COMPUTER-AIDED ANALYSIS AND DESIGN MAE 292

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L3 CAD Workflows

3D rotations: Euler angles

- Many methods to represent rotations in 3D.
- 3D rotations do not commute (order matters).
- About the global frame —> z,y,x order common.

$$R_{total} = R_{x,\gamma} R_{y,\beta} R_{z,\alpha}$$

- About the local frame —> x,y,z

$$R = R_{z,\gamma} R_{y,\beta} R_{x,\alpha}$$

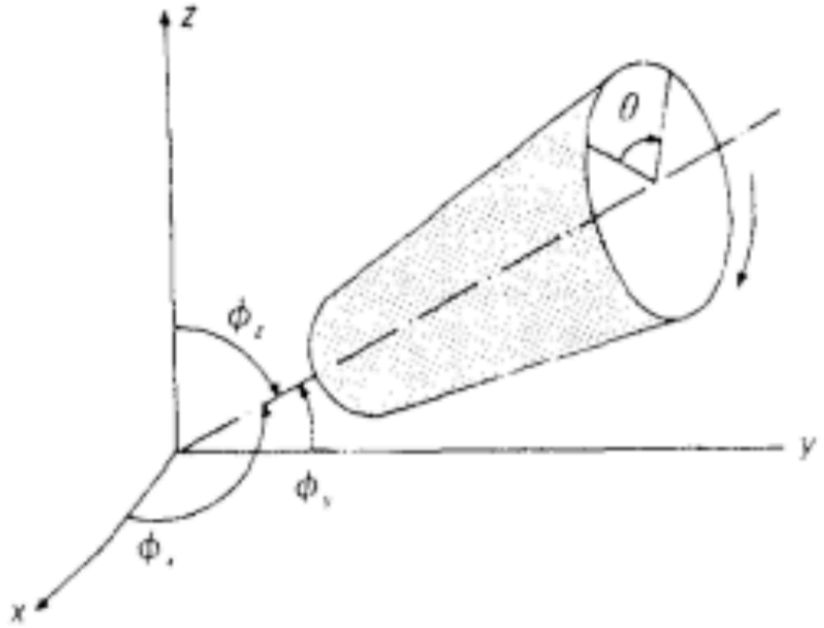
$$R_x(\theta) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix}$$

$$R_y(\theta) = \begin{bmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{bmatrix}$$

$$R_z(\theta) = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

3D rotations: axis angle

$$
\begin{aligned}
u_x &= \cos\left(\varphi_x\right) \\
u_y &= \cos\left(\varphi_y\right) \\
u_z &= \cos\left(\varphi_z\right)
\end{aligned}
$$



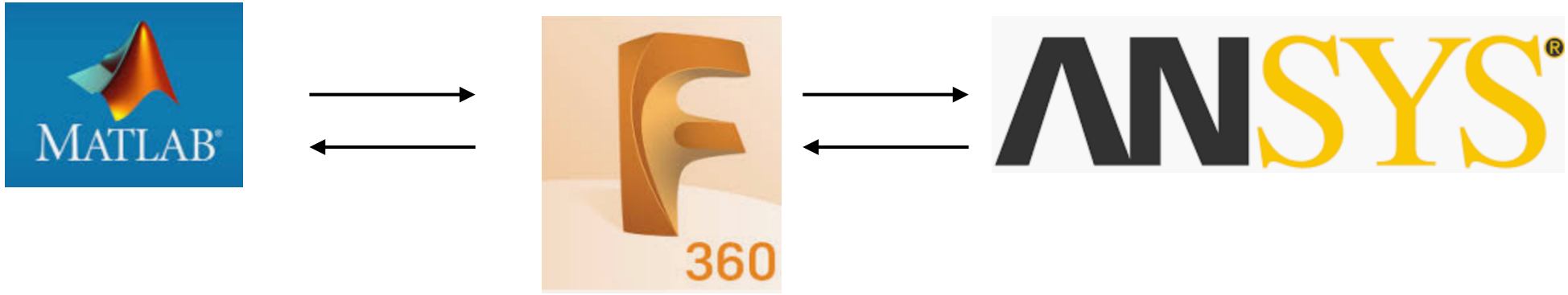
$$
R = \begin{bmatrix}
\cos\theta + u_x^2\left(1-\cos\theta\right) & u_x u_y\left(1-\cos\theta\right) - u_z\sin\theta & u_x u_z\left(1-\cos\theta\right) + u_y\sin\theta \\
u_y u_x\left(1-\cos\theta\right) + u_z\sin\theta & \cos\theta + u_y^2\left(1-\cos\theta\right) & u_y u_z\left(1-\cos\theta\right) - u_x\sin\theta \\
u_z u_x\left(1-\cos\theta\right) - u_y\sin\theta & u_z u_y\left(1-\cos\theta\right) + u_x\sin\theta & \cos\theta + u_z^2\left(1-\cos\theta\right)
\end{bmatrix}.
$$

