CATIA V5
Parametric Surface Modeling
Version 5 Release 16
### Toolbars in Generative Shape Design

#### A. Wireframe:
Create 3D curves / lines / points / plane

#### B. Surfaces:
Create surfaces

#### C. Operations:
Join surfaces, Split & Trim surfaces, Change the 3D positions of surfaces, Fillets...

#### D. Replication:
Pattern, Powercopy...

#### E. Analysis:
Connection analysis, Draft analysis, curvature analysis...

#### F. Surface-based Features:
(On Part Design Workbench), create a solid from surfaces, modify the solid by a surface...
Point

Point (Create a point in the 3D space)

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point by Coordinates</td>
<td>Create a point by defining its coordinates in 3D.</td>
</tr>
<tr>
<td>Point on a Curve</td>
<td>Create a point on a curve at a distance from a reference point.</td>
</tr>
<tr>
<td>Point on a Plane</td>
<td>Create a point on a plane at a distance from a reference point.</td>
</tr>
<tr>
<td>Point on a Surface</td>
<td>Create a point on a surface at a specified distance and direction from a reference point.</td>
</tr>
<tr>
<td>Point at a Circle/Sphere Center</td>
<td>Create a point at the center of a circle/Sphere.</td>
</tr>
<tr>
<td>Point Tangent on a Curve</td>
<td>Create curve tangent points for a specified direction.</td>
</tr>
<tr>
<td>Point Between Two Points</td>
<td>Create a point between two existing points using a ratio value.</td>
</tr>
<tr>
<td>Points Spaced on a Curve</td>
<td>Create several points equally spaced on a curve.</td>
</tr>
</tbody>
</table>

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Extremum (max or min point)

**Extremum** (create an extremum element (point, edge, or face), which is at the minimum or maximum distance on a curve, a surface, or a pad, according to given directions.)
**Line**

Line (Create a line in the 3D space)

<table>
<thead>
<tr>
<th>Type</th>
<th>Geometry</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line Between Two Points</td>
<td></td>
<td>Create a line between two selected points.</td>
</tr>
<tr>
<td>Line from a Point and Direction</td>
<td></td>
<td>Create a line based on a reference point and a specified direction.</td>
</tr>
<tr>
<td>Line at an Angle or Normal to a Curve</td>
<td></td>
<td>Create a line at an angle to a curve that passes through a point.</td>
</tr>
<tr>
<td>Line Tangent to a Curve</td>
<td></td>
<td>Create a line tangent to a single curve, a point and a curve, or two curves.</td>
</tr>
<tr>
<td>Line Normal to a Surface</td>
<td></td>
<td>Create a line normal to a surface at a selected point.</td>
</tr>
<tr>
<td>Bisecting Line</td>
<td></td>
<td>Create a line that splits the angle between two lines into equal parts.</td>
</tr>
</tbody>
</table>
### Plane (Create a plane in the 3D space)

