21MES102L
Engineering Graphics and Design
School of Mechanical Engineering

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Engineering Graphics and Design

E2 Conic Sections and Special Curves

Topics Covered

- **Conic Sections**
- Ellipse
- Parabola
- **Special Curves**
- Spiral
- Involute
- Cycloid

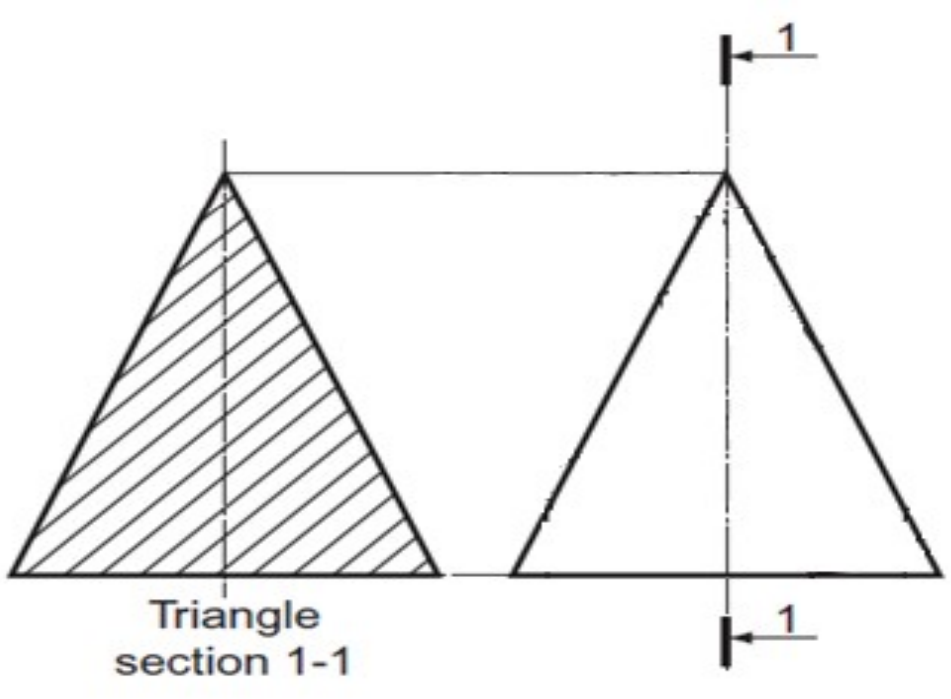
Conics

- When a **CONE** is cut by a Plane, the Curve formed along the Section is known as a **Conic Section.**

- A **CONE** may be cut by different Section Planes to obtain the different **Conic Sections**.

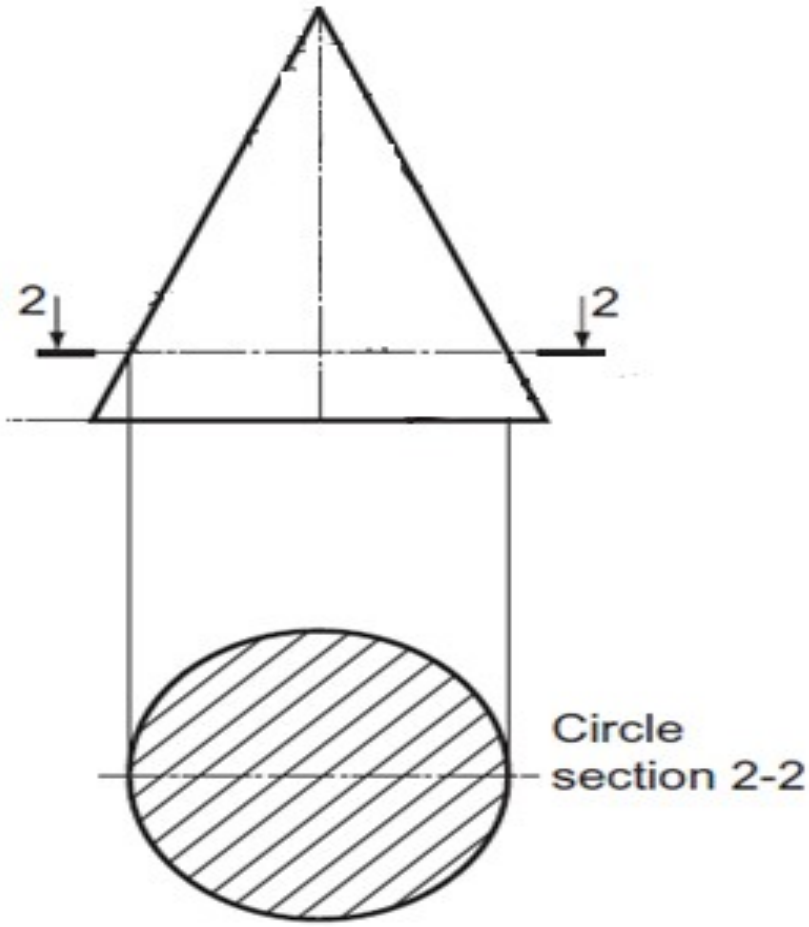
Triangle

➢ When a **Cone** is cut by a Section Plane **1-1**, passing through the **Axis,** then the Section obtained is a **Triangle.**