CAD Workflow

Geometry, design parameters, motion constraints

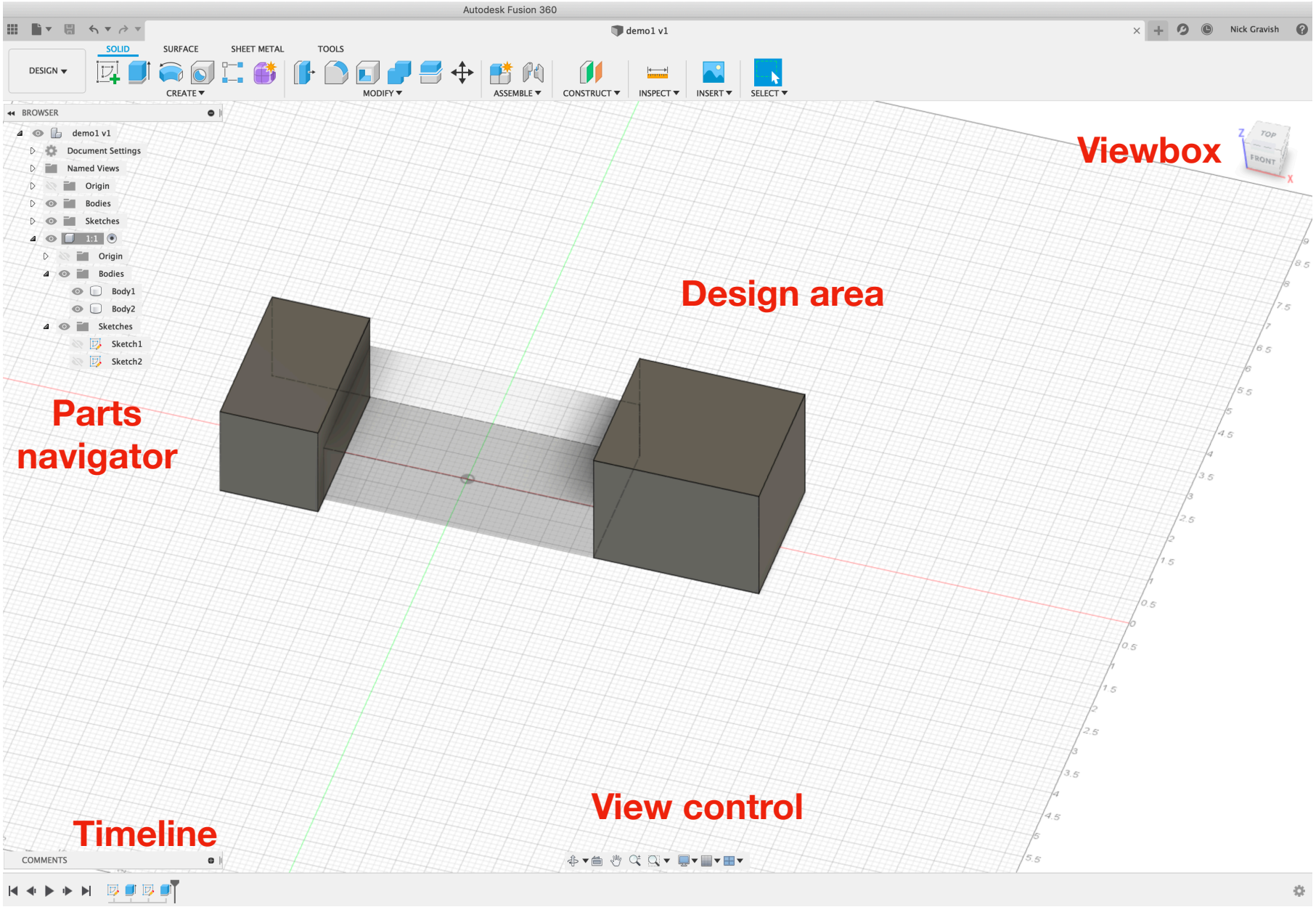
Rendering geometry, dimensioning, solid file generation for CAM

