

Engineering Sketch Pad (ESP) Training

Session 2: Sketching Fundamentals

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Overview

- Introduction
- Creating a Sketch
- Editing an existing Sketch
- Image manipulation in the Sketcher
- Sketching Best Practices
- Hands-on exercises
 - U-shaped bracket (version 1)
 - U-shaped bracket (version 2)
 - oval
 - bi-convex airfoil (with arcs)
 - swivel base
 - V-slide plate
 - bi-convex airfoil (with splines)
 - fuselage cross-section (with Beziers)



Introduction

- A Sketch is a two-dimensional figure that can be used:
 - in grown primitives, such as extrude, rule, blend, and revolve
 - to create a non-manifold Sheet Body
 - to create a non-manifold Wire Body (if open)
- Sketches are defined in terms of:
 - Segments
 - Sketch variables (and their initial values)
 - Constraints



Steps to Creating a Sketch

- 1 Define the Design Parameters
- 2 Create an empty Sketch
- 3 Draw the Segments
- 4 Constrain the Sketch
- 5 Solve the Sketch



Creating a Sketch

Step 1: Define the Design Parameters

- Press **Design Parameters** in the Tree window to create each of the Design Parameters
- Most Design Parameters are a scalar, so that they have only 1 row and 1 column
- Enter nominal value(s) in the box(es) that appears
- Press **OK** to proceed
- Repeat as needed



Creating a Sketch

Step 2: Create an Empty Sketch

- Press **Branches** in the Tree window to create a sketch Branch
 - coordinates should be specified at one point on the boundary of the Sketch
 - coordinates can be defined in terms of a Design Parameter
- A sketch is automatically created for you
- The Sketcher is entered automatically



Creating a Sketch

Step 3: Draw the Segments (1)

- Start drawing the Sketch at the point defined in the skbeg Branch
 - **X** and **Y** Constraints are automatically generated at the initial point
 - these constraints cannot be deleted
- Draw the Segments by proceeding counter-clockwise around the Sketch (which is consistent with the right-hand rule pointing out of the screen)
- Line between previous point and cursor shows proposed position of next Segment
 - blue is default color
 - if drawn in orange, a vertical (V) or horizontal constraint (H) will be added automatically



Creating a Sketch

Step 3: Draw the Segments (2)

- Supported Segment types include:
 - (straight) line Segment
 - **I** or **L** or mouse click
 - (circular) arc Segment
 - **c** or **C**
 - Segment turns red until you press the mouse button to set its approximate radius
 - cubic spline
 - **s** or **S**
 - cubic splines are shown only as straight line Segments in the Sketcher
 - Bezier curve control points
 - **b** or **B**
 - ...



Creating a Sketch

Step 3: Draw the Segments (3)

- Supported Segment types include:
 - zero-length Segment
 - **z** or **Z**
 - constraints automatically set
 - leave Sketch open (and switch mode to “Constraining...”)
 - **o** or **O**
- When Sketch is closed, its interior is filled with gray (and the mode is switched to “Constraining...”)
- Pressing the **Undo** button will remove the last Segment



Creating a Sketch

Step 4: Constrain the Sketch (1)

- As many constraints (**ncon**) must be defined as there are degrees of freedom (**ndof**) in the Sketch
 - these values are listed in the Key window
 - the fill turns to light green when they match (**ncon=ndof**)
 - having them match is necessary, but not sufficient, for a Sketch to be properly constrained



Creating a Sketch

Step 4: Constrain the Sketch (2)

- Constraints that can be applied to Segments:
 - set the Segment's length
 - **l** or **L**
 - make the Segment horizontal ($y_{\text{beg}} = y_{\text{end}}$)
 - **h** or **H**
 - might be automatically created if Segment was orange when created
 - make the Segment vertical ($x_{\text{beg}} = x_{\text{end}}$)
 - **v** or **V**
 - might be automatically created if Segment was orange when created
 - set the inclination in degrees (measured counter-clockwise from the right horizontal)
 - **i** or **I**



Creating a Sketch

Step 4: Constrain the Sketch (3)

- Constraints that can be applied to circular arcs:
 - acute radius (positive if convex when drawing counter-clockwise)
 - **r** or **R**
 - X-coordinate at arc center
 - **x** or **X**
 - Y-coordinate at arc center
 - **y** or **Y**
 - sweep angle in degrees (positive if convex when drawing counter-clockwise)
 - **s** or **S**