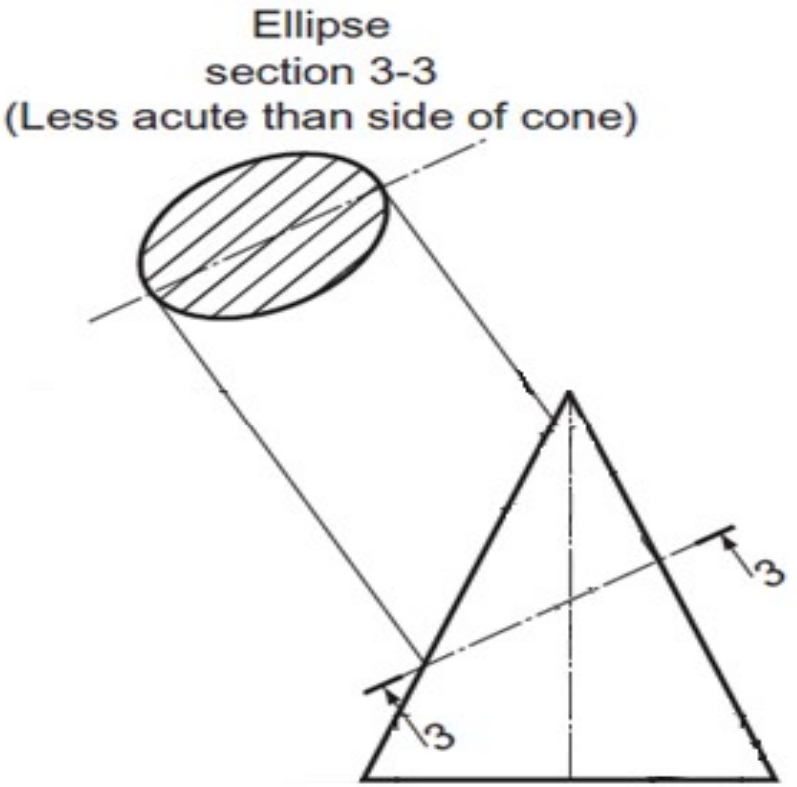


Circle

➢When a **Cone** is cut by a Section Plane **2-2** **Perpendicular to the Axis**, then the Section obtained is a **Circle**.



Ellipse

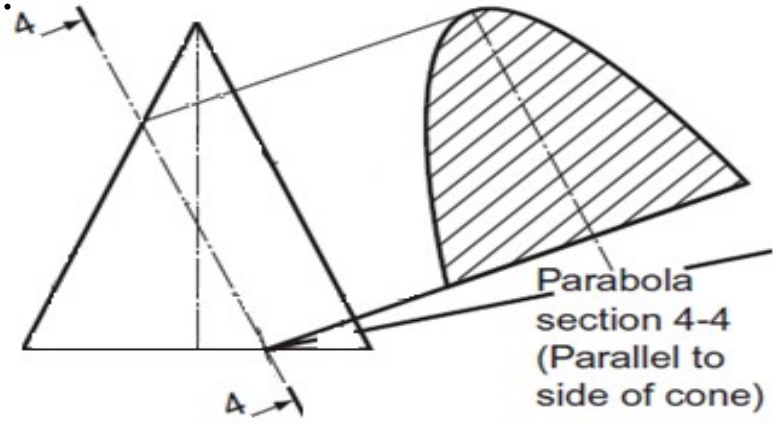


➢When a **Cone** is cut by a Section Plane **3-3** at an angle **α, 90° > α > θ** (**½** apex angle), the curve of the Section is an **Ellipse**.

➢Its size depends on the angle **α** and the distance of the Section Plane from the **Apex** of the **Cone**.

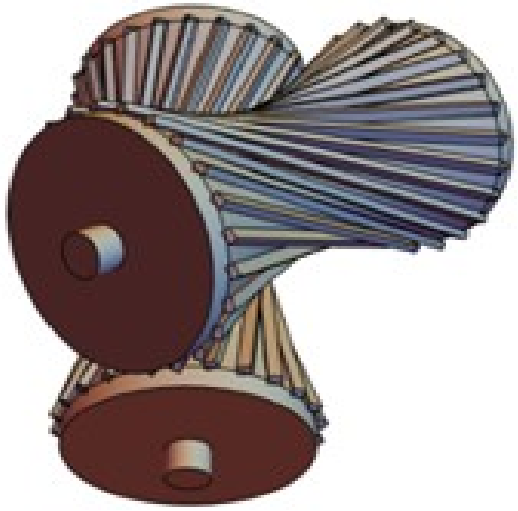
Parabola

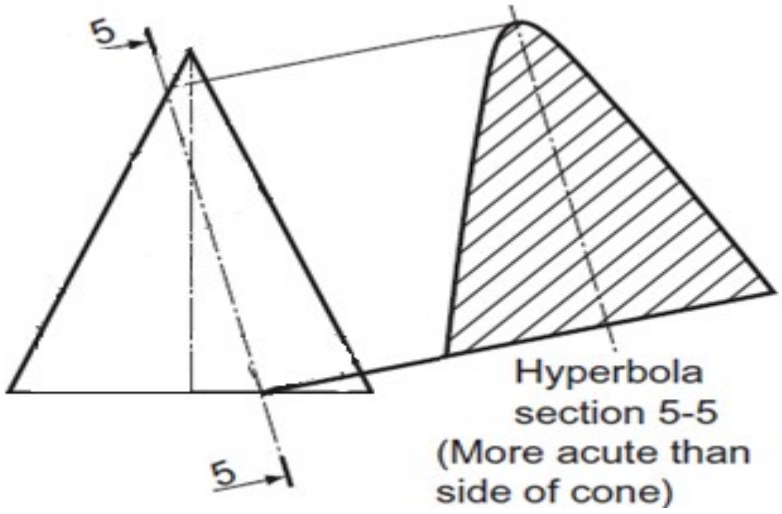
- When a **Cone** is cut by a Section Plane **4-4** Parallel to the Slant Side of the Cone, then the Curve at the Section is a **Parabola**.
- This is not a closed figure like Circle or Ellipse.
- The size of the Parabola depends upon the distance of the Section Plane from the Slant Side of the Cone.



