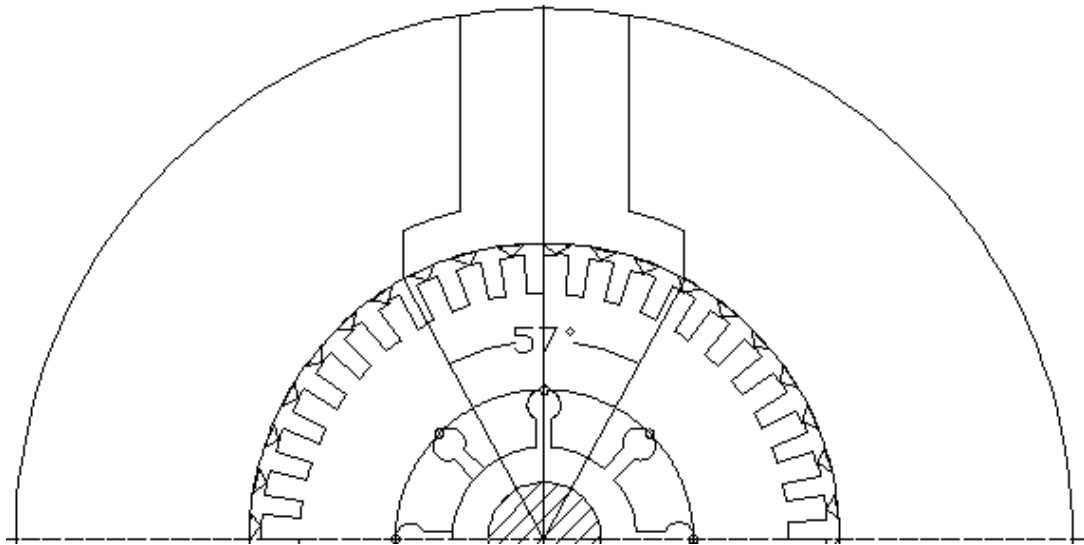
Height of pole = $16 - 3 = 13\text{cm}$ or 130mm

Width of pole = 12cm or 120mm

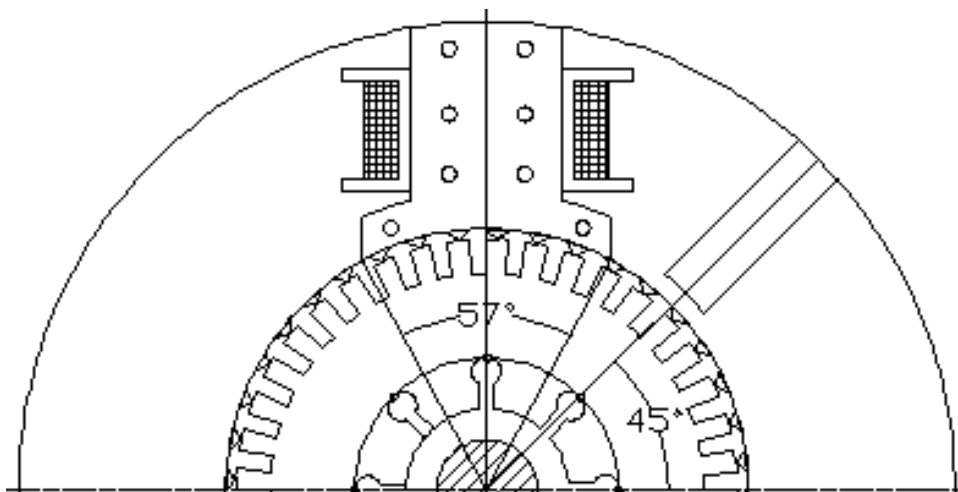
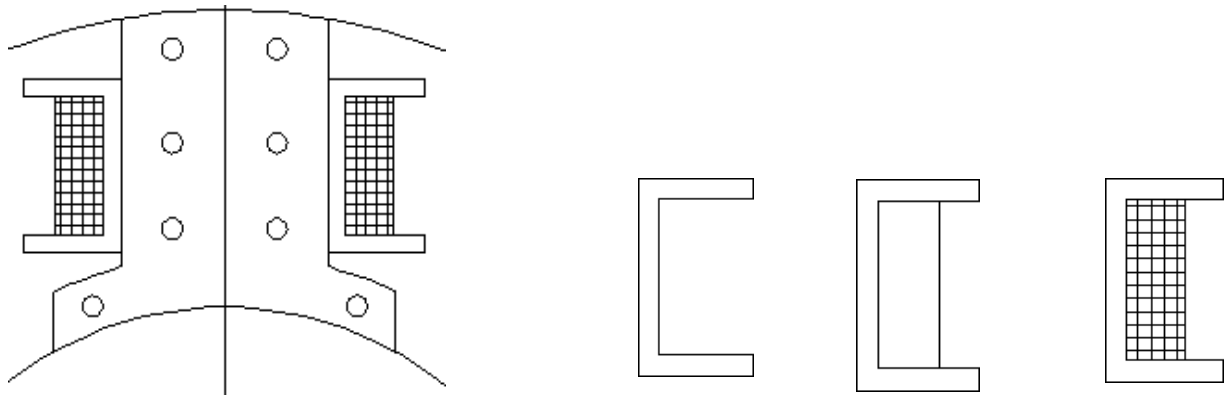
Offset pole arc = 30mm