Creating a Sketch

Step 4: Constrain the Sketch (4)

- Constraints that can be applied to points:
 - specify X -coordinate
 - x or X
 - specify Y -coordinate
 - y or Y
 - adjacent Segments are perpendicular
 - p or P
 - adjacent Segment are tangent (parallel)
 - t or T
 - turning angle between adjacent Segments in degrees (positive if turning to the left)
 - a or A



Creating a Sketch

Step 4: Constrain the Sketch (5)

- Constraints that can be applied to a pair of points:
 - specify width ($x_{\text{end}} - x_{\text{beg}}$) between two points
 - **w** or **W**
 - if first point is toward the left, a positive value should be specified
 - if first point is toward the right, a negative value should be specified
 - specify depth ($y_{\text{end}} - y_{\text{beg}}$) between two points
 - **d** or **D**
 - if first point is toward the bottom, a positive value should be specified
 - if first point is toward the top, a negative value should be specified



Creating a Sketch

Step 4: Constrain the Sketch (6)

- Other options:
 - remove Constraints
 - <
 - if more than one constraint is present, you are asked which constraint to remove
 - inquire about constraints at current point or Segment
 - ?
- Pressing the **Undo** button will remove/restore the last constraint



Creating a Sketch

Step 4: Constrain the Sketch (7)

- Special shortcuts
 - `::L[i]` is the length of the Segment i
 - `::I[i]` is the inclination of Segment i (in degrees)
 - `::R[i]` is the radius of CIRARC Segment i
 - `::S[i]` is the sweep of CIRARC Segment i (in degrees)
- Segment numbers can be determined by pressing `?` near the center of a Segment



Creating a Sketch

Step 4: Constrain the Sketch (8)

- If you need help during the constraint process
 - Press the yellow **Constraining...** button
- Redundant constraints are shown in red
 - Use the < key to remove a redundant constraint
- Suggested new constraints are shown in green
 - Add the constraint using a key that matches the hint



Creating a Sketch

Step 5: Solve the Sketch

- Press **Press to Solve**
 - if successful, Sketch will change on screen
 - if unsuccessful, read about error in Messages window to help you diagnose the problem
- Press **Sketch**→**Save** to return to normal (non-Sketching) mode
- Press **Press to Re-build** to see the completed Sketch



Editing an Existing Sketch

- Select one of the Branches between the `skbeg` and `skend` Branches (inclusive) and press **Enter Sketcher**
- Follow directions given above



Deleting an Existing Sketch

- Select each of the Branches between the skbeg and skend and press **Delete Branch** for each. Then delete the skend and skbeg Branches.
- Select the skbeg Branch and press **Delete Branch** (to delete whole sketch at once)



Image Manipulation in the Sketcher

- Recenter Sketch
 - **Ctrl-h** key or **H** button
- Move the Sketch to the left
 - **Ctrl-l** key or **L** button or ← key
- Move the Sketch to the right
 - **Ctrl-r** key or **R** button or → key
- Move the Sketch to the bottom
 - **Ctrl-b** key or **B** button or ↓ key
- Move the Sketch to the top
 - **Ctrl-t** key or **T** button or ↑ key
- Zoom in
 - **Ctrl-i** key or **PgUp** key or + button
- Zoom out
 - **Ctrl-o** key or **PgDn** key or - button



Sketching Best Practices

- Try to start the Sketch at a point with known coordinates
- Proceed around the sketch in a counter-clockwise direction
- Constrain the X -coordinate at one or more points (or arc centers)
- Constrain the Y -coordinate at one of more points (or arc centers)
- Specify the orientation of one or more Segments
 - this is sometimes done by specifying the coordinates of both ends
- Avoid redundancies, such as:
 - points at which angles are constrained and which are adjacent to Segments in which the inclination is constrained
 - dimensions specified for both a series of Segments as well as their combination



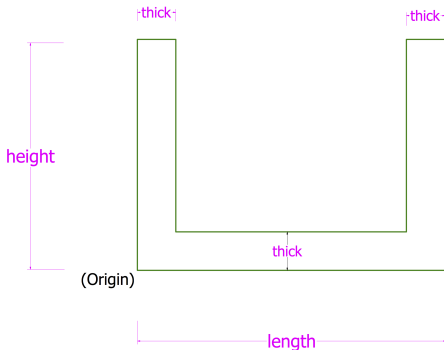
Hands-on Exercises

- U-shaped bracket (version 1)
- U-shaped bracket (version 2)
- oval
- bi-convex airfoil (with arcs)
- swivel base
- V-slide plate
- bi-convex airfoil (with splines)
- fuselage cross-section (with Beziers)