Solid mechanics modeling, fatigue and failure points, deformation and optimization



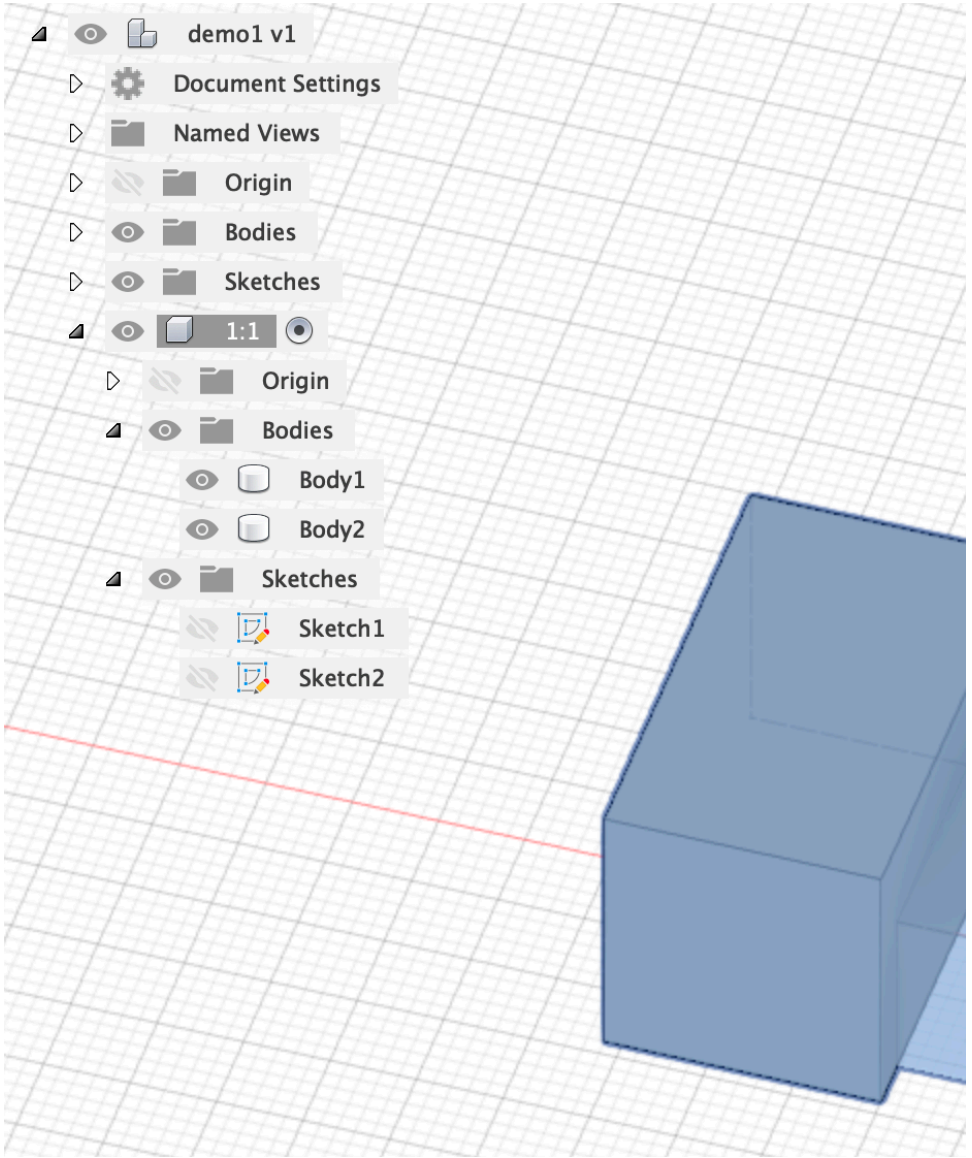
- The design workflow is iterative and cyclical.
- Feedback between tools is necessary.