Offset vertical axis both side by 60mm. After trim, we get

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Step7: Field winding



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Step8 : (Interpoles)

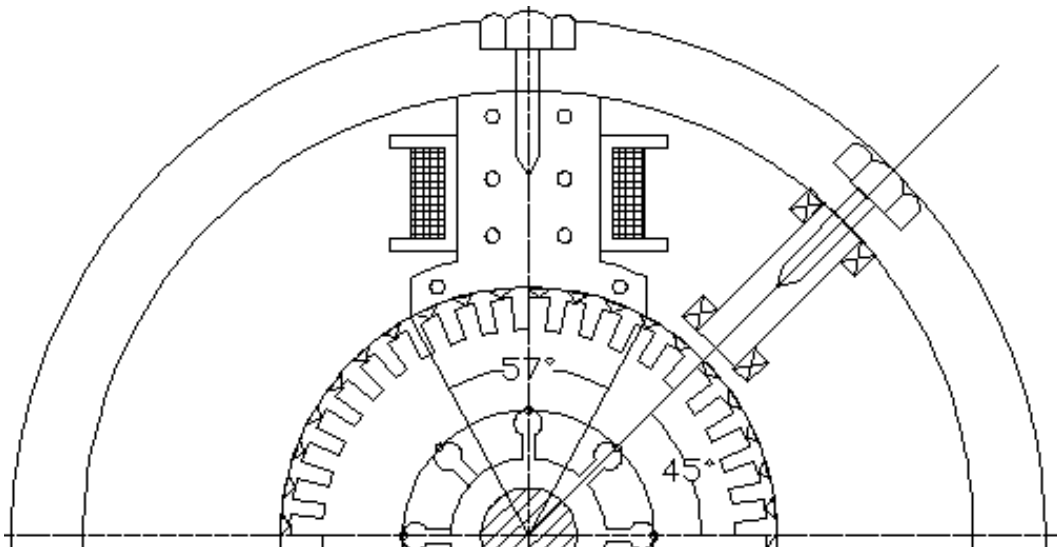
- Draw line at an angle of 45°
@ $745/2 < 45^\circ$ i.e $745/2 = 372.5$
- Offset 45° axis line both side by 22mm
- Offset the outer of stator by 150mm
- We get above fig

- ✓ Draw a rectangle
- ✓ Draw cross line inside, copy & mirror

How to Rotate?

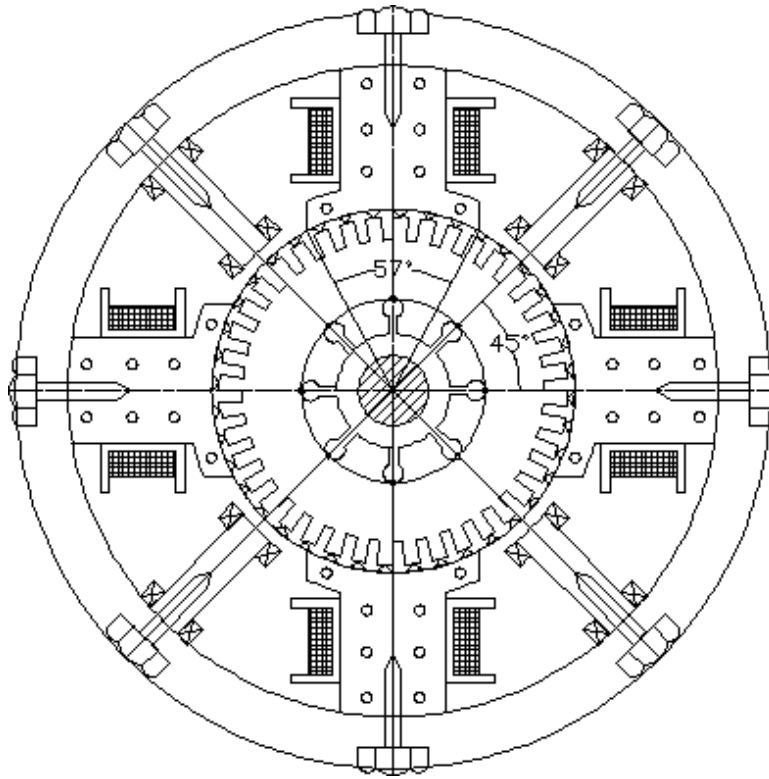
- Go to rotate icon
- Select objects
- Specify base point
- Specify rotation angle = 45°
- Enter

Step9:



- Draw over all dia of machine : 865mm
- Draw bolt for main pole & interpole
- Polar array:
 - ✓ Center point
 - ✓ Select object
 - ✓ Total no. of item : 4
 - ✓ Angle to fill : 360