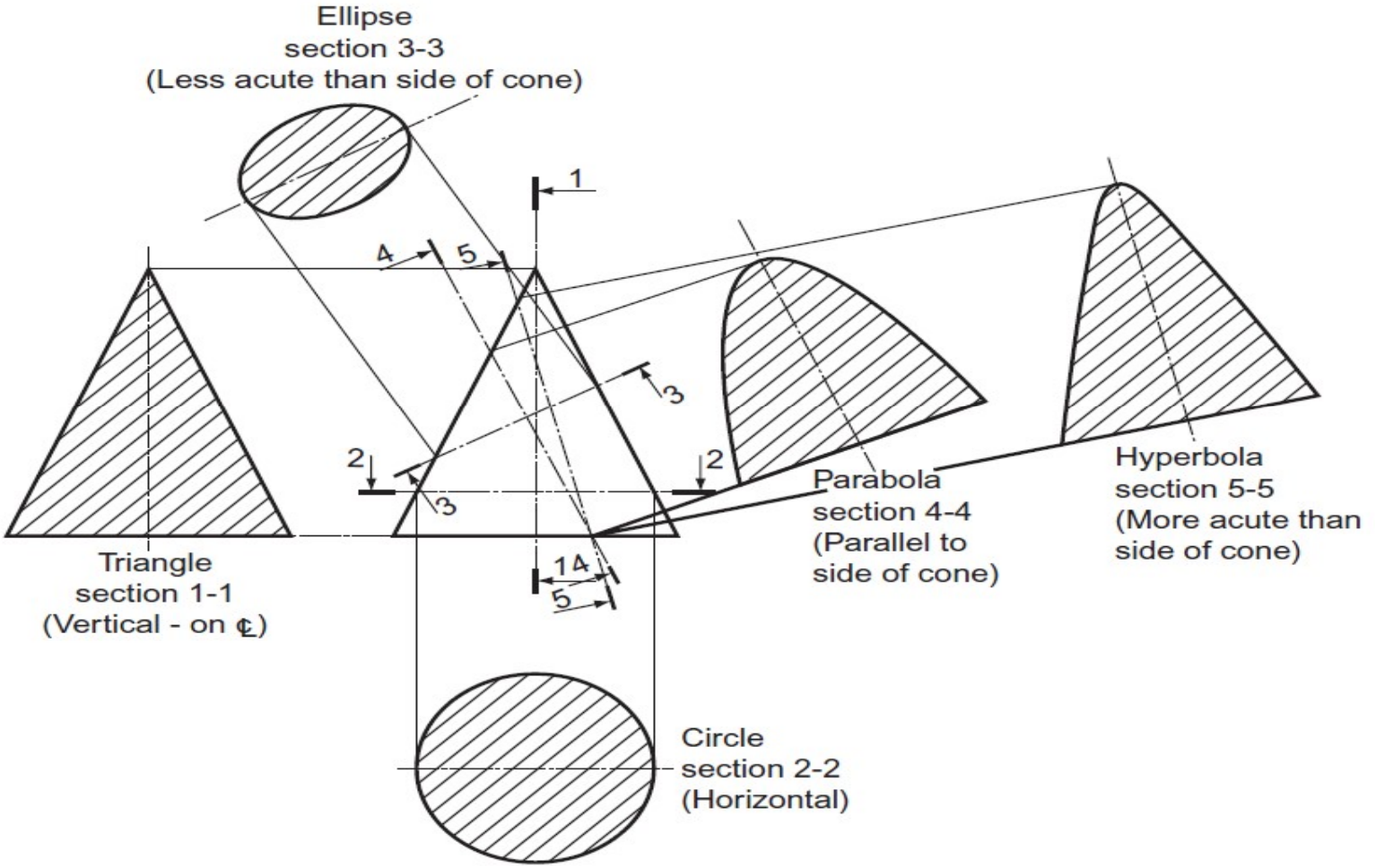
Hyperbola

- When a **Cone** is cut by a Section Plane **5-5** at an Angle **α < θ** (½ apex angle), the Curve of the Section is a **Hyperbola**.
- The Section will be a Hyperbola, if **α = θ,** provided the Section Plane is not passing through the **Apex** of the **Cone**.
- However if the Section Plane passes through the **Apex**, the Section produced is an **Isosceles Triangle**.





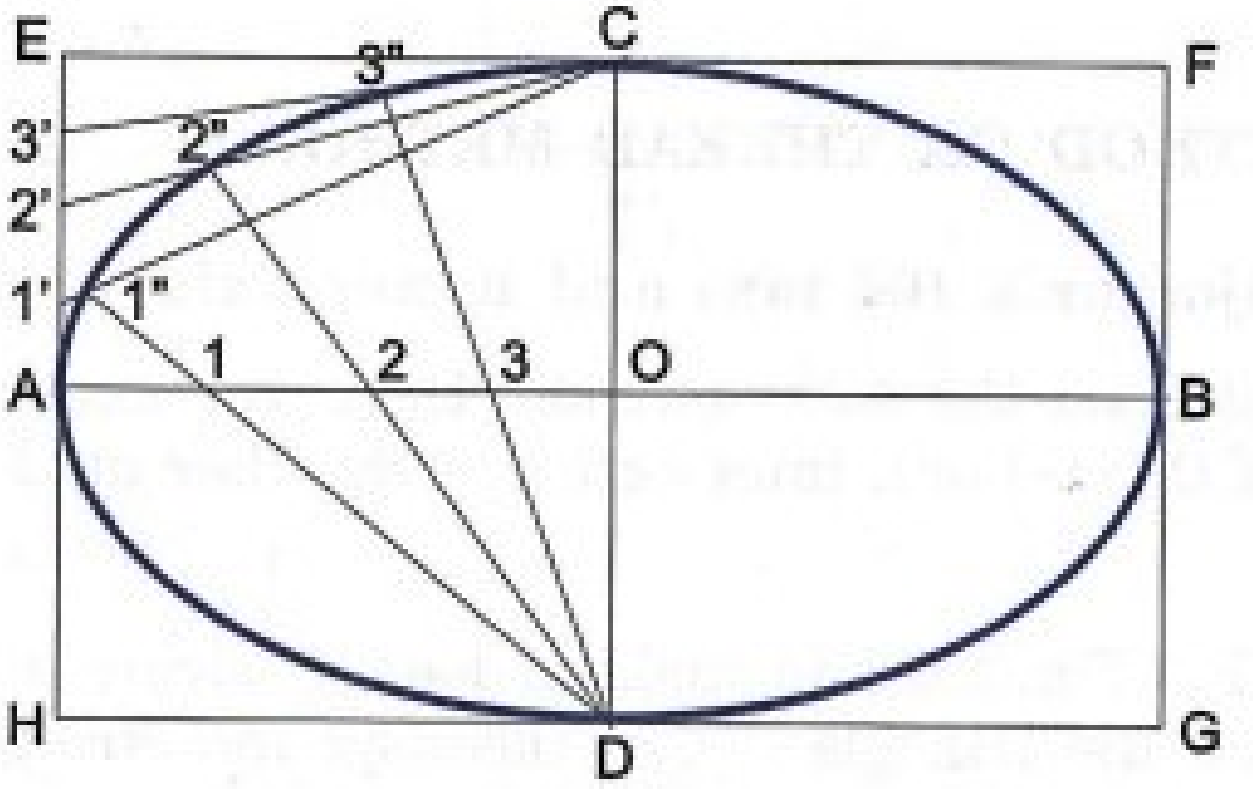
Conic section



Ellipse

- Oblong method
- Concentric circle method

Ellipse - Oblong method



Ellipse-Oblong method

- Initial setup of workspace **Drafting & Annotation** Mode
  - Type UN or **UNITS**
  - Set the Precision for **0**
  - Set the Units in Millimeters
- Type **LIMITS** Press Enter
  - Specify the Lower Left Corner as **0,0** Press Enter
  - Specify the Upper Right Corner as **210,297** Press Enter
- Type **ZOOM** Press Enter
- Type **ALL** Press Enter