Example: U-bracket (version 1)

Hint: move mouse until blue line turns orange to automatically generate horizontal and vertical constraints



Measurements

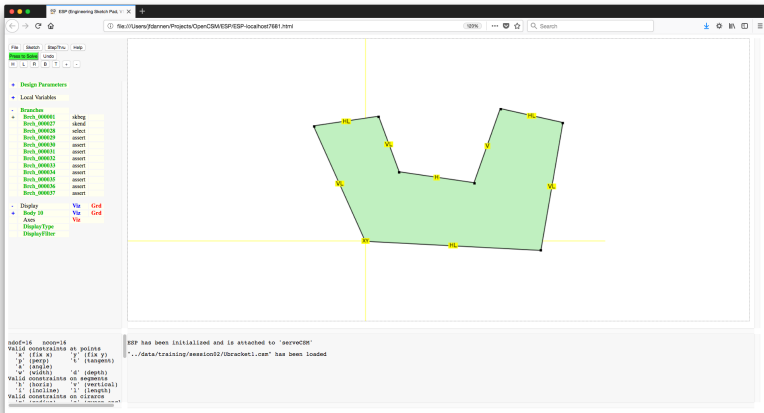
length = 4.00

height = 3.00

thick = 0.5



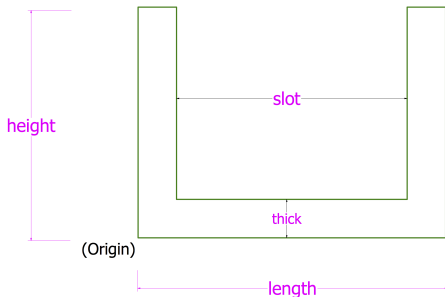
Solution: U-bracket (version 1)





Example: U-bracket (version 2)

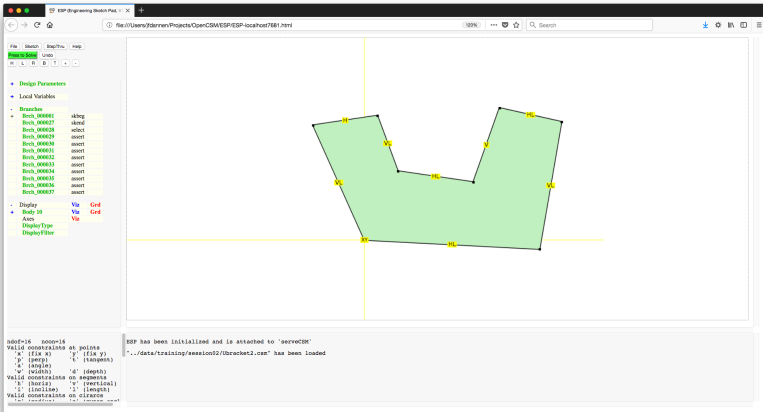
Hint: You can specify the length of a Segment to be equal to Segment 5's length with `:L[5]` (where the Segment number can be obtained with the `"?"` command).



Measurements

length = 4.00
height = 3.00
thick = 0.5
slot = 2.00

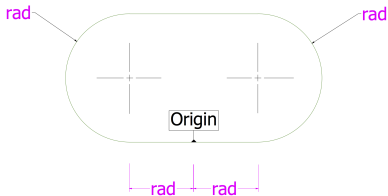
Note: slot
is centered





Example: Oval

Hint: tangency constraints may be useful for this case

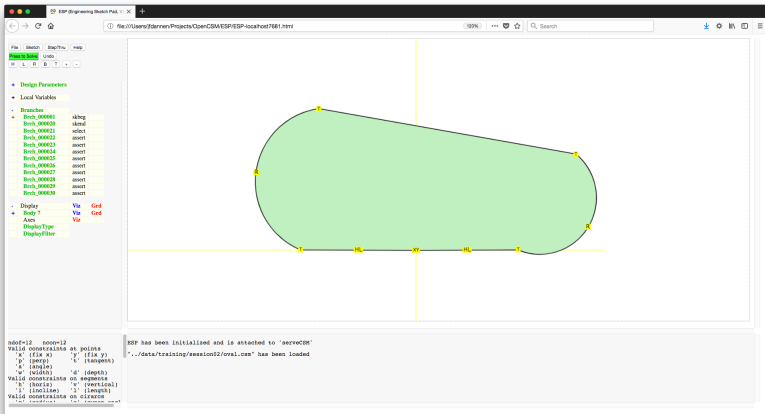


Measurements:

rad = 0.50



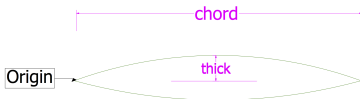
Solution: Oval (version 2)





