CP462507

Advanced Direct Modeling in T-Splines and Parametric Design

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Learning Objectives

- Learn about the benefits of direct modeling for more-intuitive and fluid design explorations.
- Discover the features available in Fusion 360 for direct modeling.
- Explore direct modeling techniques in both T-splines (Form) and parametric (Solid) environments.
- Learn how direct modeling can provide a more fun workflow with a sense of "flow."

Description

Direct modeling is an extremely powerful tool in Fusion 360. The use of features that follow natural gestures and movements (i.e., pull, twist, stretch) empowers users to fully immerse in a modeling experience that provides enjoyment, exploration, and a sense of "flow." Direct modeling can also bypass steps such as setting planes, sketches, and other 3D commands, which could get in the way of modeling workflows. While direct modeling is typically associated with T-Splines via the Form environment, it is possible to also use it in parametric settings. This presentation will illustrate the power of direct modeling in both environments in Fusion 360 software with the use of simple yet effective workflows and design examples.

Speaker

Alex Lobos focuses in design, technology and emotional attachment as means to elevate quality of life. He is Professor and Graduate Director of Industrial Design at Rochester Institute of Technology (RIT) and a Research Fellow Emeritus at Autodesk.

At RIT, Alex leads a top-ranking graduate program focused on interdisciplinary collaboration, accessible technology and applied design research. Alex and his students have collaborated with Autodesk, AT&T, Colgate-Palmolive, General Electric, Makerbot, Staples, Stryker, Unilever and others, in projects covering topics such as learning futures, generative design, digital fabrication, sustainable behaviors, and everyday living. Alex has been juror for International Design Excellence Awards (IDEA), International Housewares competition and Bienal Ibero-americana de Diseño. He is a member of Autodesk University's advisory council, holds two international patents and has been an industrial designer for General Electric.

Alex grew up in Guatemala and moved to the U.S. as a Fulbright scholar. He holds a MFA from the University of Notre Dame and a BID from Universidad Rafael Landivar.

1 Overview

A key ability for CAD products is to provide users with maximum control and flexibility so that they can translate their ideas into digital models, without compromising design intent. This ensures that concepts can be developed to their full potential, as well as to communicate them effectively to multiple stakeholders. This communication is essential in multi-disciplinary teams that could easy misinterpret ideas that come from a discipline that doesn't use familiar terms.

Traditional CAD uses a linear sequence of steps, in which different details of a design are provided to the computer separately. This workflow typically involves: selecting a plane, drawing a 2D sketch, and using a feature that converts the sketch into a three-dimensional body. This workflow is well accepted in a variety of industries but it can definitely be improved.

Products such as Fusion 360, offer a dynamic process called direct modeling. This means that geometry can be edited directly and in real-time, using gestures that mimic how objects are moved in real life: pull, push, rotate, stretch, compress, etc. Fusion 360 takes advantage of T-Splines technology to make direct modeling possible. This type of modeling feels similar to sculpting shapes instead of programing their shape in separate steps. An important advantage of this process is that users are able to react to the geometry changes they see in the screen, which further inspires their designs and can lead to solutions that hadn't been considered previously.

One of the most popular CAD methods in design and engineering is parametric modeling. This type of modeling allows to capture history of every component in a design. As features are created, they are linked to each other, creating a history timeline. This allows to go back to any step in the timeline and make edits, that are reflected in the rest of the dataset and model. This process saves time, but most importantly, it maintains critical information that involves all components of a design assembly. In the past, users had to choose between the flexibility of direct modeling or the accuracy and historical information of parametric design. Today's CAD programs such as Fusion 360 have made significant steps in closing this gap, allowing users to have a high level of history and feature dependency, even when designining with direct techniques.

This class provides examples for using direct modeling in Fusion 360, both in the Form (T-Splines) and Solid (Parametric) environments. These examples use the design of a stool and a stand mixer, to illustrate workflows across products that can be organic as well as geometric. The goal of these examples is to provide inspiration for new methods of CAD modeling that make a stronger conection between the user and the design output.

2.1 Stool modeled in Form (T-Splines) environment

Modeling for this stool takes advantage of the Free Form environment, which is based in T-Splines. This environment is ideal for creating forms that are organic and need high-quality surface-continuity. The process feels like a digital version of sculpting shapes in real life.

The design of the stool focused on three components: a metal tubing frame, a plastic seating base and a soft cushion. The process involves modeling some components in the Free Form environment, and then moving them into the main Design (parametric) environment, to add geometry via solid and surface bodies.

2.2 Stand Mixer modeled in Solid (parametric) environment

Modeling a product such as this stand mixer, typically would involve a process of selecting planes, then drawing sketches, and finally projecting them into 3D bodies with a variety of features. While there is nothing wrong with this method, it limits design exploration and many times forces designers and engineers to have a preconceived shape and proportions in mind. This stand mixer has been modeled in the Solid (parametric) environment without a single sketch. The workflow involves creating basic geometric shapes, and then editing their proportions and using commands that create geometry out of existing bodies, similar to how direct modeling happens with T-Splines.