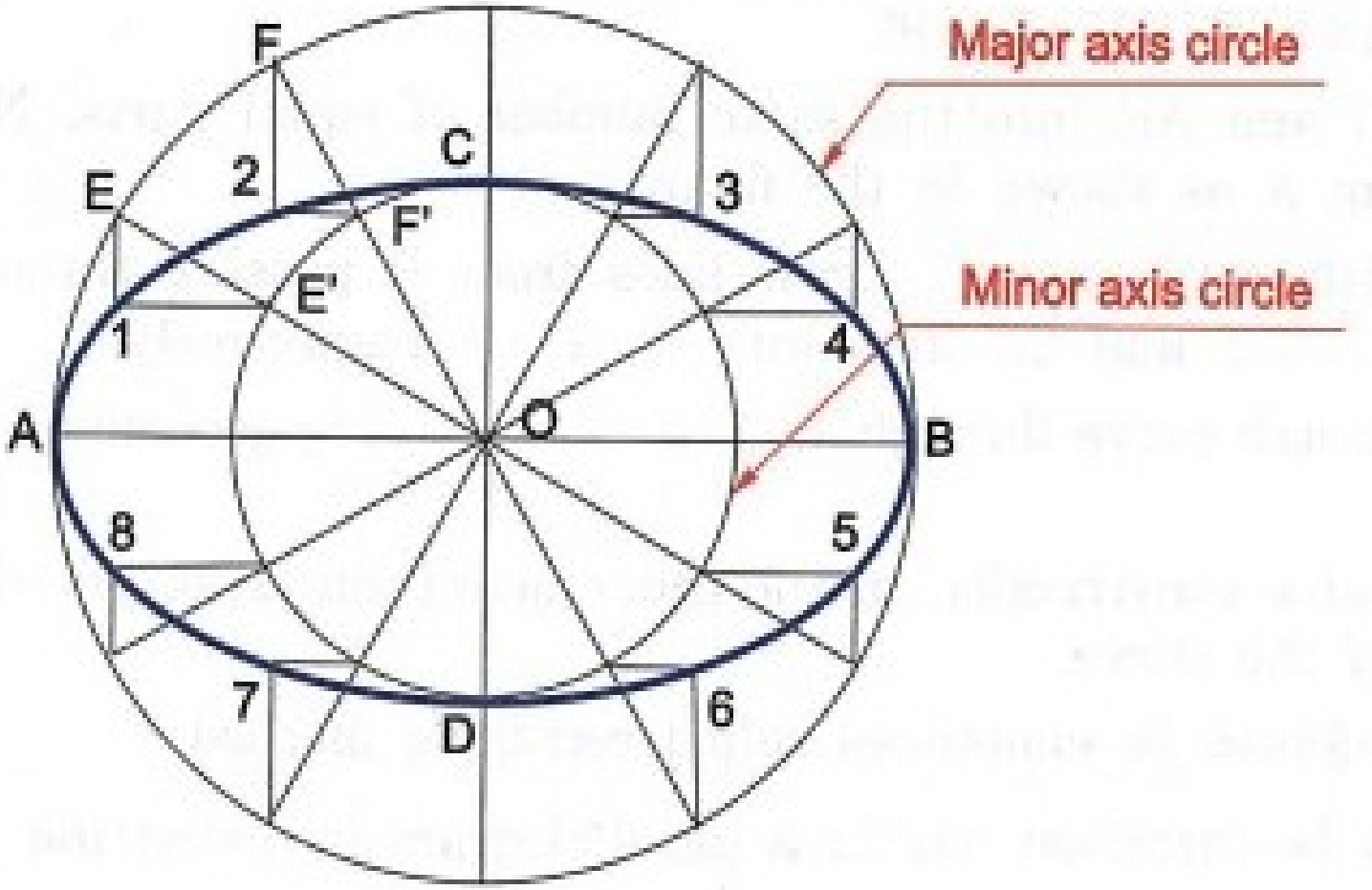
Ellipse-Oblong method

- Draw a Rectangle for the given Major axis and Minor axis dimensions of Ellipse by using **LINE** command or **Rectangular** command from **DRAW** Tool bar and name it as **EFGH** by using **SINGLE LINE TEXT** from **ANNOTATION** Tool bar.
- Use **DIVIDE** command to Divide the Rectangle into two equal parts along the Major and Minor axis and Name it as **A B** & **C D** by using **SINGLE LINE TEXT** from **ANNOTATION** Tool bar.
- Mark the point **O** at the intersection of lines **A B** & **C D**
- Use **DIVIDE** command to Divide **A O** and **A E** into same equal number of parts and name it as **1,2,3…** & **1',2',3'…**

Ellipse-Oblong method

- **Put off** Ortho mode & draw a lines from **C** to **1',2',3'…**
- Draw lines from **D** through **1,2,3…** to meet lines **C1', C2',C3'…** & mark **1",2",3"….**
- Select **Spline fit** from Draw tool bar then draw the curve from **A** through the **1",2"…** to **C**
- Use the **MIRROR** command from **MODIFY** Tool bar to complete the remaining part of the **ELLIPSE**.
- Mark the dimension by using **ANNOTATION** Tool bar

Ellipse - Concentric Circle Method



Ellipse - Concentric Circle Method

- Initial setup of workspace **Drafting & Annotation** Mode
  - Type UN or **UNITS**
  - Set the Precision for **0**
  - Set the Units in Millimeters
- Type **LIMITS** Press Enter
  - Specify the Lower Left Corner as **0,0** Press Enter
  - Specify the Upper Right Corner as **210,297** Press Enter
- Type **ZOOM** Press Enter
- Type **ALL** Press Enter

