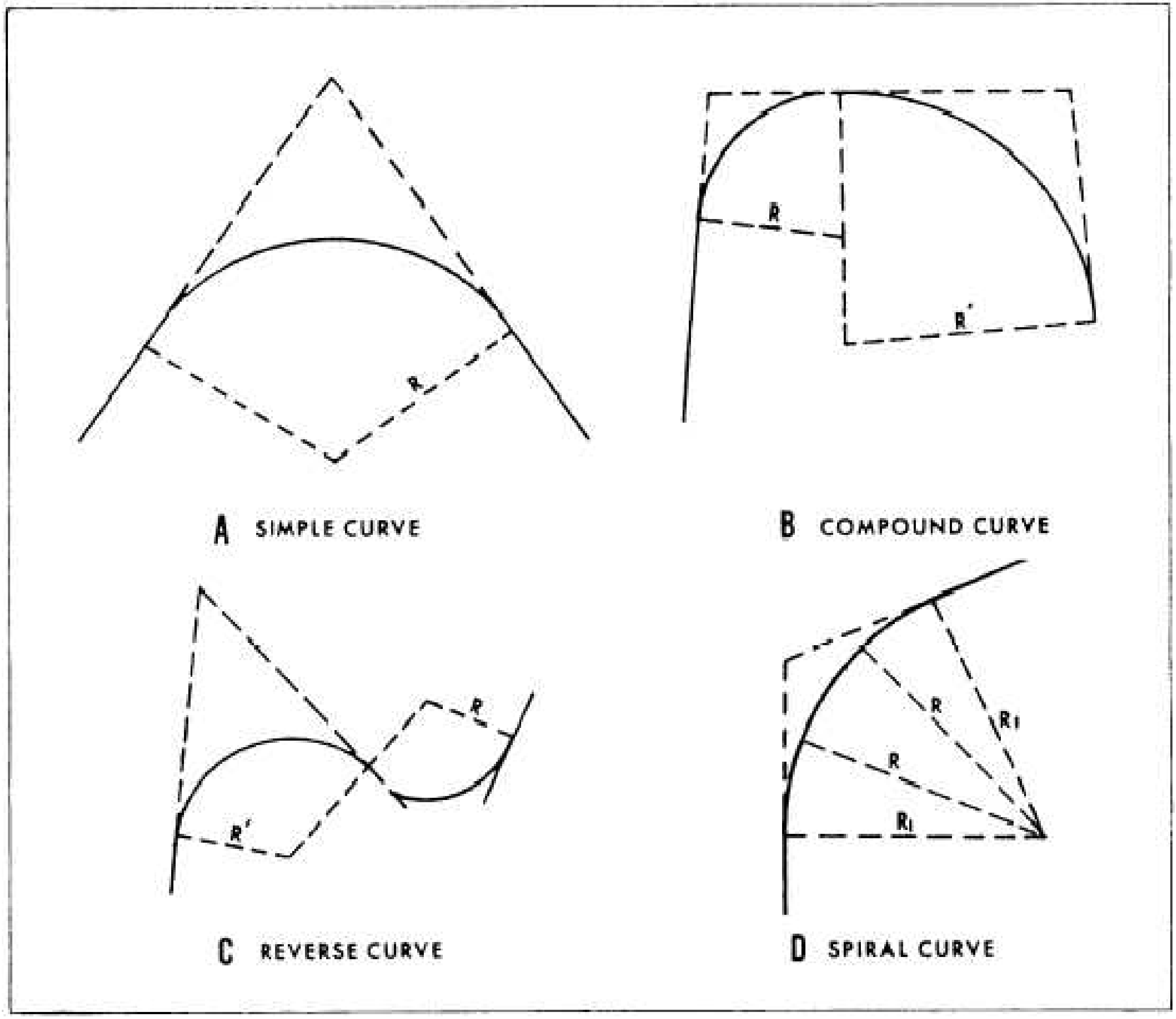
# HORIZONTAL CURVES

# TYPES OF HORIZONTAL CURVES




A SIMPLE CURVE

B COMPOUND CURVE

C REVERSE CURVE

D SPIRAL CURVE

# TYPES OF HORIZONTAL CURVES

1. SIMPLE. The simple curve is an arc of a circle. The radius of the circle determines the sharpness or flatness of the curve.