<table>
<thead>
<tr>
<th>Type</th>
<th>Geometry</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offset Plane</td>
<td><img src="image" alt="Offset Plane" /></td>
<td>Create a plane parallel to a reference plane offset at a distance.</td>
</tr>
<tr>
<td>Parallel Plane through a Point</td>
<td><img src="image" alt="Parallel Plane through a Point" /></td>
<td>Create a plane parallel to a reference plane through a point.</td>
</tr>
<tr>
<td>Plane at an Angle or Normal to a Plane</td>
<td><img src="image" alt="Plane at an Angle or Normal to a Plane" /></td>
<td>Create a plane at an angle to a reference plane based on a rotation axis.</td>
</tr>
<tr>
<td>Plane through 3 Points</td>
<td><img src="image" alt="Plane through 3 Points" /></td>
<td>Create a plane passing through 3 points.</td>
</tr>
<tr>
<td>Plane through 2 Lines</td>
<td><img src="image" alt="Plane through 2 Lines" /></td>
<td>Create a plane passing through 2 lines.</td>
</tr>
<tr>
<td>Plane through a Point and a Line</td>
<td><img src="image" alt="Plane through a Point and a Line" /></td>
<td>Create a plane passing through a point and a line.</td>
</tr>
<tr>
<td>Plane through a Planar Curve</td>
<td><img src="image" alt="Plane through a Planar Curve" /></td>
<td>Create a plane passing through a planar curve.</td>
</tr>
<tr>
<td>Plane Normal to a Curve</td>
<td><img src="image" alt="Plane Normal to a Curve" /></td>
<td>Create a plane normal to a curve at a specified point.</td>
</tr>
<tr>
<td>Plane Tangent to a Surface</td>
<td><img src="image" alt="Plane Tangent to a Surface" /></td>
<td>Create a plane tangent to a surface passing through a specified point.</td>
</tr>
<tr>
<td>Plane by an Equation</td>
<td><img src="image" alt="Plane by an Equation" /></td>
<td>Create a plane by defining the components of the equation of the plane.</td>
</tr>
<tr>
<td>Mean Plane through Points</td>
<td><img src="image" alt="Mean Plane through Points" /></td>
<td>Create a plane defined as the mean through 3 or more points.</td>
</tr>
<tr>
<td>Plane Spaced Between 2 Planes</td>
<td><img src="image" alt="Plane Spaced Between 2 Planes" /></td>
<td>Create several planes spaced equally between 2 selected reference planes.</td>
</tr>
</tbody>
</table>

**Diagram:**
- Wireframe setup
- Plane Definition dialog box
  - Plane type: Offset from plane
  - Reference: Offset from plane
  - Offset:
    - Parallel through point
    - Angle/Normal to plane
    - Through three points
    - Through two lines
    - Through point and line
    - Through planar curve
    - Normal to curve
    - Tangent to surface
    - Equation
    - Mean through points

**Image:**
- 3D modeling workspace with a plane being created through a point and a line.
Projection onto a support

**Projection** (project one or more elements onto a support. The projection can be normal to surface or along a specified direction.)

- **Normal to surface**
- **Along a direction (vertical)**
Combine Curves

**Combine Curves** (create a curve resulting from the intersection of the extrusion of two curves.)

A 3D resultant Curve

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**Reflect Line**

*Reflect Line* (create curves for which the normal to the surface in each point present the same angle with a specified direction. They can be closed or open.)

The normal of surface at all points along the curve is 38deg from the vertical axis.
Intersection

Intersection (create wireframe geometry by intersecting elements.)

Intersection curve between two surfaces

Intersection point between a curve and a surface

Intersection curve between a surface and a solid
Parallel Curve

Parallel Curve (create a curve that is parallel to a reference curve.)

We have a curve lying on the surface

Offset the curve on the surface (The resultant curve is still on the surface)
Corner

Corner (create a corner between two curves)

If several solutions may be possible, click the Next Solution button to move to another corner solution, or directly select the corner you want in the geometry.
Connect Curve (create a connecting curve between two curves.)

The curvature in the middle can be controlled by tension.

Point-continuous, tangent-continuous or curvature-continuous

Point-continuous, tangent-continuous or curvature-continuous
Spline Curve

Spline Curve (create a 2D/3D spline curve)

We can create an additional line to define the tangent direction at a point.
**Helix** (create a helix curve like a spring)

First, create a point and a straight line.