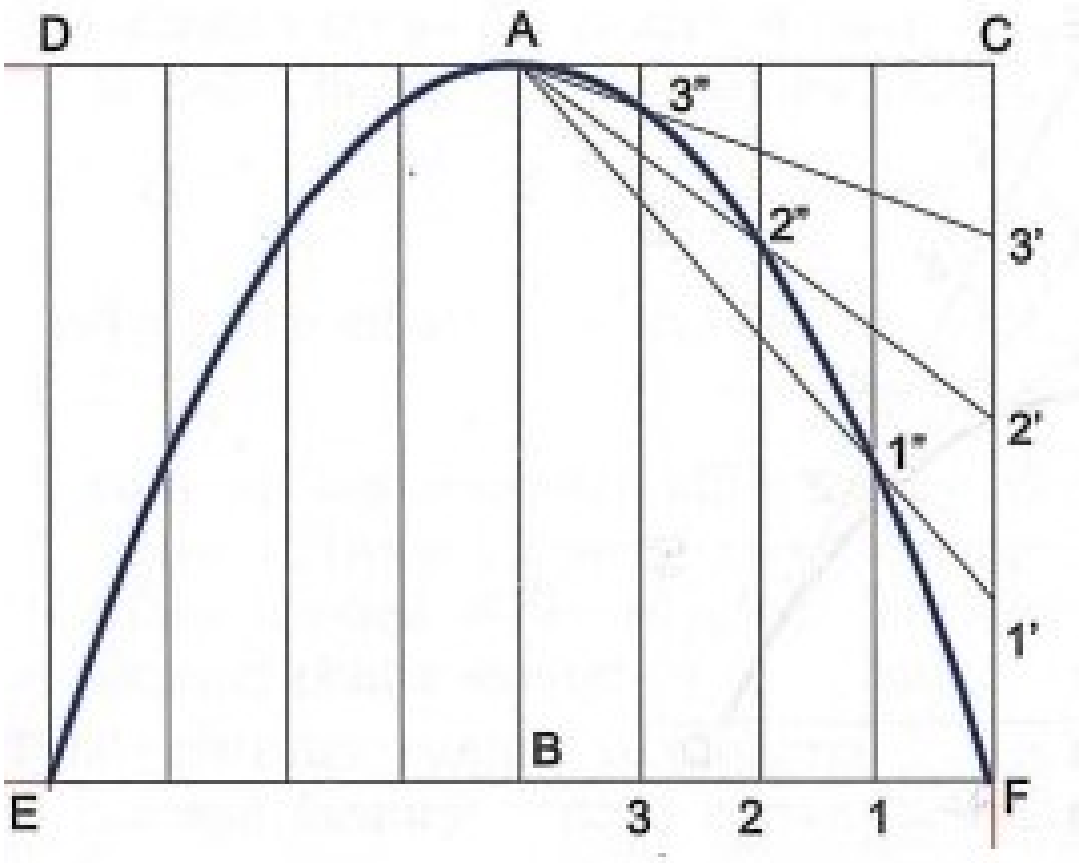
Ellipse Concentric Circle Method

- Use **CIRCLE** command from **DRAW** tool bar to draw concentric circles for the given minor and major axis dimensions of the **ELLIPSE**
- Use **DIVIDE** command to Divide the Circles into equal number of parts and name it as **O,A,B,C,D,E,F,E'** & **F'** by using **SINGLE LINE TEXT** from **ANNOTATION** Tool bar.
- Draw vertical line from **E** and Horizontal Line from **E'** and intersect each other to get point **1**

Ellipse Concentric Circle Method

- Draw vertical line from **F** and Horizontal Line from **F'** and intersect each other to get point **2**
- Select **SPLINE FIT** tool from **DRAW** tool bar then draw the curve from **A** to **C** through **1,2**
- Use the **MIRROR** command from **MODIFY** Tool bar to complete the remaining part of the **ELLIPSE**.
- Mark the dimension by using **ANNOTATION** Tool bar

Parabola-Rectangle method



➢The travelling path of the water from fountain to Earth.

Parabola-Rectangle method

- Initial setup of workspace **Drafting & Annotation** Mode
  - Type UN or **UNITS**
  - Set the Precision for **0**
  - Set the Units in Millimeters
- Type **LIMITS** Press Enter
  - Specify the Lower Left Corner as **0,0** Press Enter
  - Specify the Upper Right Corner as **210,297** Press Enter
- Type **ZOOM** Press Enter
- Type **ALL** Press Enter