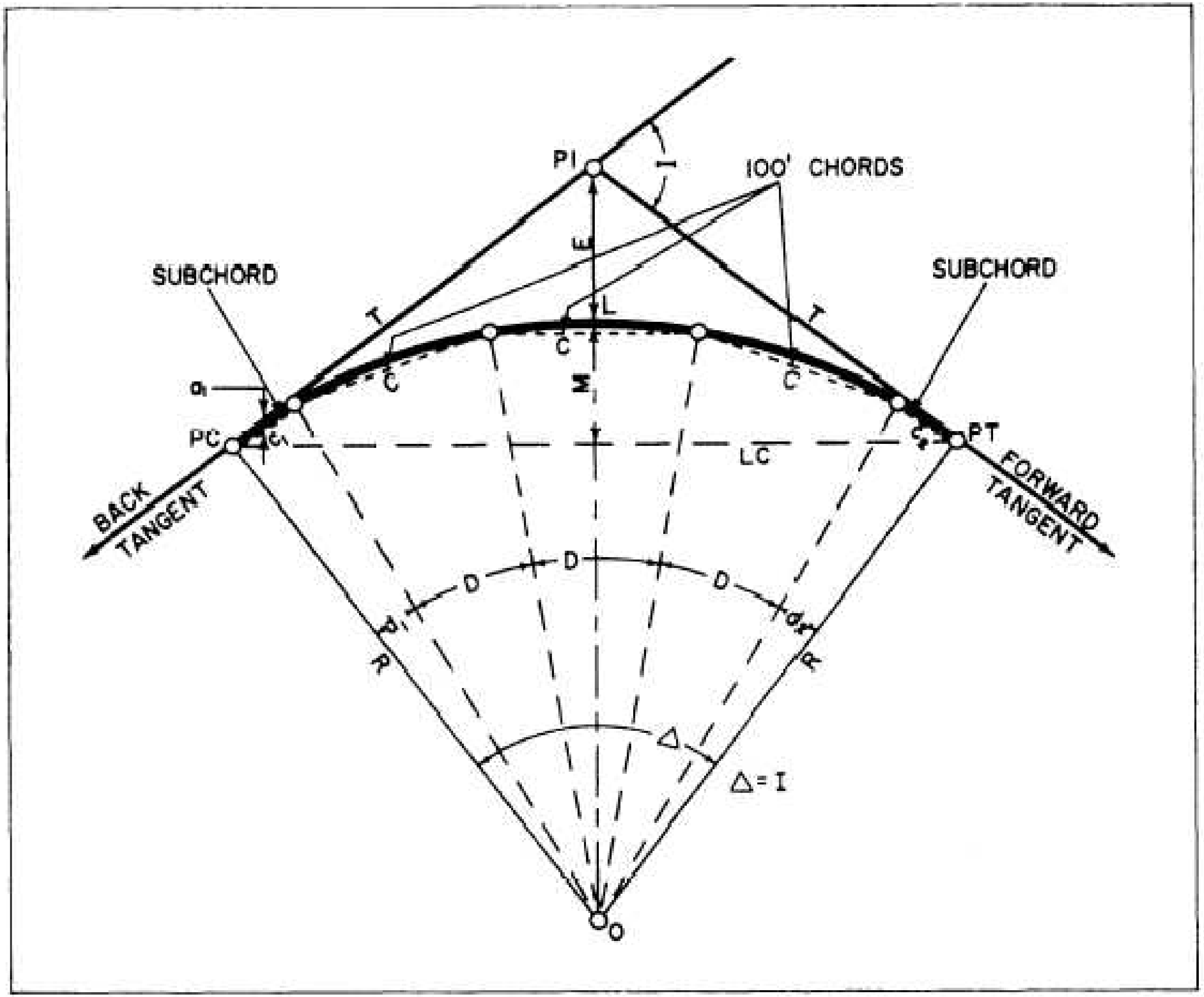
2. COMPOUND. Frequently, the terrain will require the use of the compound curve. This curve normally consists of two simple curves joined together and curving in the same direction.

# TYPES OF HORIZONTAL CURVES

3. REVERSE. A reverse curve consists of two simple curves joined together, but curving in opposite direction. For safety reasons, the use of this curve should be avoided when possible.

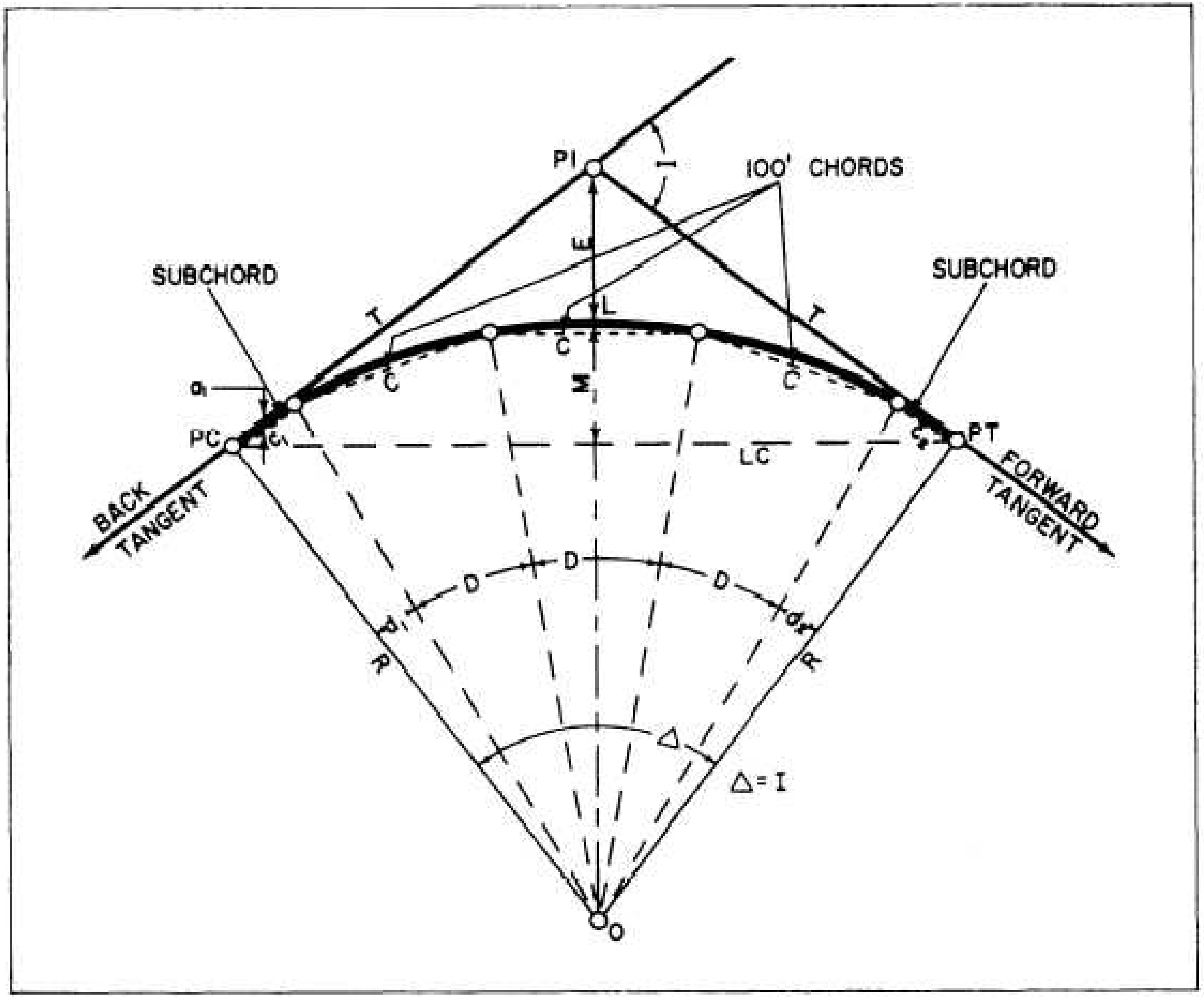
4. SPIRAL. The spiral is a curve that has a varying radius. It is used on railroads and most modern highways. Its purpose is to provide a transition from the tangent to a simple curve or between simple curves in a compound curve.