(Optional) With Taper Angle

(Optional) Follows a profile
**Extrude**

**Extrude** (create a surface by extruding a profile along a given direction)

If the profile is planar, the direction will be its normal by default. But you can change it to other direction.
Revolve

Revolve (create a surface by revolving a planar profile about an axis)

Remark: The axis must be a straight line.
Offset

**Offset** (create a surface, or a set of surfaces, by offsetting an existing surface, or a set of surfaces)
**Sweep**

*Create a surface by sweeping out a profile along one or two guide curves.*

### Sweeping an *Explicit* profile
- With reference surface (optional)
- With two guide curves (optional)
- With pulling direction (optional)
(We can use the above three options to control the profile orientation)

### Sweeping a *Linear* profile
- Two limits
- Limit and middle
- With reference surface
- With tangency surface
- With reference curve
- With two tangency surfaces
- **With draft direction**

Then create a draft surface by sweeping an inclined linear profile along a guide curve.
Sweep – Con’t

Sweeping a **Circular** profile
- Three guides
- **Two guides and radius**
- Center and two angles
- Center and radius
- Two guides and tangency surface
- One guide and tangency surface

Sweeping a **Conical** profile
- Two guides
- **Three guides**
- Four guides
- Five guides
**Fill**

**Fill** (create a surface to fill the opening among a number of boundary segments)

We can specify the desired continuity type between any selected support surfaces and the fill surface (Point, Tangent or Curvature continuous)

The four points must be tangent-continuous or curvature-continuous.

Support Surface

Passing through a point (optional)
Multi-sections Surface

**Multi-sections surface** (create a surface by sweeping two or more section curves along an automatically computed or user-defined spine. The surface can be made to respect one or more guide curves.)

Further control point-point matching by **“manual coupling”**
**Blend**

(Create a surface between two wireframe elements or surface edges)
Join (join surfaces or curves as one element)

The two original surfaces are hidden; a Join surface is created.
Split & Trim

**Split** (split a surface or wireframe element by means of a cutting element. You can split a wireframe element by a point, another wireframe element or a surface; or a surface by a wireframe element or another surface.)

**Trim** (trim two or more surface or wireframe elements)
**Boundary**

**Boundary** (create the boundary curve of a surface)

No propagation  
Tangent continuity  
Point continuity  
Complete boundary

We can select limit points to limit the boundary
**Extract**

*Extract* (extract from elements (curves, points, surfaces or solids))

- Only selected surface
- Only tangent surfaces are selected
- All surfaces are selected

For this case, the extracted element must be a curve.
Shape Fillet

**Bi-tangent Shape Fillet** (create a shape fillet between two surfaces)

Smooth: a tangency constraint is imposed at the connection between the fillet surface and the support surfaces, thus smoothing the connection.

**Tri-tangent Shape Fillet** (create a shape fillet between three surfaces)
**Edge Fillet**

Edge Fillet (create a constant radius fillet along the internal edge of a joined surface)

Select the edge of the Join Surface
Variable Fillet

Variable Fillet (create a variable radius fillet. In this type of fillet, the radius varies at selected points along a selected edge. The fillet surface is obtained by rolling a sphere, which radius would vary, over the selected edge.)

Create a point along the edge before filleting

Click the box and select the point

After entering a new value for this point, we have a different radius here

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Face-Face Fillet

**Face-Face fillet** (create a face-face fillet. The fillet surface is obtained by rolling a sphere, which radius is larger than the distance between the selected elements, between the selected surfaces.)

Remark: This is a “Joined” Surface

We can add this fillet between two faces that are not touching each other.
Tri-tangent Fillet

**Tri-tangent Fillet** (The creation of tritangent fillets involves the removal of one of the three faces selected, as the fillet surface is obtained by rolling a sphere, which radius is automatically computed to be larger than the removed surface, between the selected surfaces.)
Translate, Rotate, Symmetry, Scale

Translate

Rotate

Symmetry

Scale

Affinity
Extrapolate a surface boundary:

Tangent Continuity – this will be a straight edge

We can join the extrapolated surface with the original surface

Extrapolate a Curve:

Extrapolation without support

Extrapolation with a support
Patterns

Rectangular pattern

Circular pattern

User pattern

First create a sketch with points
Connect Checker (analyze how two surfaces are connected)

Distance - minimal distance between two vertices
Tangency - angle between two surfaces
Curvature Difference \( \frac{|C_2 - C_1|}{\left(\frac{|C_1 + C_2|}{2}\right)} \)

Curve Connect Checker (analyze how two curves are connected)

Distance - minimal distance between two vertices
Tangency - angle between two curves
Curvature Difference \( \frac{|C_2 - C_1|}{\left(\frac{|C_1 + C_2|}{2}\right)} \)
Draft Analysis

(analyze the draft angle on a surface)

(Remark: To view the draft result, we need to use the Shading with Material mode.)