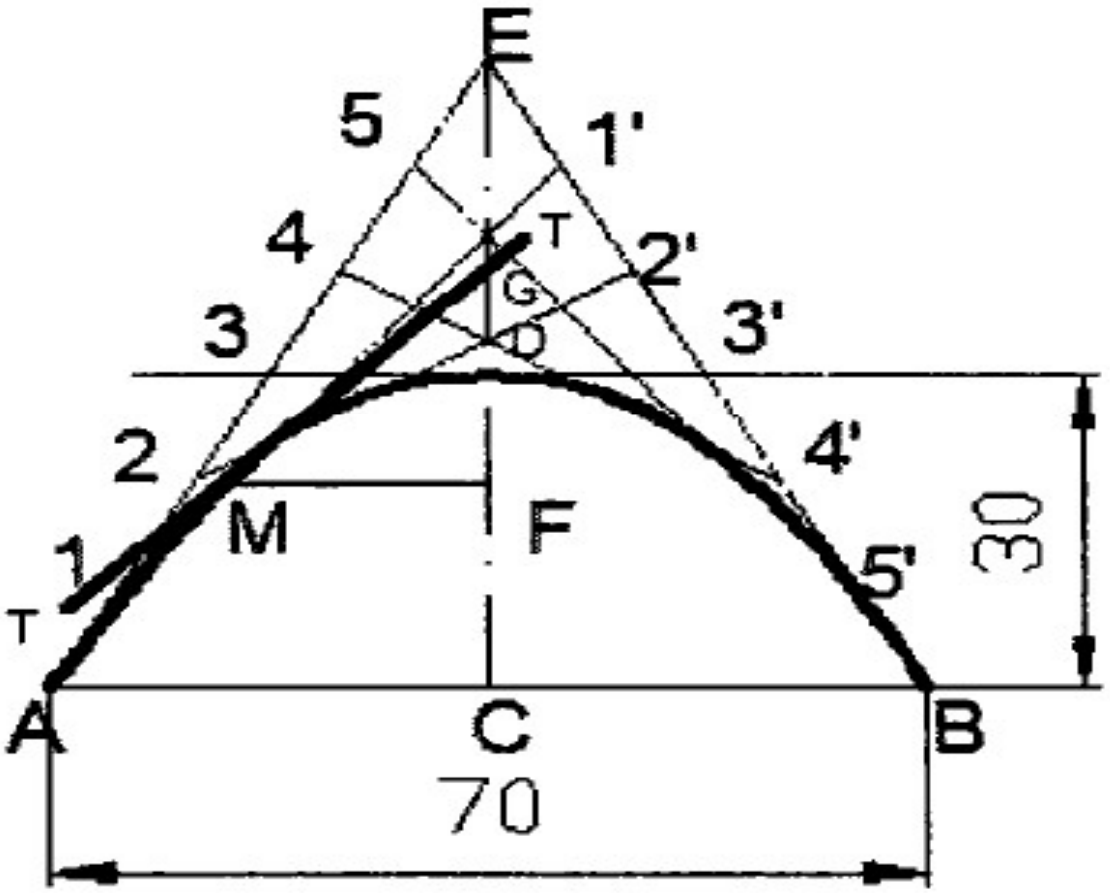
Parabola-Rectangle method

- Draw a Rectangle **CDEF** using **LINE** or **RECTANGLE** command for the Required dimension
- Use **DIVIDE** command to divide the Rectangle into two equal parts and mark **A** & **B** at the mid points of **D C** & **E F**.
- Use **DIVIDE** command to divide the base **B F** and height **C F** of the rectangle into same number of equal parts and name the points as **1,2…,** & **1',2'…,**

Parabola-Rectangle method

- Draw vertical lines from **1, 2,…,** upto **A C** line.
- Put off **ORTHO MODE** and draw lines from **A** to **1', A** to **2'…,**
- Select **SPLINE FIT** curve from draw tool bar and draw a curve through **F, 1", 2"… & A.**
- Use **MIRROR** command from **MODIFY** Tool bar to complete the remaining half of the **Parabola**
- Mark the dimension by using **ANNOTATION** Tool bar

Parabola - Tangent Method



The travelling path of a Basket ball thrown.

Parabola - Tangent Method

- Initial setup of workspace **Drafting & Annotation** Mode
  - Type UN or **UNITS**
  - Set the Precision for **0**
  - Set the Units in Millimeters
- Type **LIMITS** Press Enter
  - Specify the Lower Left Corner as **0,0** Press Enter
  - Specify the Upper Right Corner as **210,297** Press Enter
- Type **ZOOM** Press Enter
- Type **ALL** Press Enter

Parabola - Tangent Method

- Draw a Horizontal Line for the given base of the Parabola and name it as **AB**.
- From the mid of the Horizontal line **AB** draw a vertical line **TWICE** the given Height of the Parabola and name it as **E.**
- Connect the Apex point **E** to **A** and **B**.
- Use **Divide** command to divide the line **EA** and **EB** into same number of equal parts and name the points.

Parabola - Tangent Method

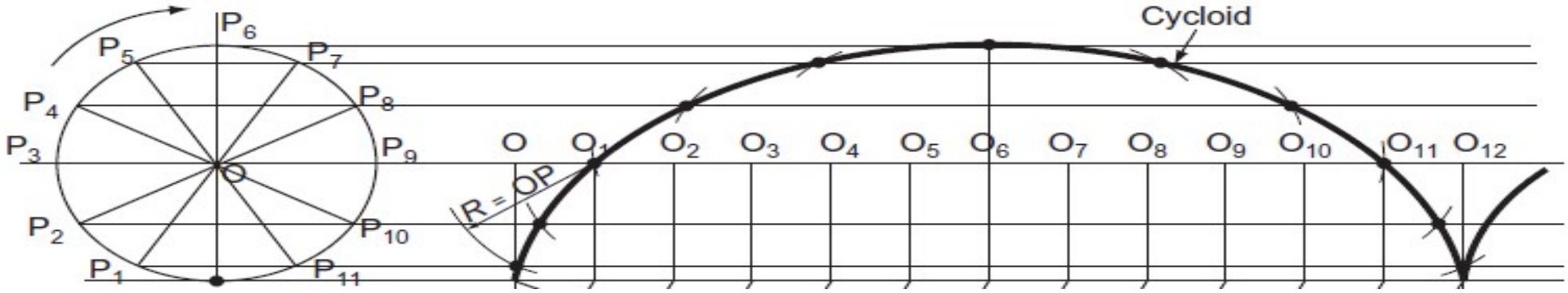
- Put off the **ORTHO MODE** and connect the **1 & 1', 2 & 2'…,**
- Select **Spline fit** tool from Draw tool bar then Start from **A** and run the Curve Tangential to the lines **1** & **1', 2 & 2'…,** and make sure that it crosses the point **B** and press Enter to obtain the **PARABOLA.**
- Mark the dimension by using **ANNOTATION** Tool bar

Special curves

- **Cycloid**
- Epi – cycloid
- Hypo – cycloid
- Trochoid
- **Involute**
- **Spiral**
- Helix

- A **cycloid** is the curve traced by a point on a circle as it rolls along a straight line without slipping.
- The **involute of a circle** is the path traced out by a point on a straight line that rolls around a **circle**.
- The **Archimedean spiral** has the property that any ray from the origin intersects successive turnings of the **spiral** in points with a constant separation distance.
- Spiral is a plane curve generated by a point moving around a fixed point while constantly receding from or approaching it.