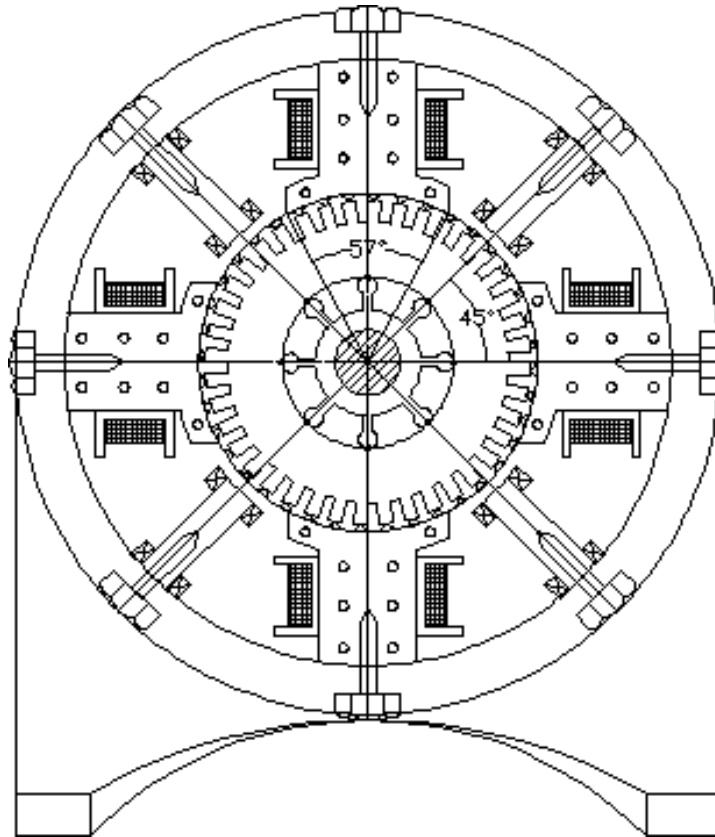
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Step10: To draw pole shoe:

Using 3 point arc , we get:

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Problem 5 :

Draw to suitable scale a neat and sectional view of the following as per dimension :

DC, 6 poles, 150HP motor

Armature dia=55cm, no. of slots= 61, size of slot = 1 * 4.5cm, airgap length(radial) = 0.5 at main pole and 0.6 at interpole

Details of main pole: Breadth = 14, arc = 20, height with shoe = 21

Interpole details: Breadth = 4cm, outside dia of yoke = 115cm, shaft dia at bearing = 10cm

The method of fixing the pole lamination and the pole to the yoke should be clearly shown.

Solution:

1. Shaft = 10cm
2. Armature dia = 55cm
Size of slot = 1 * 4.5
Length = $R\theta$; R is radius of armature [D=55cm, hence $R=27.5\text{cm} - 4.5\text{cm} = 23\text{cm}$]
 $\theta = l/R = 1\text{cm}/23 * 180/\pi = 2.5^\circ$
Slot angle = $360/\text{no of slot} = 360/60 = 6^\circ$
3. **Main pole:**
Pole arc = $R\theta$; R = armature radius + airgap = $27.5 + 0.5 = 28$
 $\theta = \text{pole arc}/R$ in radians
a) $\theta = \text{pole arc}/R * 180/\pi = 20/28 * 180/\pi = 41^\circ$

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- b) Breadth or width = 14cm
- c) Height of pole with shoe = 21cm
Assume shoe = 3cm, hence height of pole body only = $21 - 3 = 18$ cm

4. Interpole :

5. Yoke:

Inner dia of yoke = dia of armature + airgap + 2 * height of pole with shoe

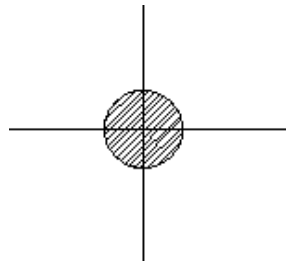
$$= 55 + 2 * 0.5 + 2 * 21\text{cm} = 98\text{cm}$$

Outer dia of yoke = 115cm

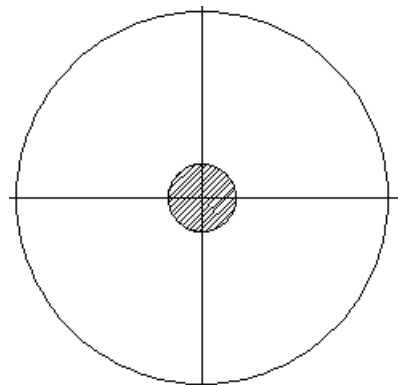
Step1: Limits: left corner 0,0 >> right corner : 1500,1500 >> zoom >> all

Step2: To draw shaft, armature & armature slot.