**STEPS:**
1. Click “Feature Draft Analysis
2. Define the color scale (e.g. -1, 0, +1 deg)
3. Click the option “Compass” on the pop-up menu
4. Select all surfaces
Create a New Geometrical Set

To CREATE a new geometrical set:-
- Select “Insert/Geometrical Set…” on the top menu
- Click ok

(Remark: Provided that Hybrid Design is disabled, a geometrical set will be created automatically when the first wireframe/surface/ plane is created)

To MOVE a surface from One Geometrical Set to the other:-
- Right-click on the surface to access the contextual menu
- Select “Change Geometrical Set…”
- Select the other geometrical set from the list of Destination
Split (by Surface)

Remark:

The surface-based features (Split, Thick Surface, Close surface & Sew) are available only on **Part Design** Workbench

**Split** (split a solid with a plane, face or surface)
Thick Surface

Thick Surface (add material to a surface in two opposite directions or in one direction)
Close Surface

*Close Surface* (Add material inside the enclosed surface so that a solid is created)
Sew Surface

Sew Surface (a Boolean operation combining a surface with a body. This capability adds or removes material by modifying the surface of the solid.)
Exercise

Exercise 1
- Sweep/ Extrude/ Offset
- Blend/ Split/ Boundary
- Fill/ Join

Exercise 2
- Revolve/ Sweep/ Split
- Shape Fillet/ Extrude
- Symmetry/ Join
- Thick Surface
Exercise 1

(1) Start/Shape/Generative Shape Design

(2) To make a Sweep surface:-
- Click “Sketch” icon and select \textit{yz plane}
- Draw an arc (R500) with one end (0,0) as shown in Fig.1
- Click “Exit” to complete
- Deselect Sketch.1
- Click “Sketch” icon again and select \textit{zx plane}
- Draw an arc (R400) with symmetric endpoints as shown in Fig.2
- Click “Exit” to complete
Exercise 1

(Con’t)

- Click “Sweep” icon
- Select “Explicit” as Profile Type
- Select Sketch.1 as Profile
- Select Sketch.2 as Guide Curve
- Click ok to complete
- Hide Sketch.1 & Sketch.2

(3) To make an Offset Plane:-

- Click “Plane” icon
- Select xy plane as Reference
- Enter 160mm as Offset (upward)
- Click ok to complete

(4) To make a sketch on the offset plane:-

- Click “Sketch” icon and select Plane.1
- Draw the Profile as shown in Fig.3
- Click “Exit” to complete
Exercise 1

(5) To Project the sketch onto the surface:-

- Click “Projection” icon
- Select “Along a direction” as Projection type
- Select Sketch.3 as Projected
- Select Sweep.1 as Support
- Select xy plane as Direction
- Click ok to complete

(6) To Split the surface:-

- Click “Split” icon
- Select Sweep.1 as Element to cut
- Select Project.1 as Cutting element
- (Click “Other Side” option to choose the outer portion)
- Click ok to complete
- Hide Sketch.3 & Project.1

(6b) To Offset the surface:-

- Click “Offset” icon
- Select Sweep.1 as Surface
- Enter 6mm as Offset (Downward)
- Click ok to complete
Exercise 1

(7) To Create Two offset planes:-
- Click “Plane” icon
- Select **zx plane** as Reference
- Enter 50mm as Offset (positive side)
- Click ok to complete
- Click “Plane” icon again
- Select **zx plane** as Reference
- Enter 230mm as Offset (positive side)
- Click ok to complete

