Constraint-based Sketchers:

• 2D profile geometry not explicitly defined, but rather driven by the constraints.
• Constraints stored internally as equations.
• Equations are solved to resolve the sketch geometry.
Constrained Sketches

- Sketches are 2D.
- They exist within an XY plane frequently referred to as the “sketch plane”.
- Within the sketcher, point locations are not constrained.
- Rather they have a temporary value.
Constrained Sketches

• Similarly, relationships between entities are not fixed.
  – (despite display, two lines may not be parallel, perpendicular, etc.)
• Point locations represent degrees of freedom of the sketch.
• We may think of them as the “unknowns” which have to be found to “solve” the sketch.
Constrained Sketches

- Each point in sketch has 2 dof
- Line segment has 4 dof
- Simple closed piecewise linear loop of “n” vertices has 2n dof
- Loop of “n” vertices has “n” segments
  - Why doesn’t loop have 4n dof?
  - Endpoint continuity means coincidence which removes 1 dof per vertex
Constrained Sketches

- The sketch shown would then have unknowns of an x and a y coordinate for each of 4 points.
- Therefore there exist 8 d.o.f (degrees of freedom) or 8 unknown values.
Constrained Sketches

- Constraints are applied to the sketch to “solve” for these unknowns.

- Constraints may be dimensional or geometric. Both are applied as equations.
Dimensional constraints

• Input in form of a dimension
• e.g. linear, angular, diametric, radial
• Applied as an equation
  For example, linear dimension between points P1 and P2:
  \[ L = \sqrt{(x1-x2)^2 + (y1-y2)^2} \]
• Dimension drives the geometry
  e.g. vary value for L, position of endpoint changes
Geometric Constraints

• Input as a relationship between entities or applied to an entity
  e.g. a line is parallel to another, an arc is tangent to a line

• Applied as an equation
  For example for a horizontal line AB
  \[ Y_A = Y_B \]

• Some geometric constraints may be inferred and created by the system during entity creation.
Geometric Constraints

• Examples of geometric constraints:
  – parallelism, co-linearity, perpendicularity, equal length/angle/diameter/radius, horizontal, vertical
  – concentric arcs/circles, horizontal, vertical, parallel, tangent
Constrained sketch

• One point within the sketch must be invariant.
  – e.g. fixed position
Constrained sketch

• Setting invariant point may be accomplished (for example)
  – by dimensionally constraining a location to the solid,
  – by geometrically “fixing” a location
  – by geometrically forcing a line on the sketch
Constrained sketch

• Adding constraints provides information to “solve” for point positions and hence shape
• For example, geometric constraints may be applied to force lines Horizontal and Vertical
Constrained sketch

- Dimensional constraints may be applied to control feature size.
Solving constraint equations

- Set of constraint equations solved to define a solution profile.
- Equations may be solved sequentially
  - referred to as “parametric system”
  - results of each previous solution used in next
- Equations may be solved simultaneously
  - referred to as “variational system”
- In practice, many systems use a combination of both techniques