# ELEMENTS OF A HORIZONTAL CURVE



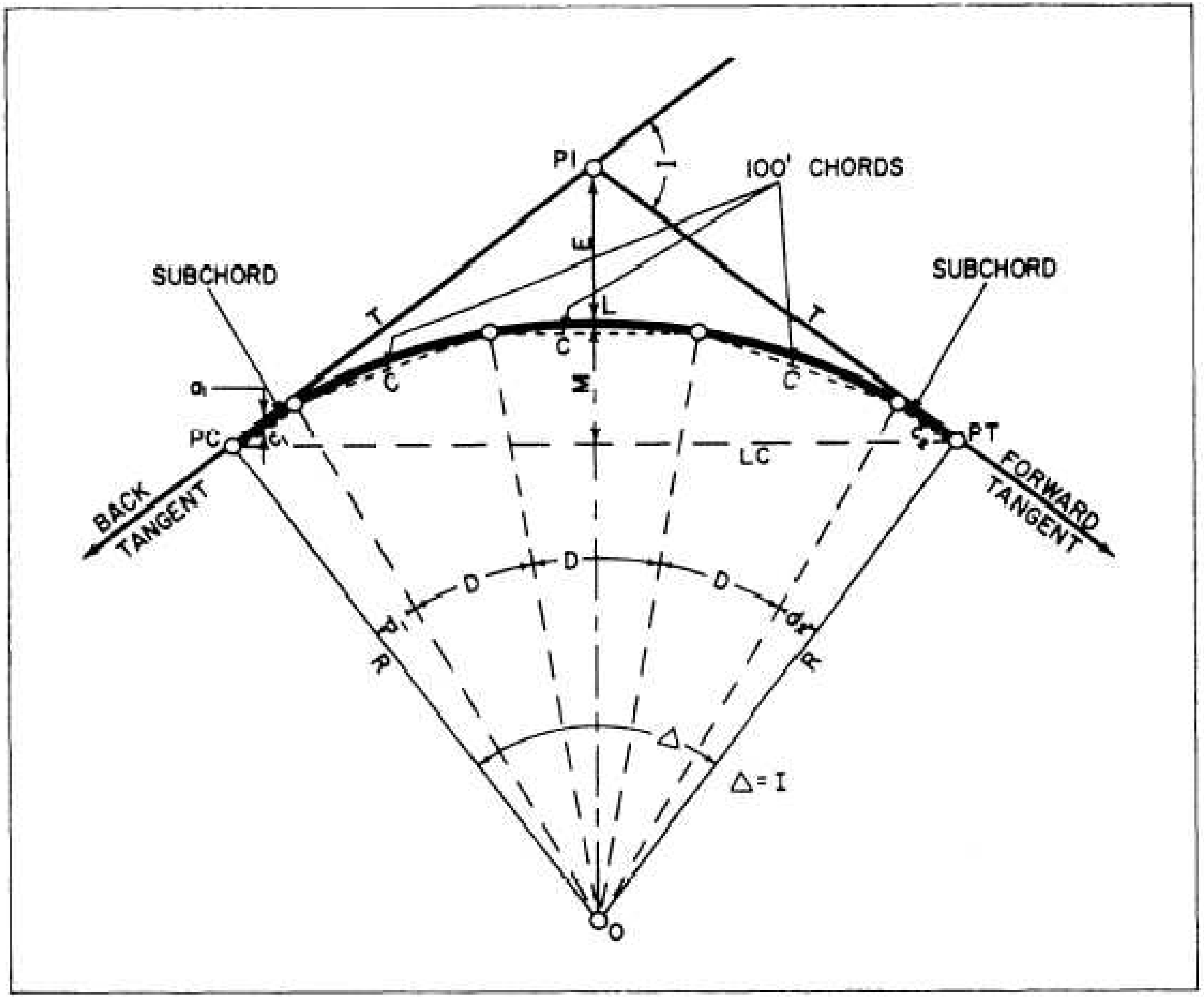
- (**PI**) **POINT OF INTERSECTION**. The point of intersection is the point where the back and forward tangents intersect. Sometimes, the point of intersection is designated as V (vertex).
- (**I**) **INTERSECTING ANGLE**. The intersecting angle is the deflection angle at the PI. Its value is either computed from the preliminary traverse angles or measured in the field.
- (**A**) **CENTRAL ANGLE**. The central angle is the angle formed by two radii drawn from the center of the circle (O) to the PC and PT. The value of the central angle is equal to the I angle.
  Some authorities call both the intersecting angle and central angle either I or A.
- (**R**) **RADIUS**. The radius of the circle of which the curve is an arc, or segment. The radius is always perpendicular to back and forward tangents.