3 Key commands and workflows

The modeling commands highlighted in this design example are below. For more information visit Fusion 360's product documentation:

3.1 Edit Form
Design>Form>Modify>Edit Form

This is the heart and soul of T-Splines modeling. It allows to take any part of a model (vertex, edge or face) and edit it in real time by moving, rotating or scaling it. In Edit Form is also possible to add components to a body, also in real time.
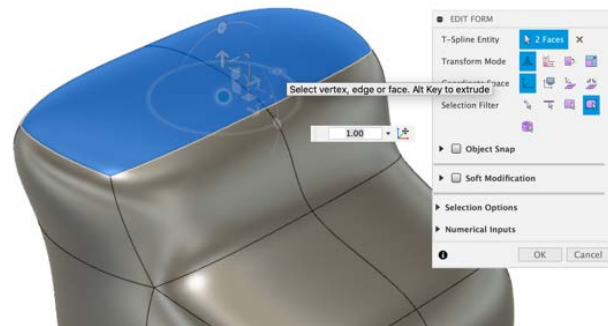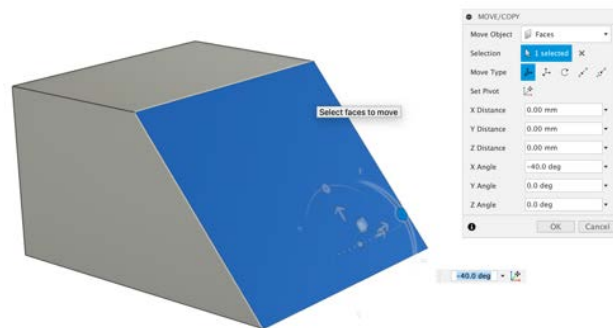
3.2 Pipe
Design>Form>Create>Pipe

Pipe allows to create a T-spline body following a path defined by a sketch or by edges in a body.
The resulting Pipe can be adjusted in terms of its profile, diameter, number of segments, etc.
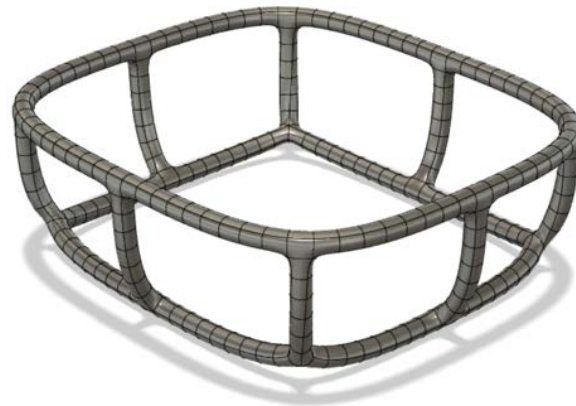
3.3 Patch
Design>Surface>Create>Patch

Patch creates a planar or 3D surface within the boundary of a closed loop. It is an effective way to enclose an open surface. Surfaces are then stitched together and can be converted to solid bodies.
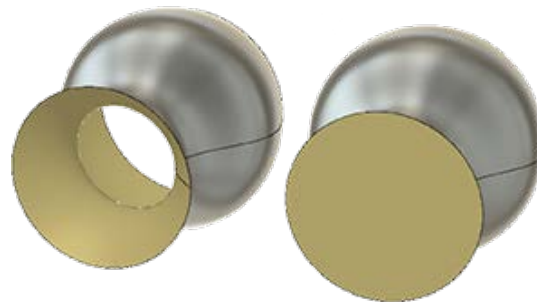
3.4 Primitive Bodies
(i.e. Box and Cylinder)
Design>Solid>Create>Box

This is the heart and soul of T-Splines modeling. It allows to take any part of a model (vertex, edge or face) and edit it in real time by moving, rotating or scaling it.

In Edit Form is also possible to add components to a body, also in real time.