1. Draw a circle of radius $100\text{mm}/2 = 50\text{mm}$ Fill shaft hatching lines



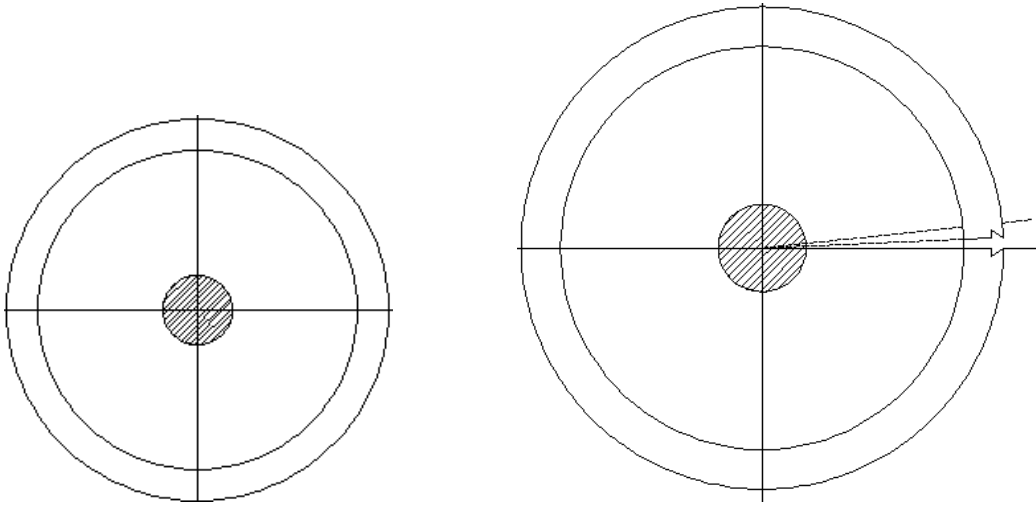
2. Draw armature of dia = 550mm



3. Offset armature by 45mm

Draw a line : $@550/2 < 2.5^\circ$, again $@550/2 < 6^\circ$

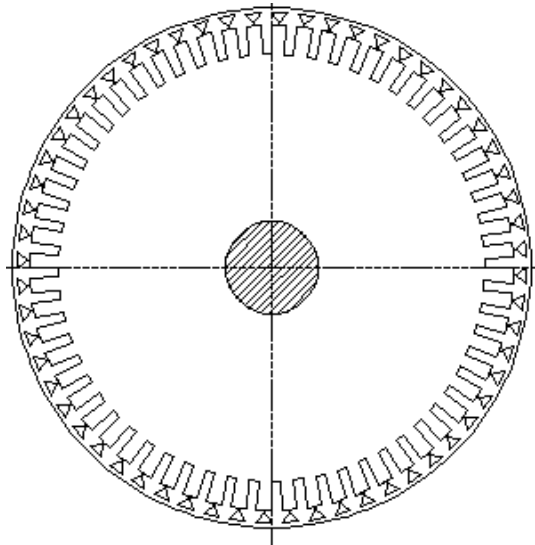
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Polar array : Select center point >> total no of items:60 >> angle to fill : 360 >> OK

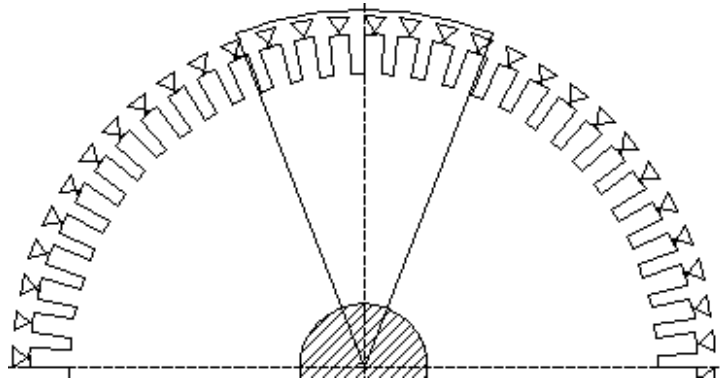
Step 3: Main pole

1. Draw a circle of radius = 280cm

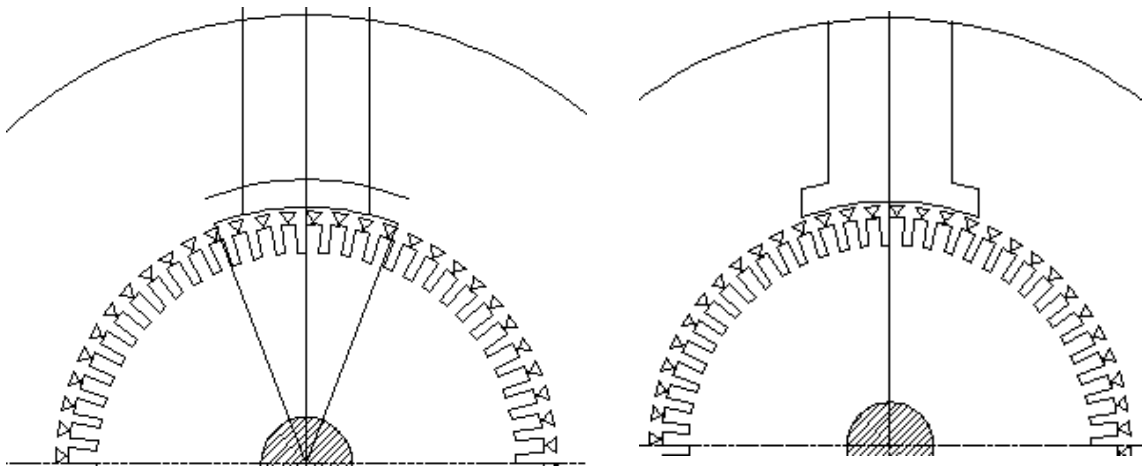


2. Draw a inclined line (pole arc)
@280<69°
@280<111°
Trim we get

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3. To draw pole width: Offset 70mm both sides (width = 140mm)