# ELEMENTS OF A HORIZONTAL CURVE



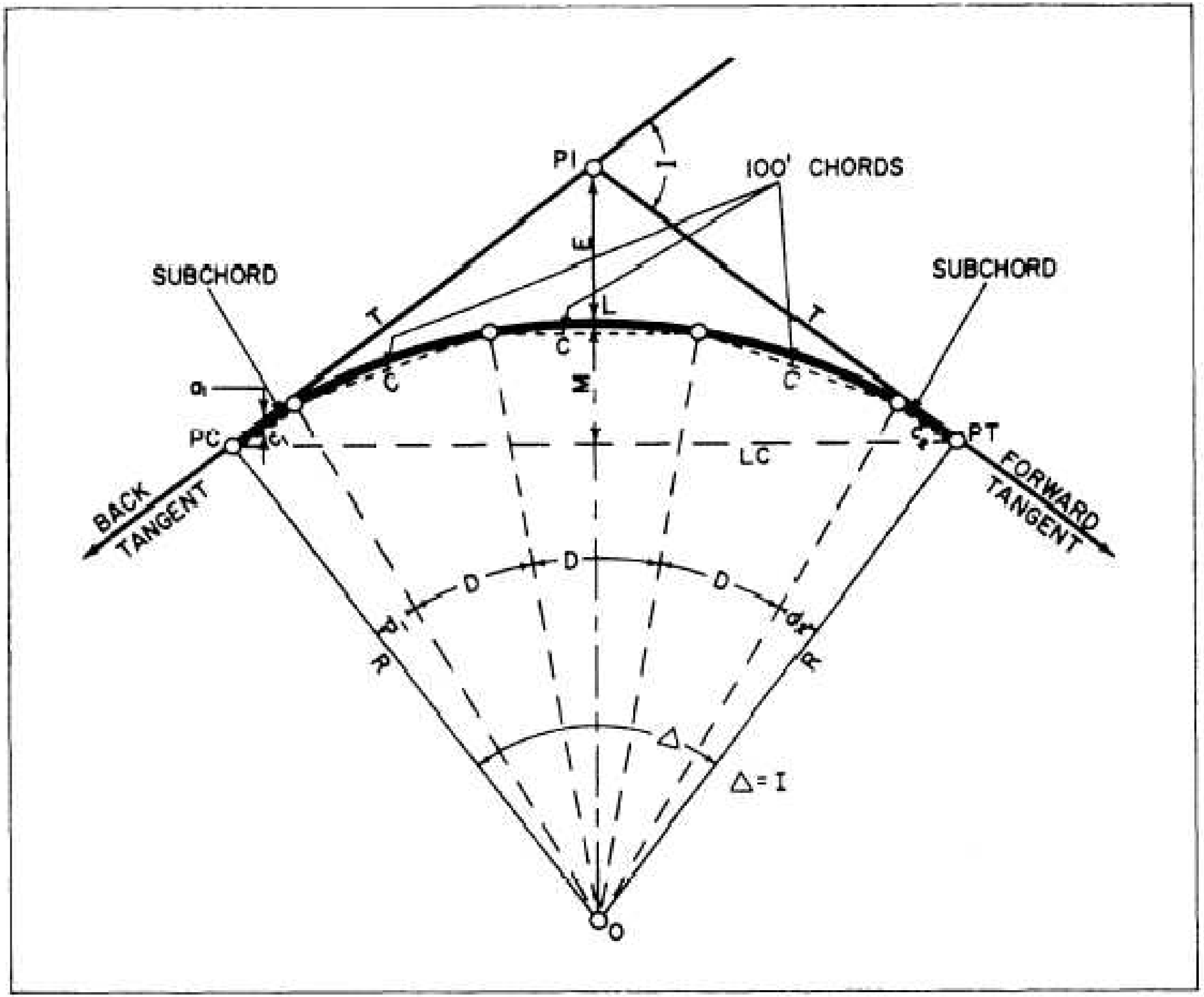
- (**PC**) **POINT OF CURVATURE**. The point of curvature is the point on the back tangent where the circular curve begins. It is sometimes designated as BC (beginning of curve) or TC (tangent to curve).
- (**PT**) **POINT OF TANGENCY**. The point of tangency is the point on the forward tangent where the curve ends. It is sometimes designated as EC (end of curve) or CT (curve to tangent).
- (**POC**) **POINT OF CURVE**. The point of curve is any point along the curve.
- (**L**) **LENGTH OF CURVE**. The length of curve is the distance from the PC to the PT, measured along the curve.
- (**T**) **TANGENT DISTANCE**. The tangent distance is the distance along the tangents from the PI to the PC or the PT. These distances are equal on a simple curve.

# ELEMENTS OF A HORIZONTAL CURVE



- (**LC**) **LONG CHORD**. The long chord is the straight-line distance from the PC to the PT. Other types of chords are designated as follows:
- (**C**) The **full chord distance** between adjacent stations (full, half, quarter, or one- tenth stations) along a curve.
- (**$c_1$**) The **subchord** distance between the PC and the first station on the curve.
- (**$c_2$**) The **subchord** distance between the last station on the curve and the PT.