Fusion 360 interface



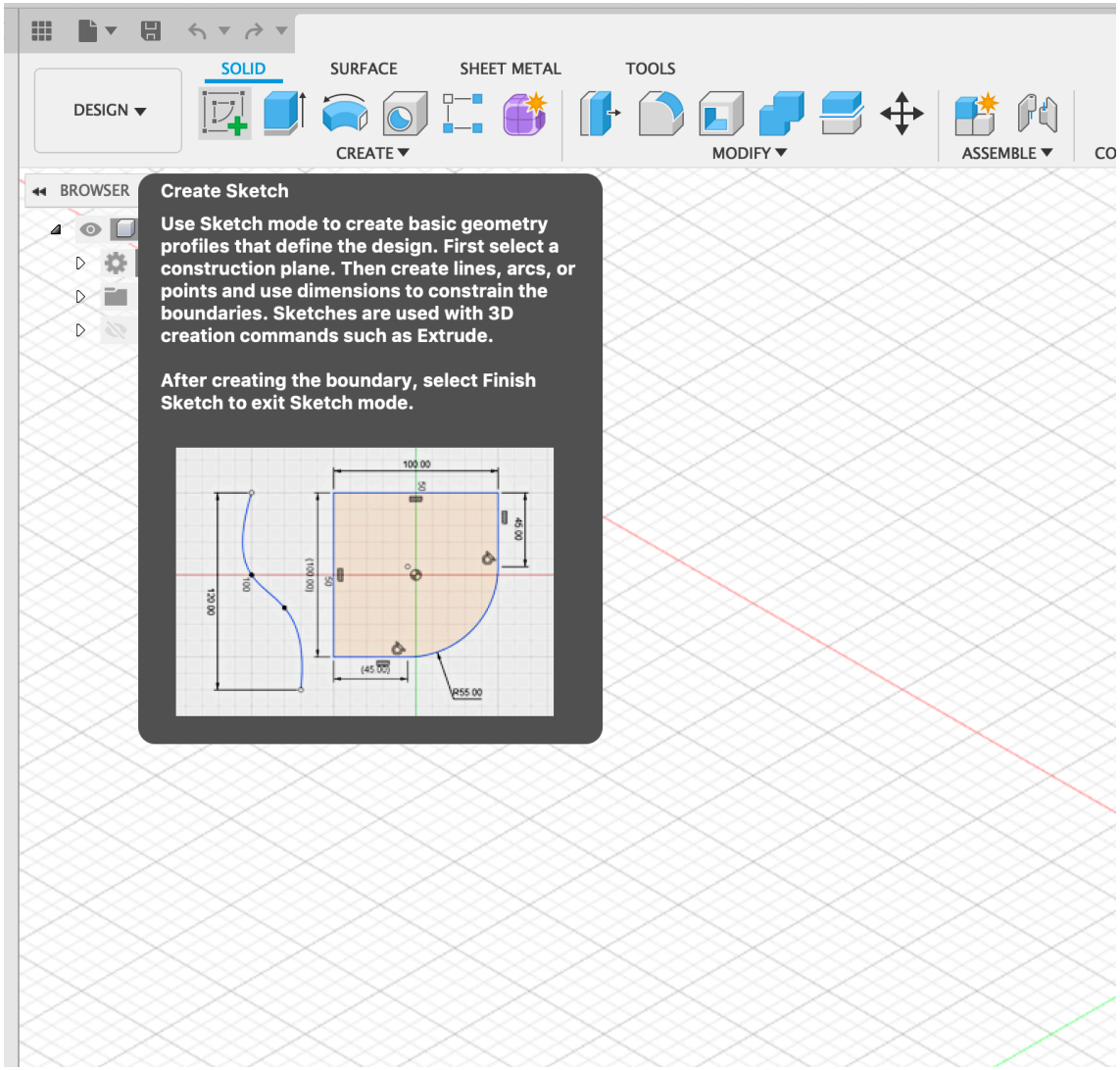
CAD terminology

- Sketch
  - Defines geometry and construction curves
- Bodies
  - 3D objects that occupy space
  - Typically a single connected object
- Components
  - Multi-body objects