Example: Biconvex airfoil (with arcs)

Hint: the `radius()` function can be used if one knows the bounding coordinates and the “dip” (see “Help” for details)



Measurements:

chord = 2.00

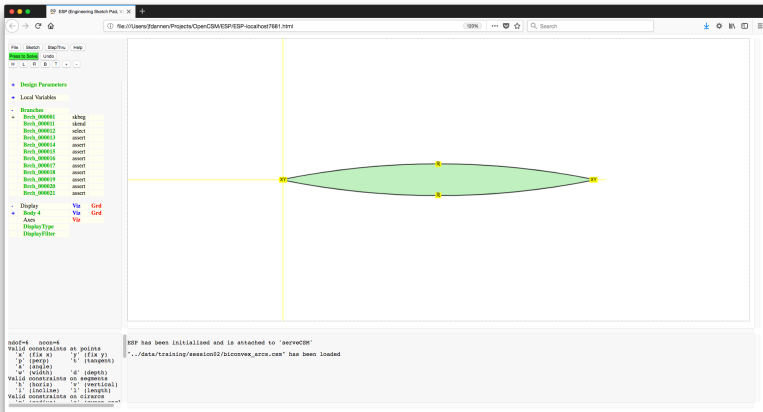
thick = 0.10

Note:

Circular Arcs



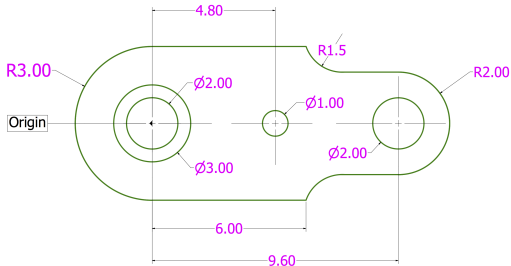
Solution: Biconvex airfoil (with arcs)