(8) To Split Surfaces:-
- Hide Surface Split.1; Show Surface Sweep.1
- Click “Split” icon
- Select Sweep.1 as Element to cut
- Select Plane.2 as Cutting element
- Click “Other Side” option to choose the smaller portion
- Click ok to complete
- Click “Split” icon again
- Select Offset.1 as Element to cut
- Select Plane.3 as Cutting element
- Click “Other Side” option to choose the smaller portion
- Click ok to complete
Exercise 1

(9) To Create a Blend:-
- Click "Blend" icon
- Select the edge of Split.2 as First Curve
- Select Split.2 as First Support
- Select the edge of Split.3 as Second Curve
- Select Split.3 as Second Support
- Select Tangency for First continuity and Second continuity
- Click ok to complete

(10) To make a sketch on the offset plane:-
- Click "Sketch" icon and select Plane.1
- Draw the Profile as shown in Fig.4
- Click "Exit" to complete
(11) To Project the sketch onto the Blend:–

- Click “Projection” icon
- Select “Along a direction” as Projection type
- Select Sketch.4 as Projected
- Select Blend.1 as Support
- Select xy plane as Direction
- Click ok to complete

(12) To Split the Blend:–

- Click “Split” icon
- Select Blend.1 as Element to cut
- Select Project.2 as Cutting element
- (Click “Other Side” option to choose the inner portion)
- Click ok to complete
- Hide Sketch.4 & Project.2
Exercise 1

(13) To Hide all constructive elements:-
- Hide all elements except Split.1 & Split.4

(14) To make 4 boundaries:-
(1st Boundary)
- Click “Boundary” icon
- Select “Tangency continuity” as Propagation type
- Select the edge as shown in Fig.5
- Click ok to complete

(2nd Boundary)
- Click “Boundary” icon again
- Select “Tangency continuity” as Propagation type
- Select the edge as shown in Fig.5
- Click ok to complete
Exercise 1

(3rd Boundary)
- Click “Boundary” icon again
- Select the edge as shown in Fig.6
- Select the point ★ as Limit 1
- Click ok to complete

(4th Boundary)
- Click “Boundary” icon again
- Select the edge as shown in Fig.6
- Select the point ★ as Limit 1
- Click ok to complete

(15) To Create a Fill:-
- Click “Fill” icon
- Select Boundary.1 then Split.4 then Tangent
- Select Boundary.2 then Split.1 then Tangent
- Select Boundary.3 then Split.1 then Tangent
- Select Boundary.4 then Split.1 then Tangent
- Click ok to complete
Exercise 1

(16) To Join surfaces:-
- Click “Join” icon
- Select Split.1, Fill.1 & Split.4
- Click ok to complete

(17) Hide all Boundaries

Result: No sharp edge between the step-down and the original surface

END of Exercise.1

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(1) Start/Shape/Generative Shape Design

(2) To make a Revolve surface:-

- Click “Sketch” icon and select \textit{zx plane}
- Draw an \textbf{arc} (R160) with one end (0,30) as shown in Fig.1, which should be tangent to a horizontal axis
- Draw another horizontal axis on x-axis (which will be selected to be the axis of rotation later)
- Click “Exit” to complete

**Fig.1**
Exercise 2 (con’t)

- Click “Revolve” icon
- Select Sketch.1 as Profile
- (Sketch axis will be selected as Revolution axis)
- Enter 0deg as Angle.1
- Enter 180deg as Angle.2
- Click ok to complete
- Hide Sketch.1

(3) To make the 2nd Sketch:-
- Click “Sketch” icon and select xy Plane
- Draw an Arc (R90) as shown in Fig.2
- Click “Exit” icon to complete
Exercise 2

(4) To make reference planes:-

- Click “Plane” icon
- select yz Plane
- then select the end point of the arc
  (“Parallel through point” will be automatically selected as “Plane Type”)
- Click ok to complete