Sketches

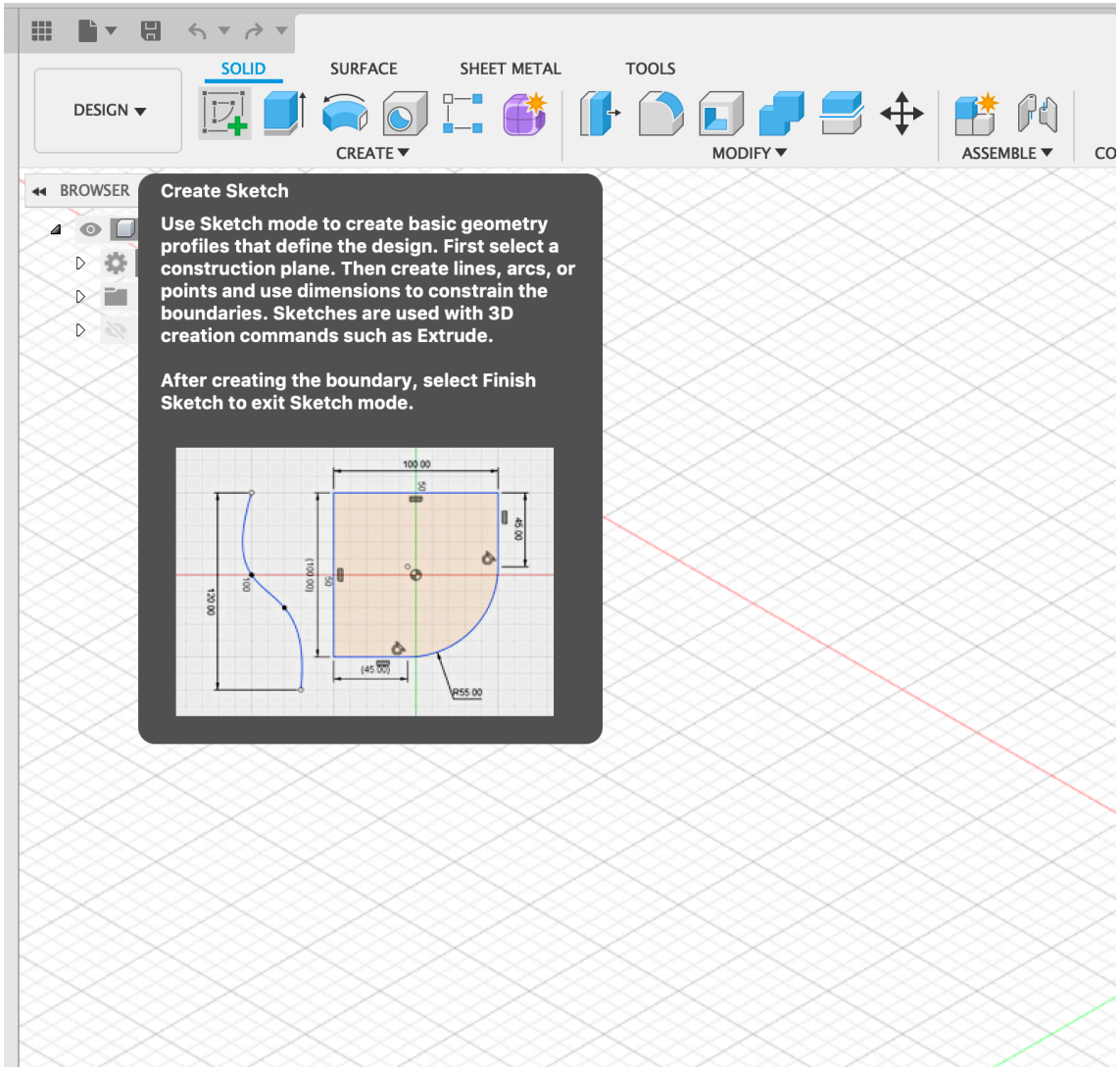
- Defines shapes and curves.
- Defines constraint relationships on 2D geometry.
- Is the underlying shapes from which 3D extrusions/revolutions/ etc come from.