# ELEMENTS OF A HORIZONTAL CURVE

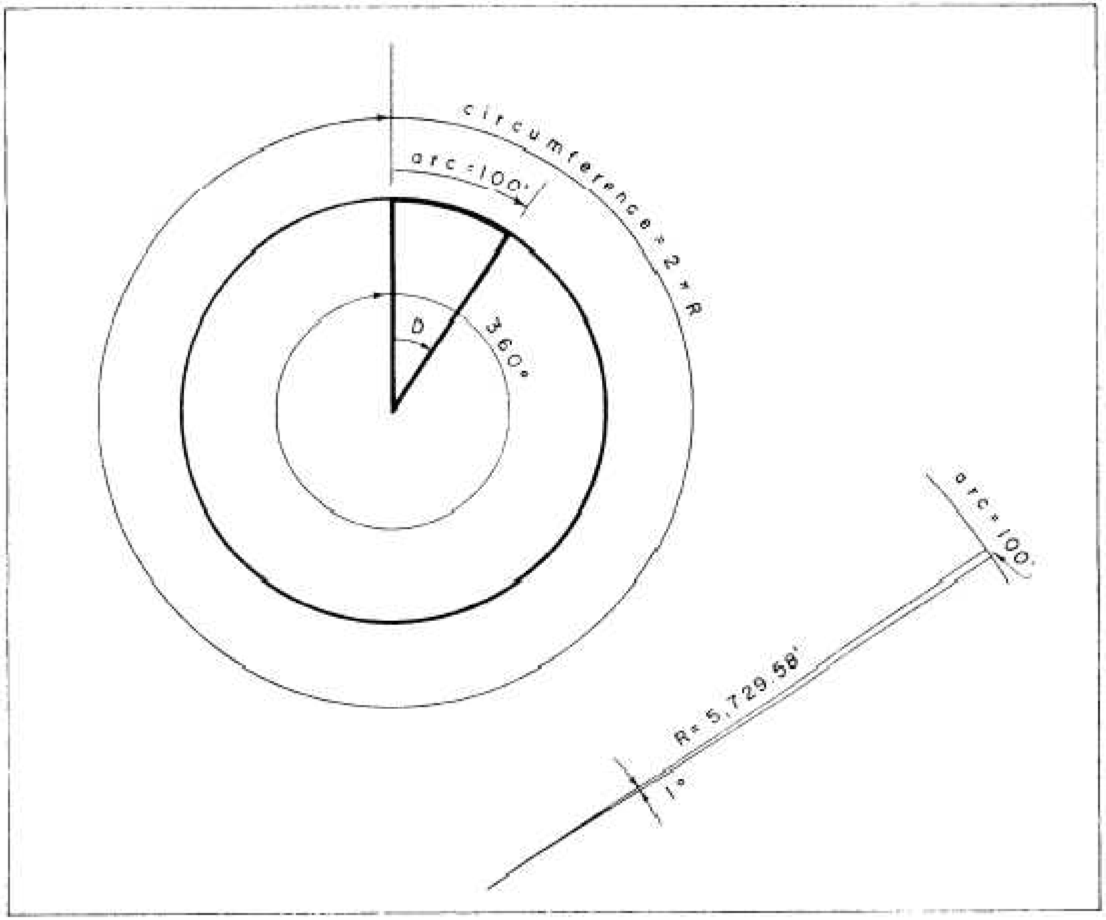


- (**E**) **EXTERNAL DISTANCE**. The external distance (also called the external secant) is the distance from the PI to the midpoint of the curve. The external distance bisects the interior angle at the PI.
- (**M**) **MIDDLE ORDINATE**. The middle ordinate is the distance from the midpoint of the curve to the midpoint of the long chord. The extension of the middle ordinate bisects the central angle.
- (**D**) **DEGREE OF CURVE**. The degree of curve defines the sharpness or flatness of the curve.

# DEGREE OF CURVATURE

- Curvature may be expressed by simply stating the length of the radius of the curve.
- For highway and railway work, however, curvature is expressed by the degree of curve.
- Two definitions are used for the degree of curve.

# Degree of Curve (Arc Definition)




- most frequently used in high-way design

# Degree of Curve (Arc Definition)

$$\frac{D}{360^\circ} = \frac{100}{C}.$$

Since the circumference of a circle equals $2\pi R$, the above expression can be written as:

$$\frac{D}{360^\circ} = \frac{100}{2\pi R}.$$

Solving this expression for R:

$$R = \frac{5729.58}{D}$$

and also D:

$$D = \frac{5729.58}{R}.$$

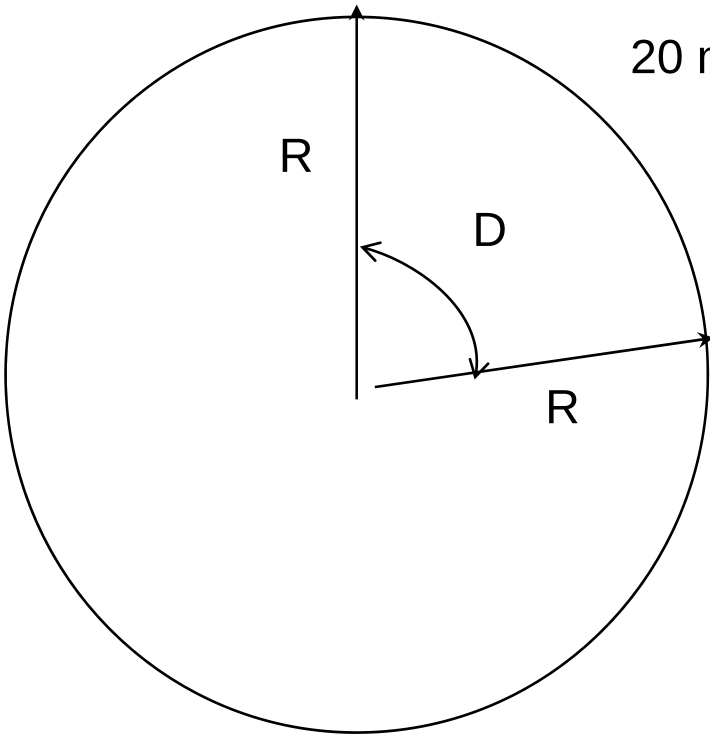
For a 1° curve, D = 1; therefore R = 5,729.58 feet.