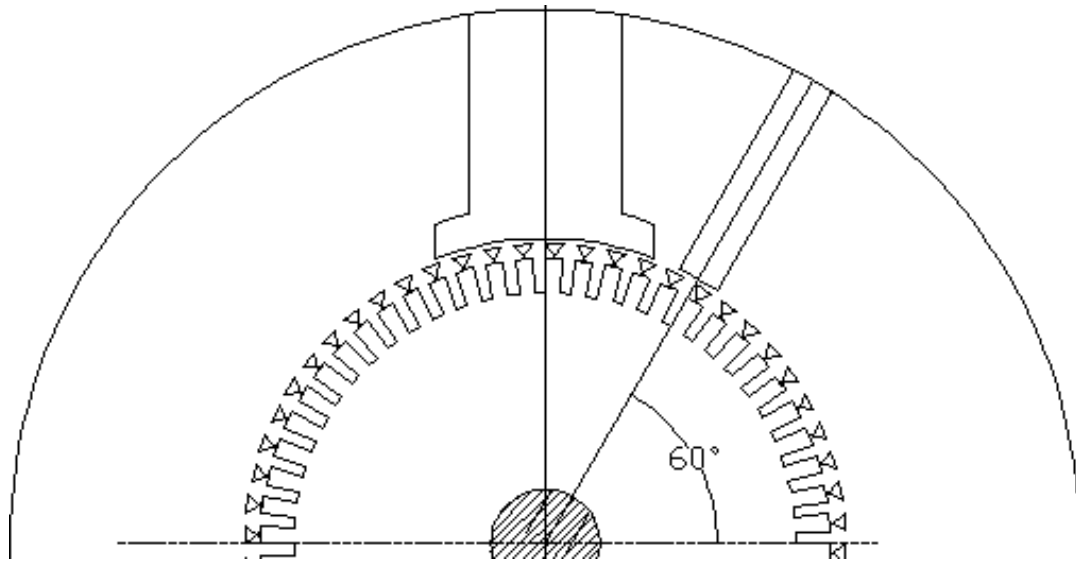


4. To draw pole shoe: Offset the arc by 30mm
5. To draw pole height with shoe: Draw the circle of dia = 98cm or 980mm i.e inner dia of yoke, we get.

Step 4: To draw interpoles:

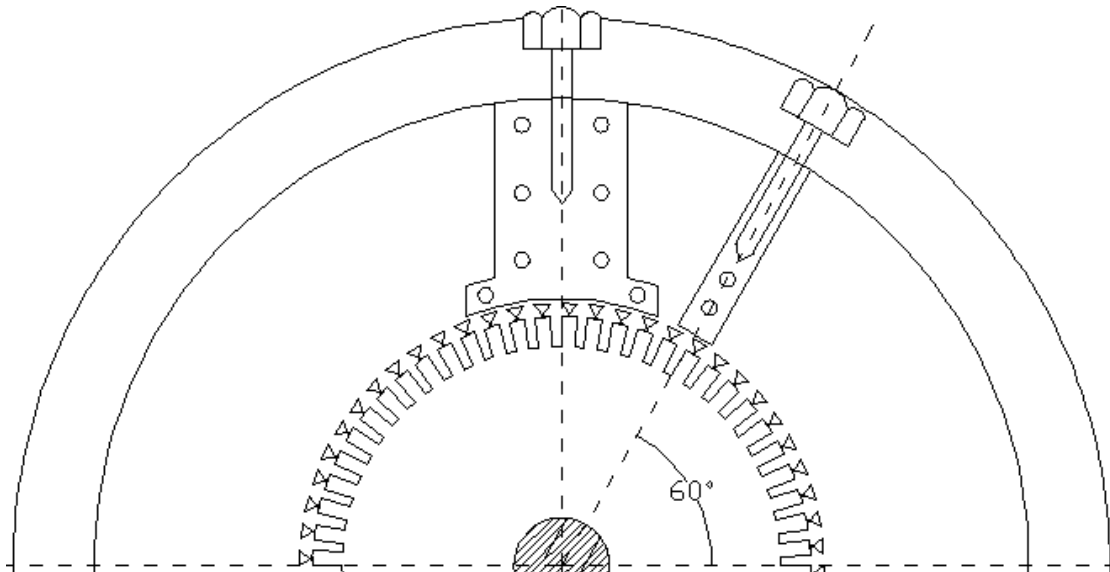
- Draw a 60° line i.e @ $980/2 < 60^\circ$
- Offset 60° line by 20mm both side (because breadth of interpole = 40mm)
- Since height of interpole = height of main pole body with shoe. Offset inner dia of yoke by 210mm
- Trim , we get

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Step 5 : To draw yoke and bolt

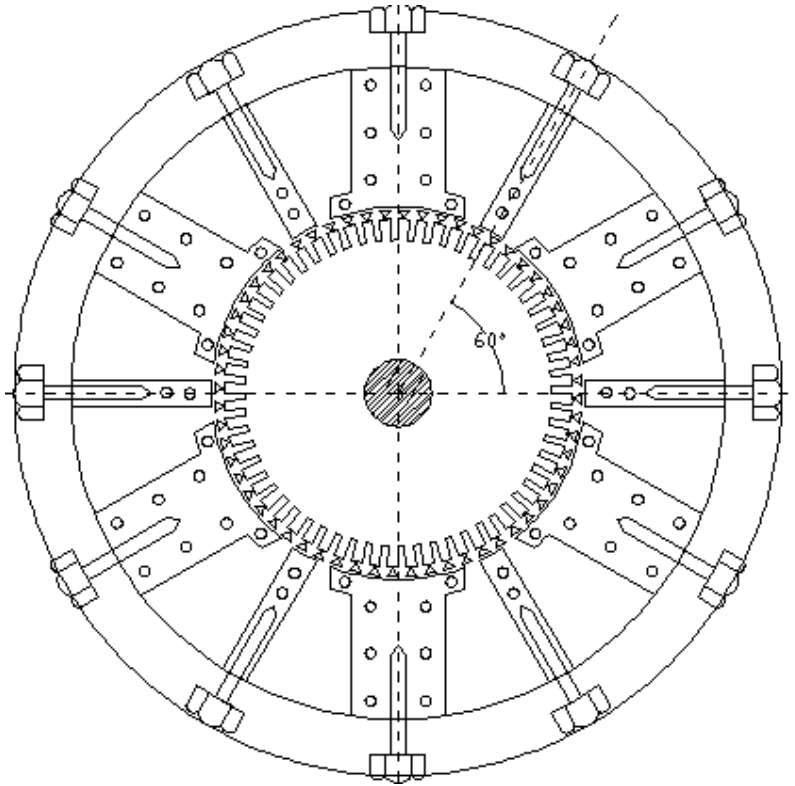
- Draw outer dia of yoke = 1150mm
- Draw a bolt to main pole
- Using polar array, copy the bolt to interpole:
 - ✓ Select object
 - ✓ Select center
 - ✓ Total no of item = 2
 - ✓ Method : select angle to fill and angle between item.
 - ✓ Angle to fill = -30°
 - ✓ Angle between item = 30
 - ✓ Ok