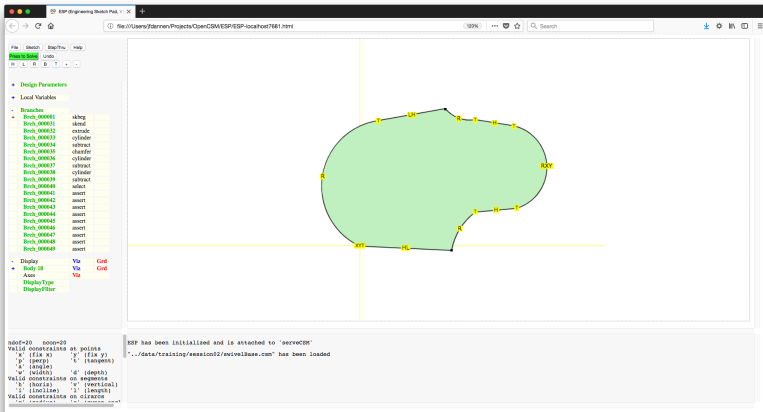
Example: Swivel Base

Hint: nested Sketches can be generated with a series of Sketches





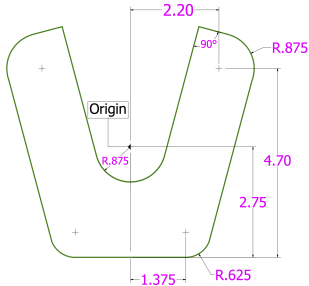
Solution: Swivel Base





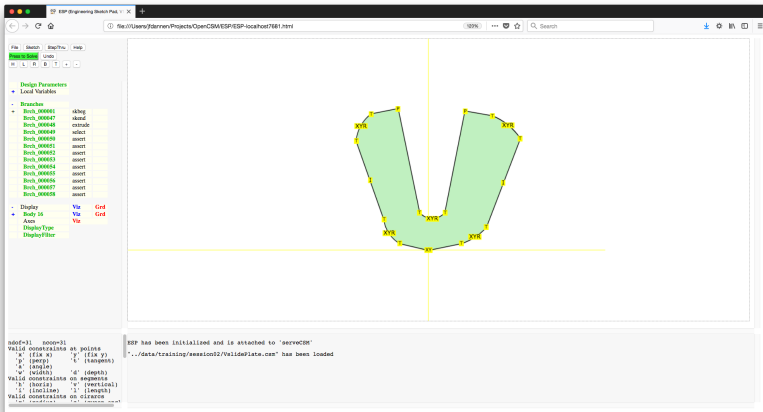
Example: V-slide Plate

Hint: to make Segments parallel, set an inclination Constraint (and see “Expression rules” in Help)





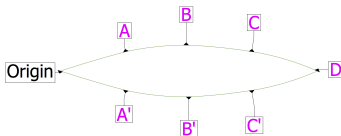
Solution: V-slide Plate





Example: Biconvex Airfoil (with splines)

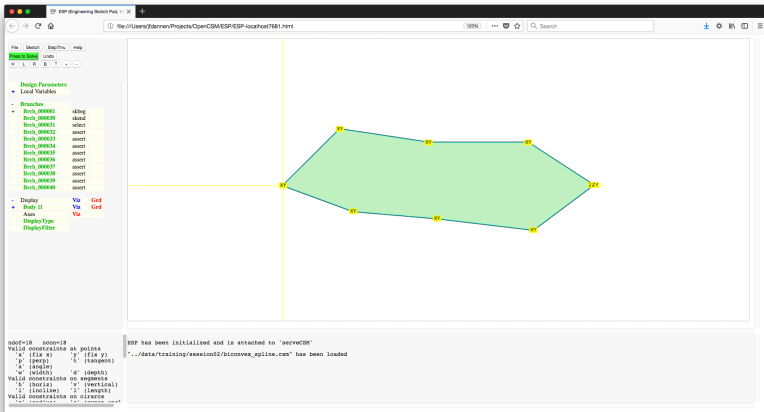
Hint: adjacent splines (with slope discontinuities) can be obtained by putting a zero-length line Segments between them



	x	y
A:	.255	.075
B:	.500	.100
C:	.745	.075
D:	1.00	0.00



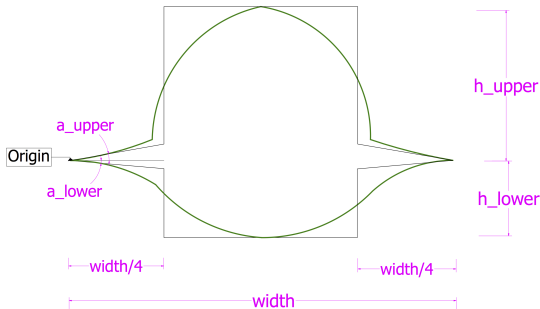
Solution: Biconvex Airfoil (with splines)





Example: Fuselage X-section (with Beziers)

Hint: the Bezier control points are constrained in the same way as any other point

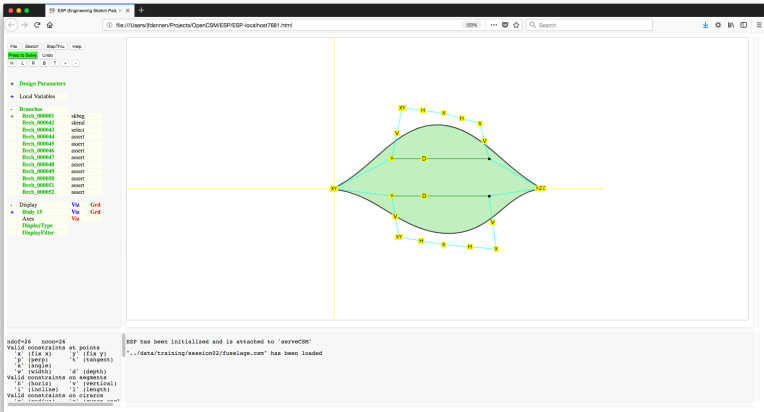


Measurements:

width = 5.00
h_upper = 2.00
h_lower = 1.00
a_upper = 10°
a_lower = 5°

Note:

4 Bezier Cubics





Muddy Cards

- What operations were most confusing to you?
- How easy was it for you to diagnose problems when they occurred?
- What operations would you like to see added to the Sketcher?
- ...