# Degree of Curve (Arc Definition)

- Metric System

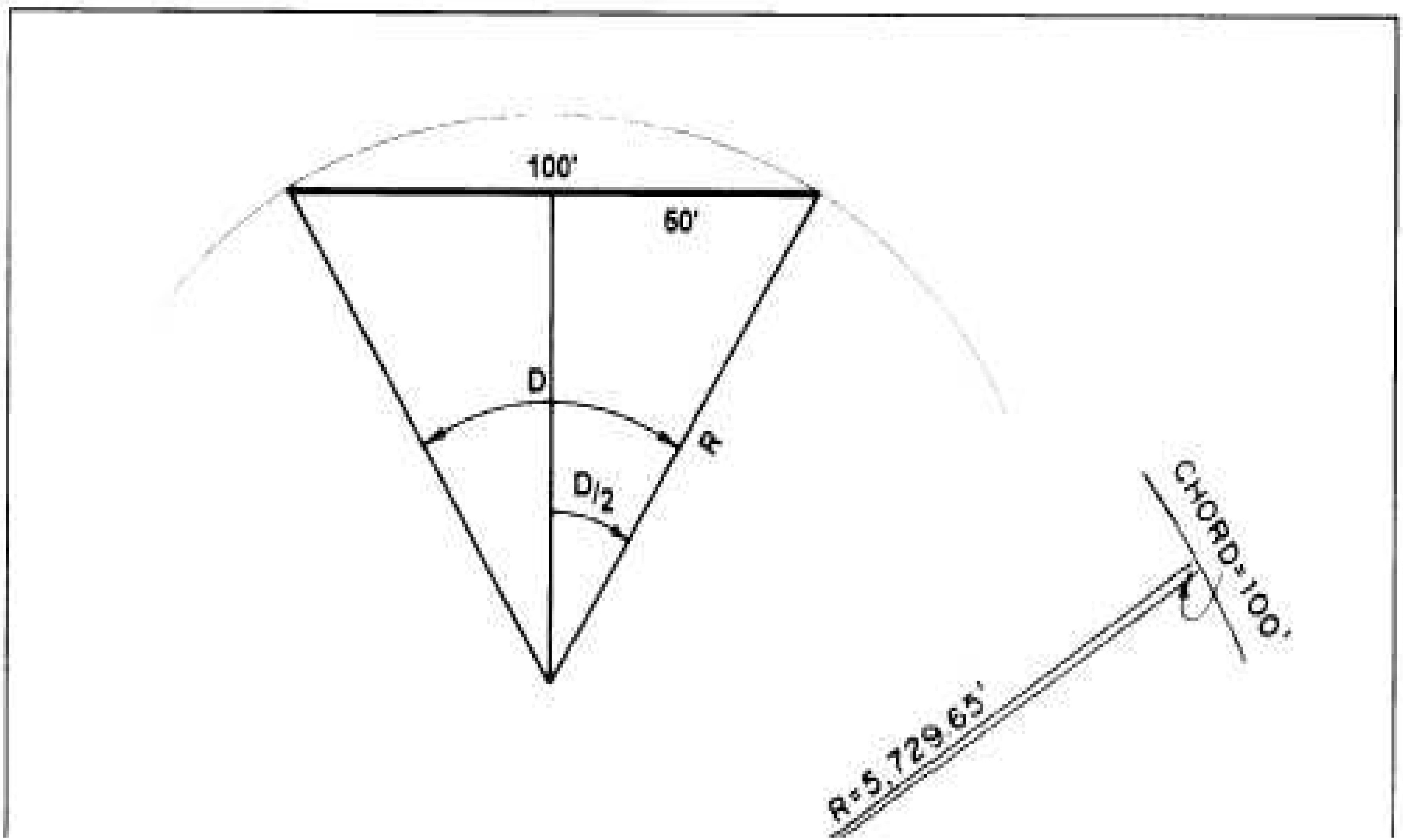
$$\frac{20}{D} = \frac{2\pi R}{360}$$

$$D = \frac{1145.916}{R}$$



***In practice the design engineer usually selects the degree of curvature on the basis of such factors as the design speed and allowable superelevation. Then the radius is calculated.***

# Degree of Curve (Chord Basis)



# Degree of Curve (Chord Basis)

$$\sin\left(\frac{D}{2}\right) = \frac{50}{R}.$$

Then, solving for R:

$$R = \frac{50}{\sin \frac{1}{2} D}.$$

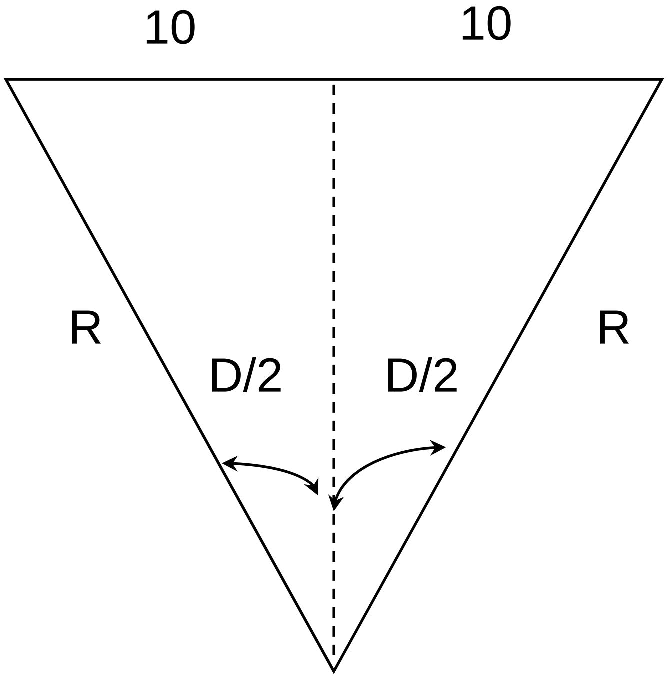
For a 10 curve (chord definition), D = 1; therefore R = 5,729.65 feet, or meters, depending upon the system of units you are using.