Sketches

- In F360 sketches can live within the main component, or within individual components.

- Sketches can reference geometry from other sketches in other components (Beware this can present problems if not appreciated)



CAD Workflows

- Top down versus bottom up design approach

Bottom up

  - Individual parts of an assembly are modeled in separate files and linked together in an assembly.
  - Geometries don’t reference each other and thus changes
  - Often used when you have lots of stock components that already have geometry defined.
  - Can be challenging when designing a new assembly using all “designed” components as opposed to stock components.

CAD Workflows

- Top down versus bottom up design approach

Top down

  - All parts are created/modeled in the same assembly.
  - Geometry is typically referenced across bodies and sketches so that the assemblies “shape” is close to fully parameterized.
  - The “driving” of dimensions across parts can lead to a real problem when trying to break those links and separate dependencies.

CAD Workflows

- Most 3D CAD software enables either top down, bottom up, or a combination of both for assembly modeling.

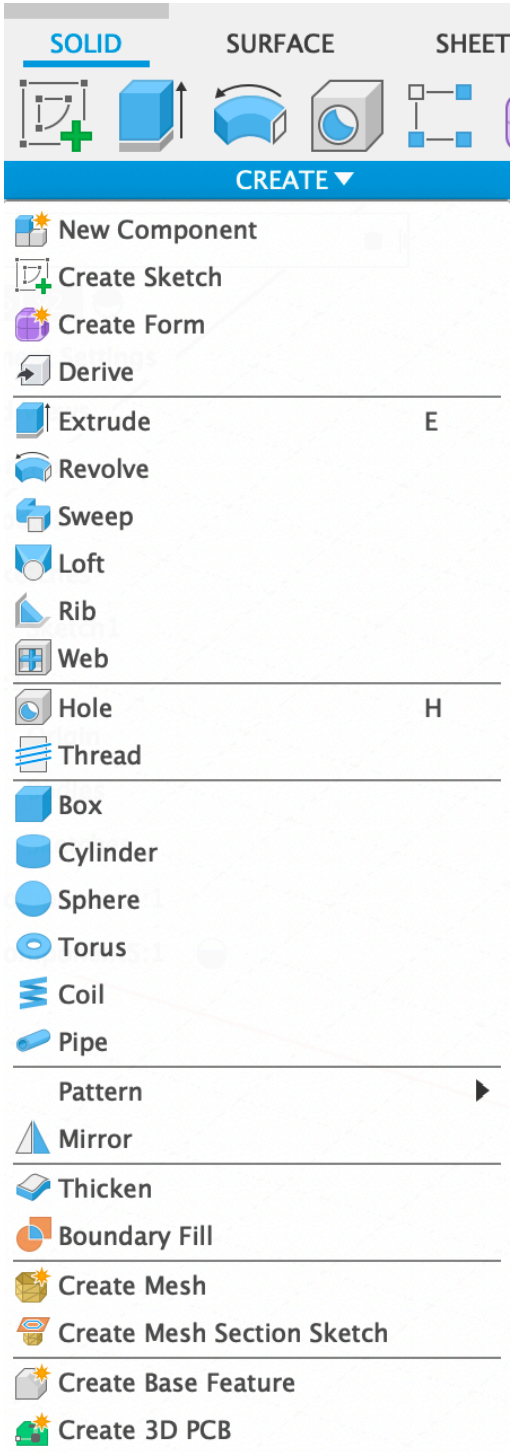
- These techniques ultimately also relate to how you manage files:

  - Top-down —> Many components within a single assembly file. Easy to manage files and links won't break if file is moved. Default Fusion 360 workflow.