- Click “Plane” icon again
- select yz Plane
- then select the end point of the arc
- Click ok to complete

(5) To make the 3rd Sketch:-

- Click “Sketch” icon and select Plane.1
- Draw an ellipse with one end touching Sketch.2 as shown in Fig.3
  (While adding the constraint (D30), right-click and select “semiminor axis”)
- Click Exit to complete
Exercise 2

(6) To make the 4th Sketch:-
  • Click “Sketch” icon and select Plane.2
  • Draw an ellipse with one end touching Sketch.2 as shown in Fig.4
  • (While adding the constraint (D10), right-click and select “semiminor axis”)
  • Click Exit to complete

(7) To make a symmetric curve:-
  • Click “Symmetry” icon
  • Select Sketch.2 as Element
  • select zx Plane as Reference
  • Click ok to complete
Exercise 2

(7) To make a Multi-sections Surface:-

• Click “Multi-sections Surface” icon
• Select Sketch.3 as Section#1
• Select Sketch.4 as Section#2
• Select Sketch.2 as Guide#1
• Select Symmetry.1 as Guide#2
• Click ok to complete
• Hide Sketch.2, Sketch.3, Sketch.4, Symmetry.1, Plane.1 & Plane.2

(8) To Split the surface:-

• Click “Split” icon
• Select Multi-sections Surface.1 as Element to cut
• Select zx Plane as Cutting element
• (Click “Other Side” option to choose the correct portion)
• Click ok to complete
Exercise 2

(9) To make a Fillet between 2 surfaces:-
- Click “Shape Fillet” icon
- Select Split.1 as Support.1
- Select “Trim Support.1”
- Select Revolute.1 as Support.2
- Select “Trim Support.2”
- Enter 10mm as Radius
  - (Click on the red arrow if it is not pointing outward)
  - Click ok to complete

(10) To make 5th Sketch:-
- Click “Sketch” icon and select xy Plane
- Draw an Arc (R78, center at (0,0)) as shown in Fig.5
  - (One endpoint must be on x-axis)
- Click ok to complete
Exercise 2

(11) To make an Extrude:-
- Click “Extrude” icon
- Select Sketch.5 as Profile
- (The Sketch Plane, xy Plane will be automatically selected as Direction)
- Enter 20mm as Limit.1
- Enter 20mm as Limit.2
- Click ok to complete

(12) To Split Surface:-
- Click “Split” icon
- Select Fillet.1 as Element to cut
- Select Extrude.1 as Cutting element
- (Click “Other Side” option to choose the bigger portion)
- Click ok to complete
- Hide Extrude.1 & Sketch.5
Exercise 2

(13) To make a Symmetry:-
- Click “Symmetry” icon
- Select Split.2 as Element
- Select zx Plane as Reference
- Click ok to complete

(14) To visual-check the tangency continuity along the interface:-
- Click “Shading” icon
- (All black surface edges now disappear)
- Check if any sharp edge appears along the centre interface. If yes, go back to previous step(s) to correct the error.

(15) To Join Surfaces:-
- Click “Join” icon
- Select Split.2 and Symmetry.2 as Elements to Join
- Click ok to complete
- (Split.2 & Symmetry.2 will be hidden automatically)
Exercise 2

(16) To make a Solid:-
- Start/Mechanical Design/Part Design
- Click “Thick Surface” icon
- Click ok on the pop-up warning window
- Select Join.1 as Object to Offset
- Enter 2mm as First Offset
- (If the red-arrows are not pointing inward, click “Reverse Direction” or directly click on an arrow to change the direction)
- Click ok to complete
- Hide Geometrical Set.1

(17) To add Fillets onto the solid: -
- Click “Edge Fillet” icon
- Select all sharp edges
- Enter 0.5mm as Radius
- Click ok to complete

END of Exercise.2