Cycloid



A 1 2 11 B

Cycloid

- Initial setup of workspace **Drafting & Annotation** Mode
  - Type UN or **UNITS**
  - Set the Precision for **0**
  - Set the Units in Millimeters
- Type **LIMITS** Press Enter
  - Specify the Lower Left Corner as **0,0** Press Enter
  - Specify the Upper Right Corner as **210,297** Press Enter
- Type **ZOOM** Press Enter
- Type **ALL** Press Enter

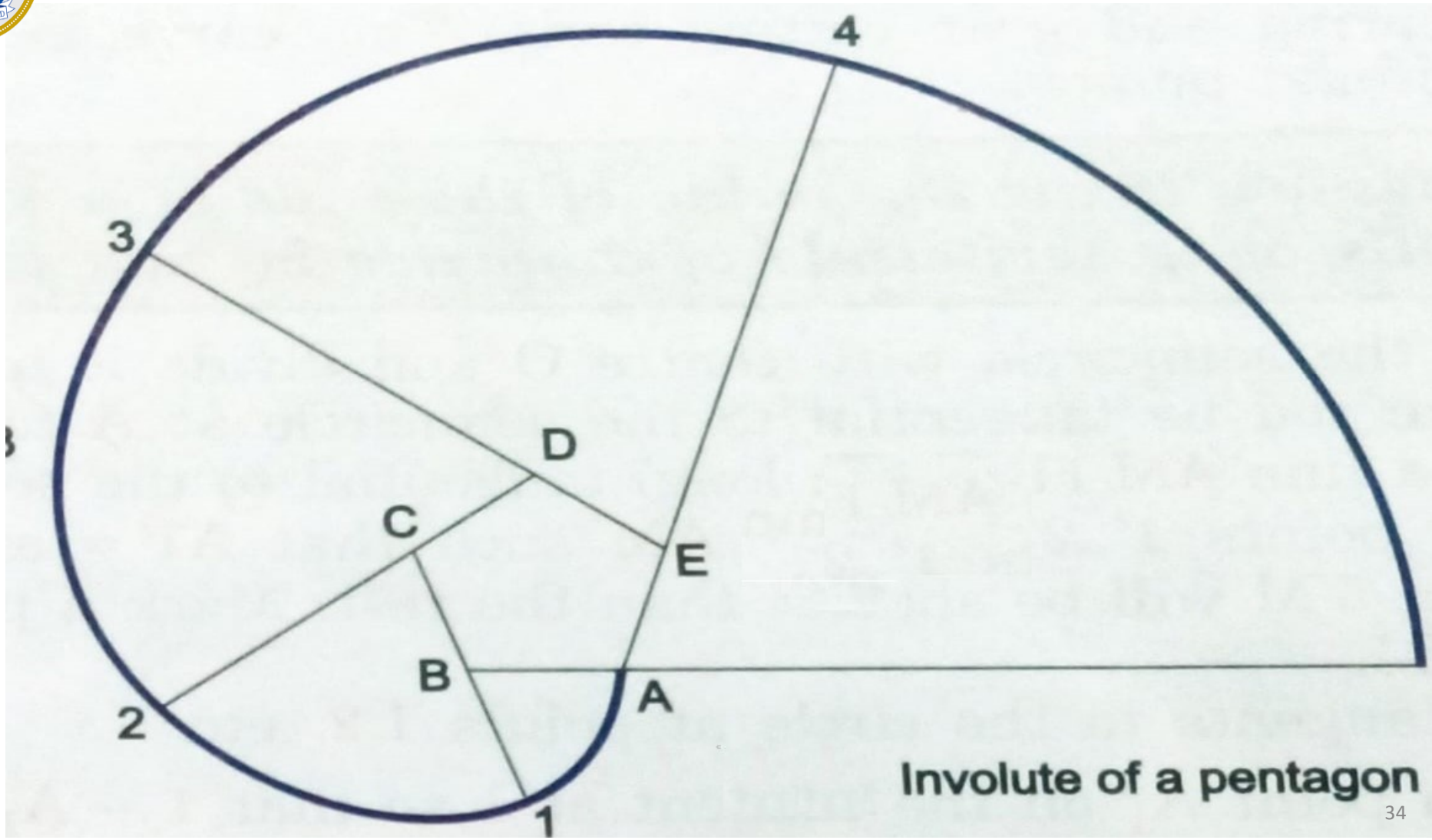
Procedure for Drawing Cycloid

- Use **CIRCLE** command from **DRAW** tool bar to draw a Generating Circle of given radius & Divide into **8** or **12** equal parts using **DIVIDE** command & name the points as **P_1 , P_2,…..** by using **SINGLE LINE TEXT** from **ANNOTATION** Tool bar.
- Draw a line **A B** for **π D** & divide into **8** or **12** parts as divided in circle
- Project lines horizontally from points **P_0 , P_1,….**
- Draw vertical lines from **A , 1, 2,….**up to point **B** to intersect the line coming from center of the circle & name it as **O_1, O_2,….**

Procedure for Drawing Cycloid

- Draw a circle using **CIRCLE** command from **DRAW** Tool bar for the given radius with **O** as the center to intersect the line coming from $\mathbf{P_o}$.
- Use **POINT** command to locate the intersecting point.
- Use **MOVE** command to obtain the next intersecting point on the line coming from $\mathbf{P_1}$ & Repeat the same up to the midpoint of the line **AB**.
- Use **Mirror** command to fetch the remaining part of the line **AB**.
- Use **Spline fit** Curve to connect the intersection points to obtain a **CYCLOID CURVE.**
- Mark the dimension by using **ANNOTATION** Tool bar.