# Degree of Curve (Chord Basis)

- Metric System

$$\sin\frac{D}{2} = \frac{10}{R}$$

$$R = \frac{10}{\sin D/2}$$



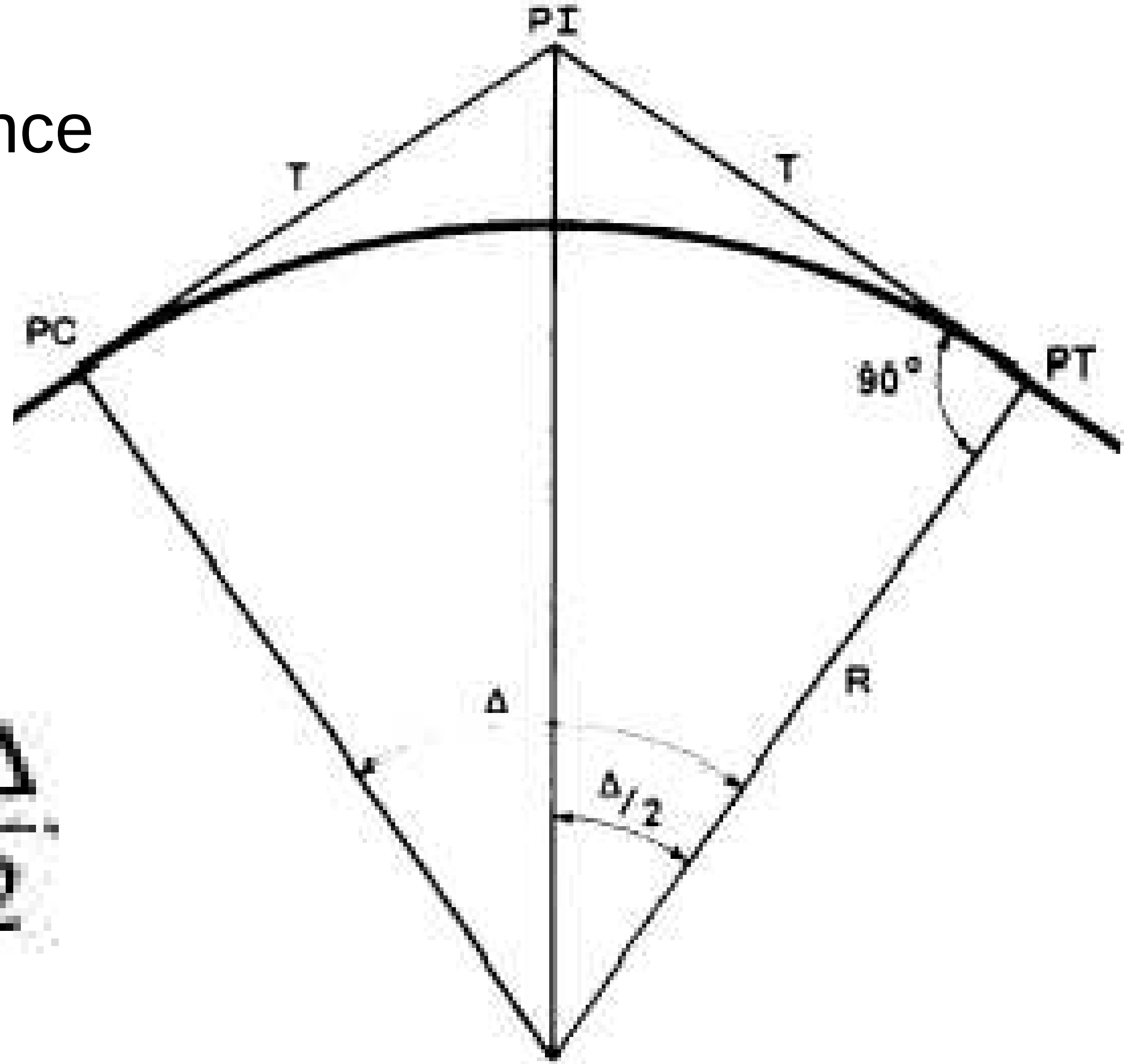
# CURVE FORMULAS

- Tangent Distance

$$\tan\frac{\Delta}{2}=\frac{T}{R}$$

and solving for T

$$T=R\tan\frac{\Delta}{2}.$$



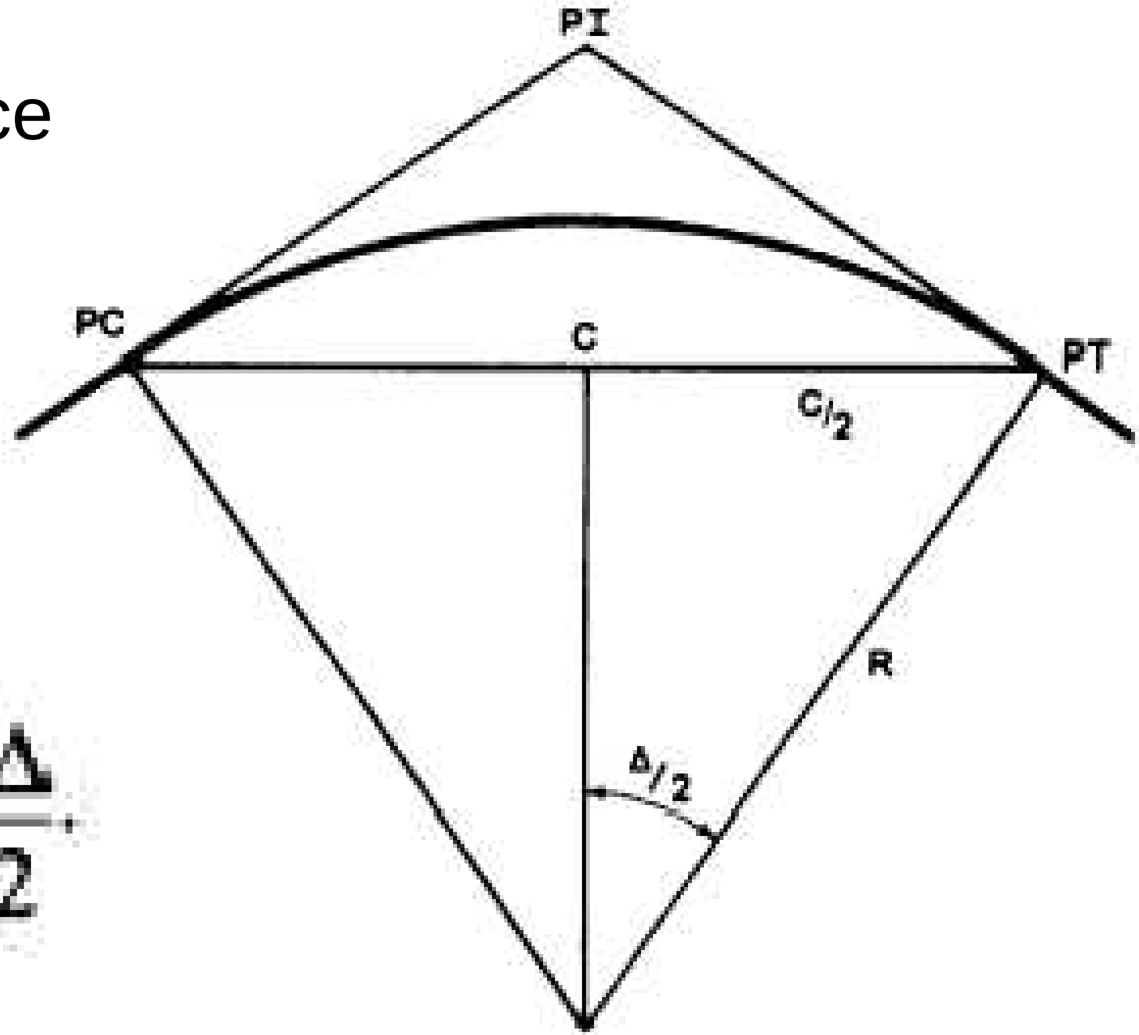
# CURVE FORMULAS

- Chord Distance

$$\sin\frac{\Delta}{2} = \frac{C/2}{R}$$