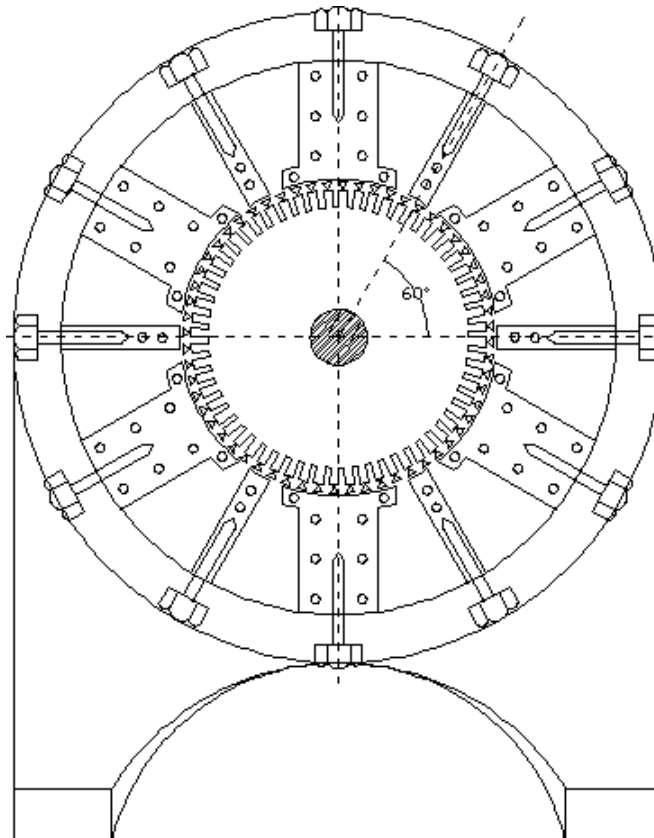
Step 6 : Polar array , main pole, interpole with their bolts

Select polar array >> Select center point >> Select object >> Total no of items :6 >> Angle to fill : 360 >>OK

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Step 7: To draw pole shoe - Using 3 point arc , we get



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Problem 6:

Fig shows the isometric view of an field pole and its coil, draw the half sectional elevation and full plan assembled.

All dimensions are in mm.

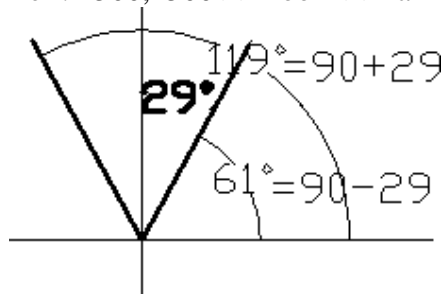
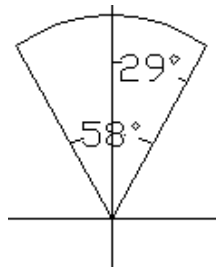
Note: Rest of the data can be neglected

From fig: Radius $R = 161.2\text{mm}$, pole arc = 164.2mm , pole shoe = 55.8mm , height of pole body with shoe = 86.2mm

Pole arc = $R\theta$

θ in deg = pole arc/ R * $180/\pi = 164.2/161.2 * 180/\pi = 58^\circ$

Step 1: Limits: Left corner 0,0 >> right corner : 1500,1500 >> zoom >> all



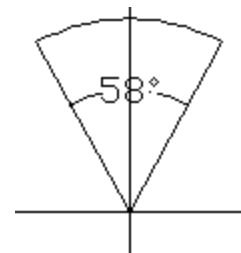
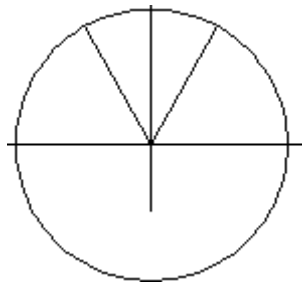
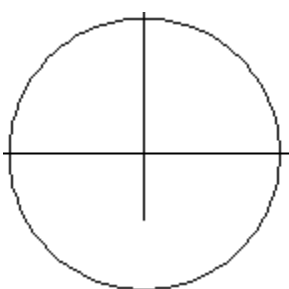
Step 2:

Draw a line at angle of 29° to either side of vertical axis

@ $161.2 < 61^\circ$

@ $161.2 < 119^\circ$

Draw a circle of radius 161.2mm after trim, we get



Step 3:

$R = 161.2\text{mm}$

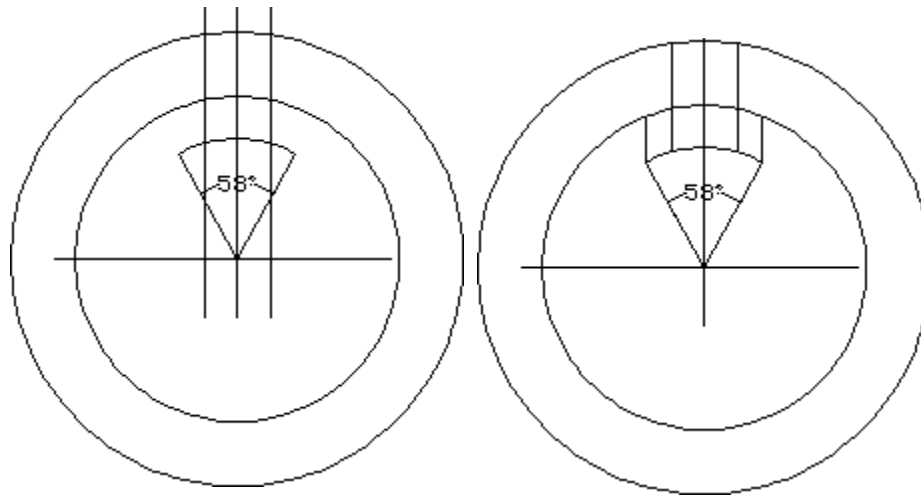
$R_1 = R + \text{pole shoe} = 161.2 + 55.8 = 217\text{mm}$

$R_2 = R_1 + \text{height of pole body without shoe} = 217 + 86.2 = 303.2\text{mm}$

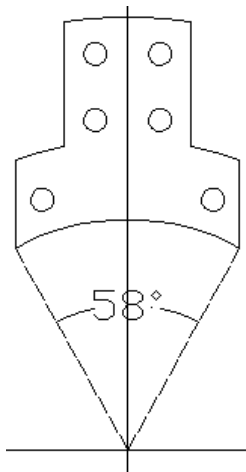
Draw a circle of radius $R_1 = 217\text{mm}$, $R_2 = 303.2\text{mm}$

Offset vertical axis by $89/2 = 44.5\text{mm}$ by both sides, we get

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After Trim



Step 4: Field winding

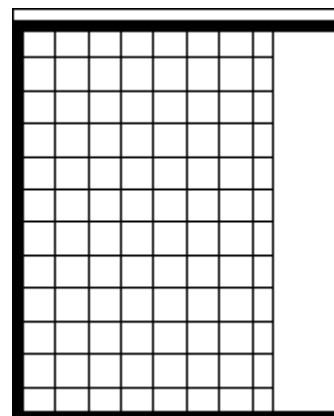
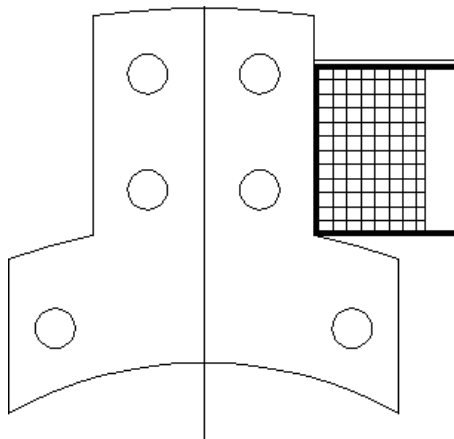
Offset 101.15 from vertical axis both side