INVOLUTE



Procedure for Drawing Involute of a Pentagon

- Initial setup of workspace **Drafting & Annotation** Mode
  - Type UN or **UNITS**
  - Set the Precision for **0**
  - Set the Units in Millimeters
- Type **LIMITS** Press Enter
  - Specify the Lower Left Corner as **0,0** Press Enter
  - Specify the Upper Right Corner as **210,297** Press Enter
- Type **ZOOM** Press Enter
- Type **ALL** Press Enter

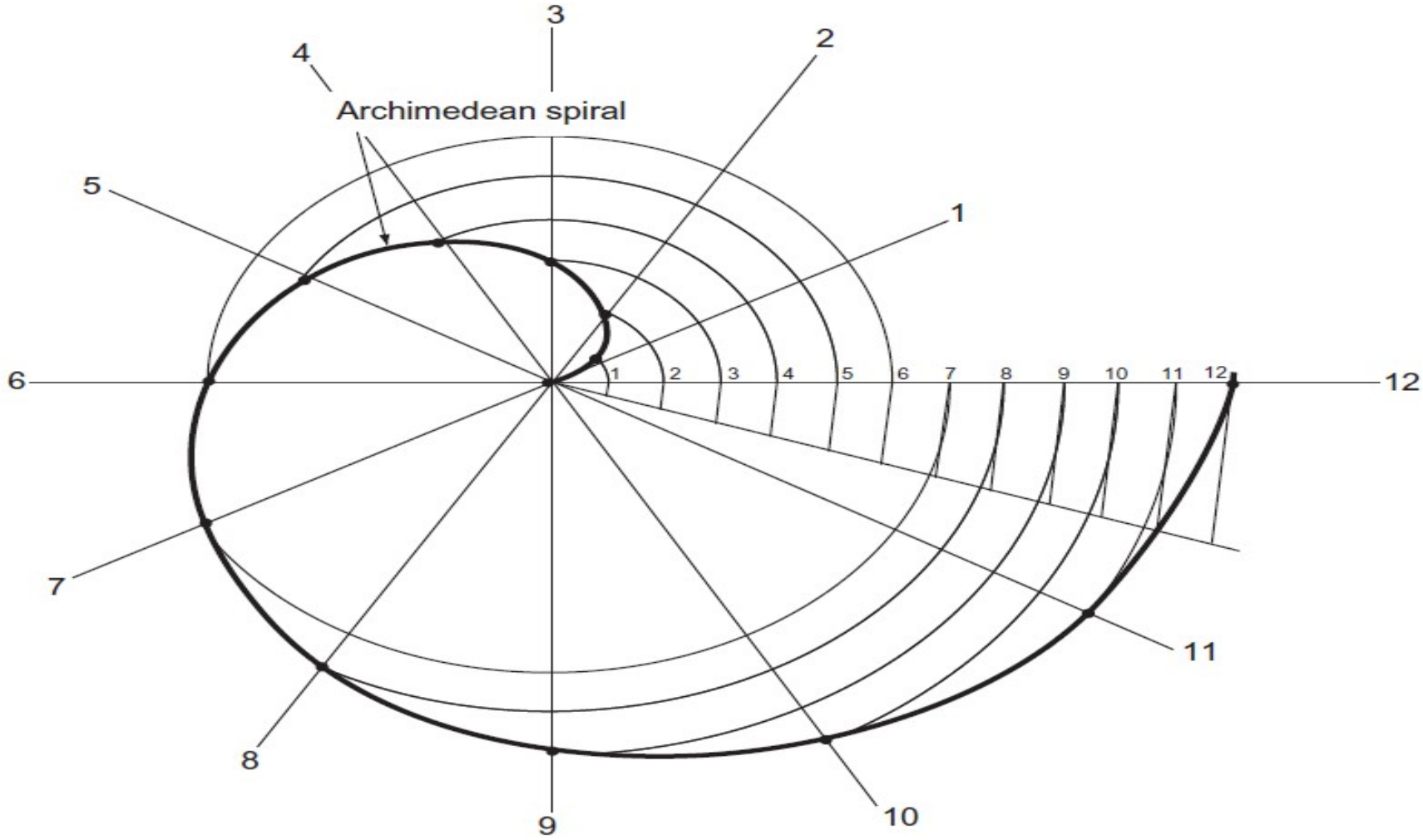
Procedure for Drawing Involute of a Pentagon

- Draw a **Pentagon** for a required Base side & name it as **A, B… E** by using **SINGLE LINE TEXT** from **ANNOTATION** Tool bar.
- Use **EXPLODE** command to explode the **Pentagon**.
- Use **EXTEND** command to extend the line **C B** for the given base length & mark the point as **1.**
- **EXTEND** the line **D C** twice the base length & mark the point **2**.
- **EXTEND** the line **E D** thrice the base length & mark the point **3.**

Procedure for Drawing Involute of a Pentagon

- **EXTEND** the line **A E** Four times the base length & mark the point **4**.
- **EXTEND** the line **B A** Five times the base length & mark the point **5**.
- Use **SPLINE fit** command to connect the points **A,1,2,…5** to fetch a **INVOLUTE** of a **PENTAGON**.
- Mark the dimension by using **ANNOTATION** Tool bar.

Archimedean Spiral



Procedure for Drawing Archimedean Spiral for One & Half Revolutions

- Initial setup of workspace **Drafting & Annotation** Mode
  - Type UN or **UNITS**
  - Set the Precision for **0**
  - Set the Units in Millimeters
- Type **LIMITS** Press Enter
  - Specify the Lower Left Corner as **0,0** Press Enter
  - Specify the Upper Right Corner as **210,297** Press Enter
- Type **ZOOM** Press Enter
- Type **ALL** Press Enter

- Draw a Concentric circles for given Minimum & Maximum diameters & divide into **8 (1,2…8)** equal parts & draw the lines from Center to Extreme End of Maximum diameter circle.
- Divide the line lying horizontally in between the Minimum & Maximum circle into **(8+4) 12** equal parts & name the points **1, 2, ….12** for getting a **One** & **Half** Revolution of the **SPIRAL**.
- From the **ARC** command select **Center Start End** , Draw an arc with **CENTER** point is **O** , **START** point is **1** (which is lying in the line between the circles) **END** point is **First division** of the Concentric circles.

- Repeat the above by changing the **START** points (**2, 3,… 8** which is lying in the line between the circles) & **END** points (**2, 3,…** second, third,….eighth division of the concentric circles.
- For the remaining divisions which is lying in the line between the circles **START** point is **9, 10, 11** & **12** & **END** points is **First, Second Third** & **Fourth** Divisions of the Concentric Circles.
- Use the **SPLINE FIT** command to connect from center of the circle to the ends of the arcs for obtaining the **Archimedean Spiral** for **One** & **Half** Revolutions.

REFERENCE BOOKS

- JEYAPOOVAN T, “ENGINEERING GRAPHICS AND DESIGN”, 2023, Vikas Publishing House Pvt Ltd,
- K.V.NATARAJAN, “Engineering Graphics”, 2015, Dhanalakshmi Publishers.