and solving for C

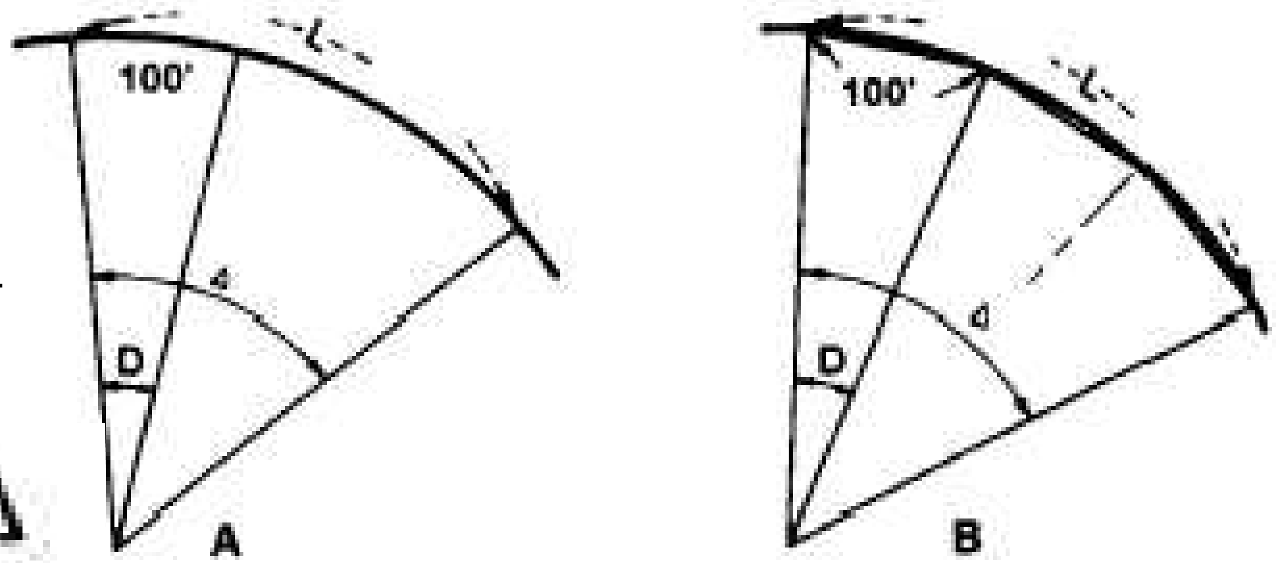
$$C = 2R\sin\frac{\Delta}{2}.$$



# CURVE FORMULAS

- Length of Curve

$$\frac{L}{100} = \frac{\Delta}{D}.$$




Then, solving for L

$$L = 100\,\frac{\Delta}{D}.$$

# CURVE FORMULAS

- Middle Ordinate and External Distance

$$M = R\left(1 - \cos\frac{\Delta}{2}\right)$$

$$E = T\tan\frac{\Delta}{4} = R\left(\frac{1}{\cos \Delta/2} - 1\right).$$