  - Bottom up —> Many individual files in a folder referenced within a single assembly. Can lead to problems if files are moved or misplaced.

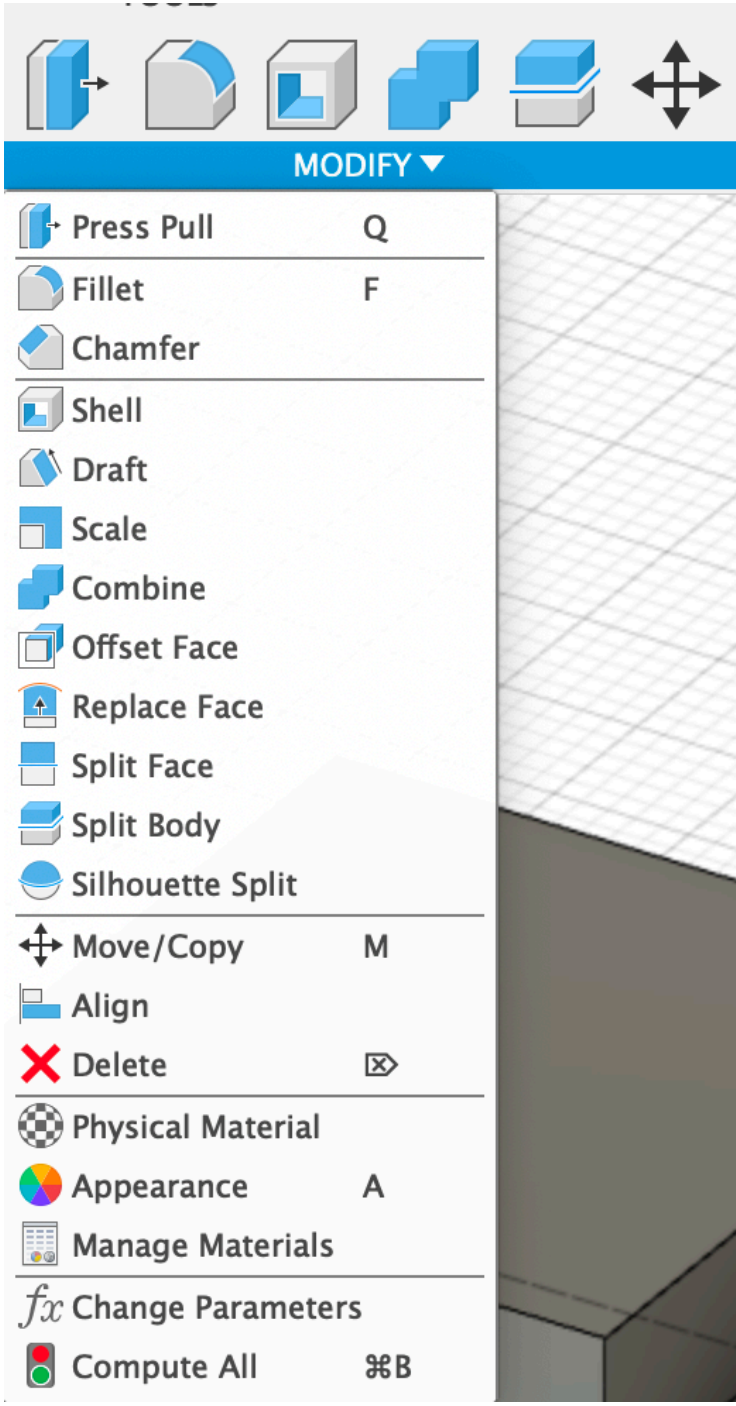
3D creation

- Extrude —> Linear 2D-3D conversion
- Revolve —> Rotational 2D-3D conversion
- Sweep —> Extrude along a path
- Loft —> Extrude between two dissimilar shapes



3D modification

- Press pull —> Linear modification
- Fillet —> Add rotational edges
- Chamfer —> Add an angled edge
- Combine —> Join bodies that are in contact



Todays model