At point (a) draw line: @68.2<90° and @44.5<0

Offset 44.5mm line all side by 1.6mm

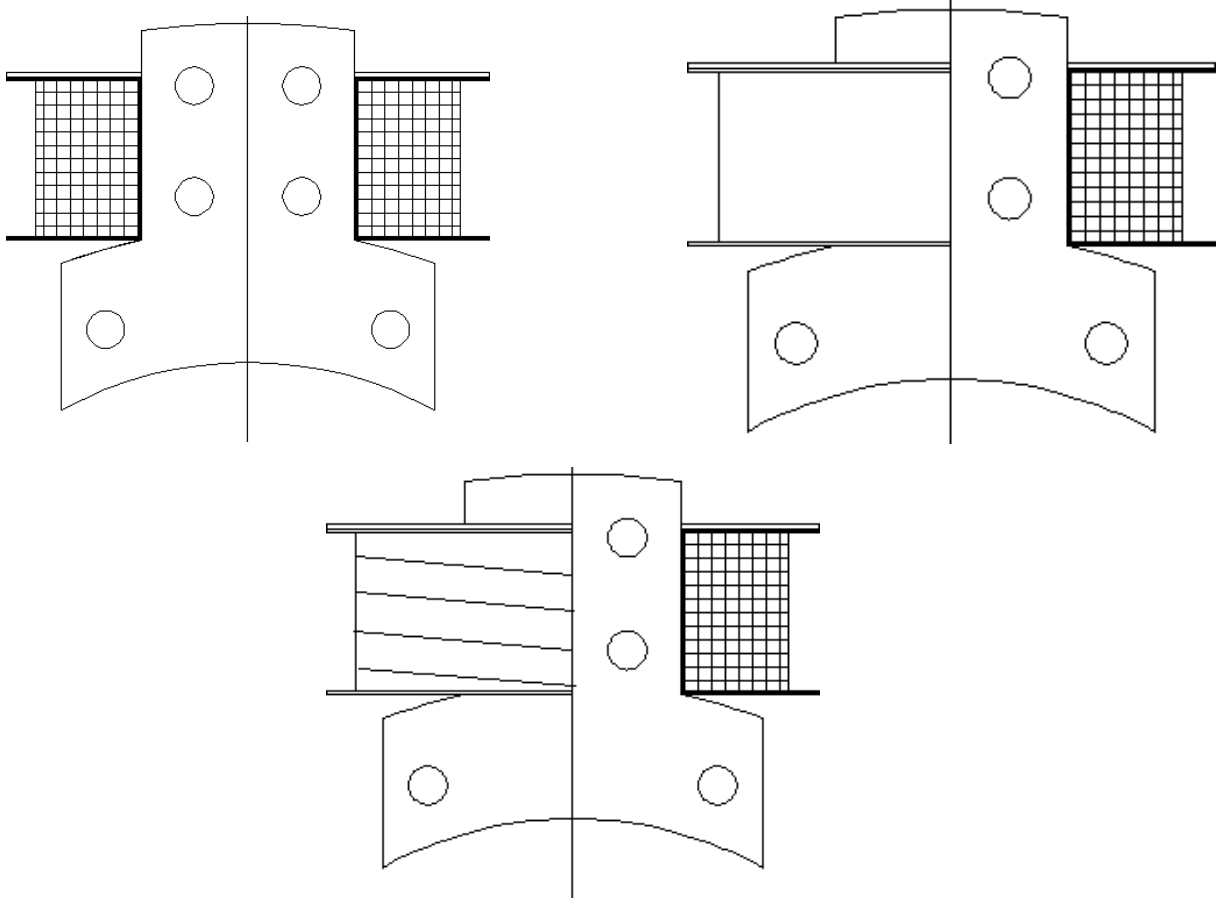
In the top offset by 2mm

- Fill solid for 1.6mm insulation
- Use “Net” in hatch



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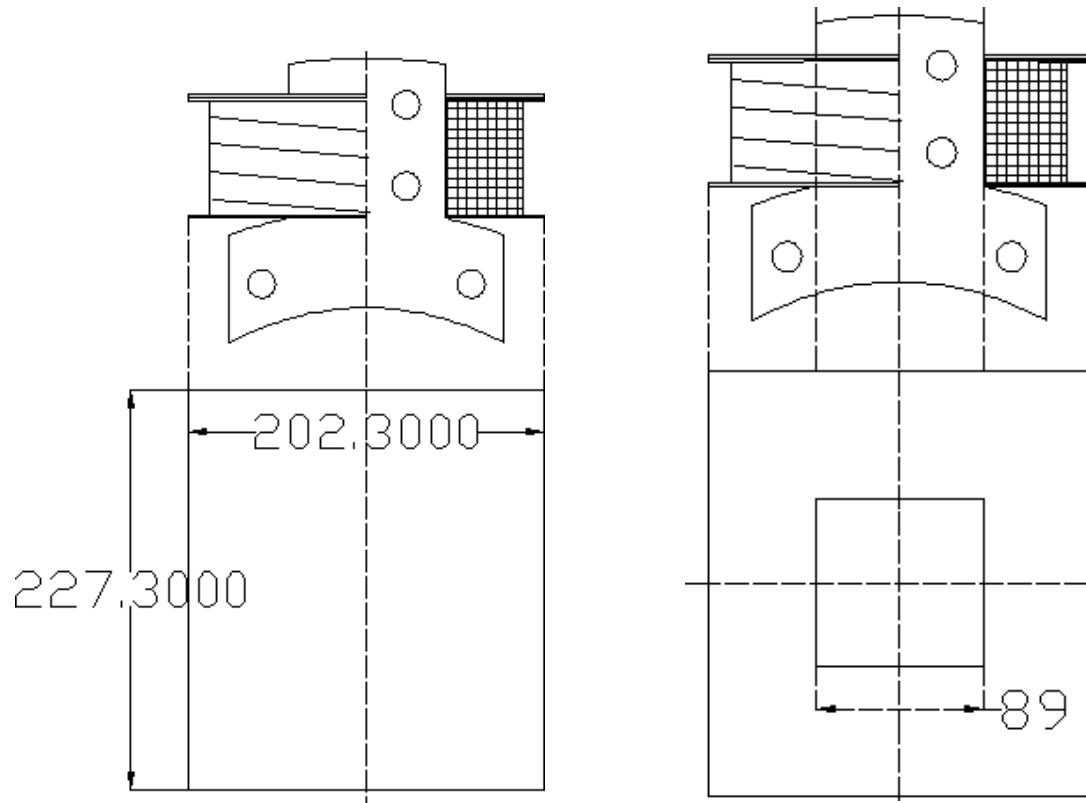
Step 5: Mirror the field winding to left side



Given :

Step 6 : Offset all side of axis by 44.5mm we get

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Outcome: students will be able to draw the sectional views of yoke, field system, armature and commutator