3.5 Move/Copy
Design>Solid>Modify>Move/Copy

At a basic level, Move allows to move bodies around the workspace.
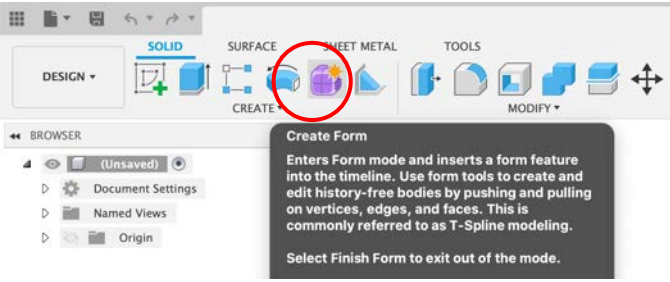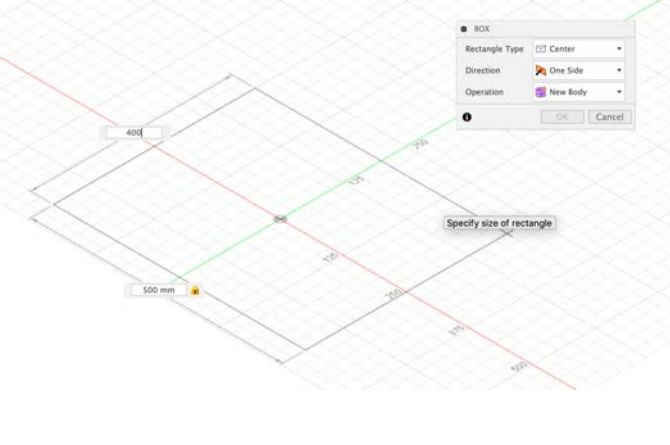
When set to "Faces", this command is a powerful tool to edit shape in a similar way to how Edit Form works for T-Spline bodies.
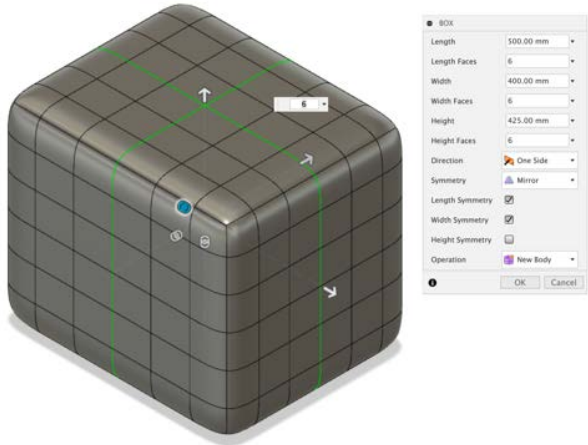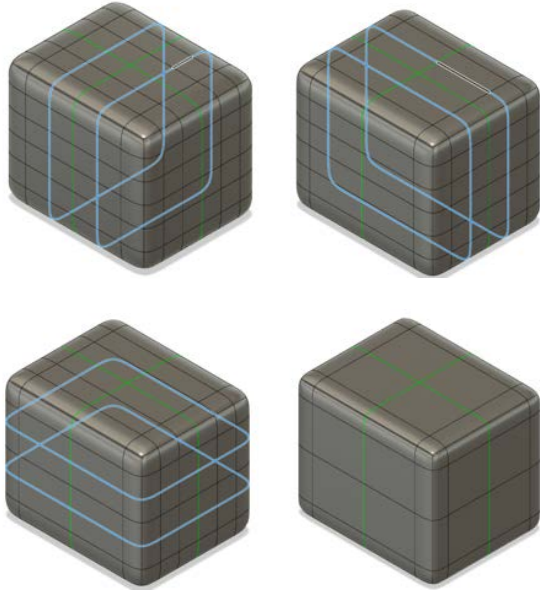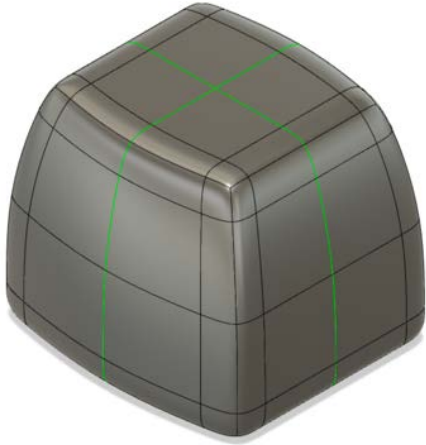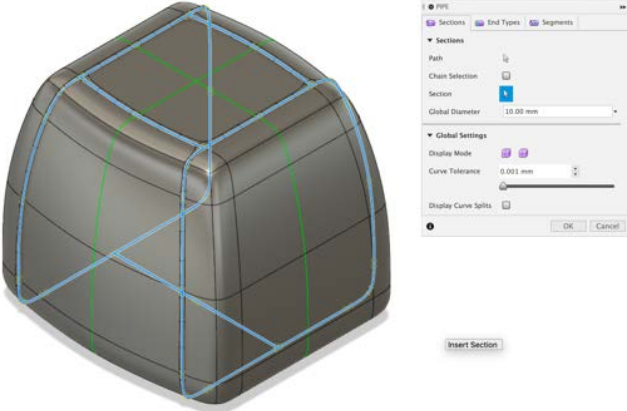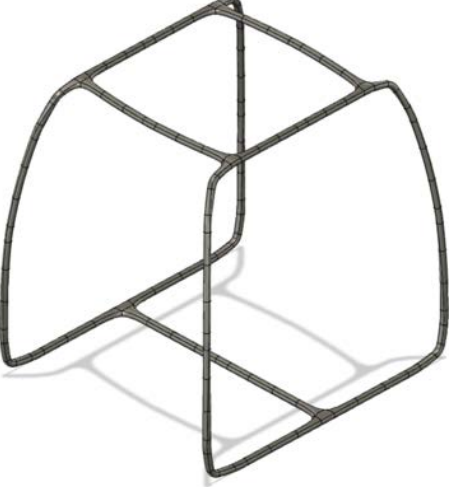
4 Stool modeling step-by-step tutorial

4.1 Tubing frame		
Enter Sculpt	Open Fusion to a new design Go to Create>Create Form to enter the Form (T-Splines) environment	
Create box	Go to Create>Box In the Box Window, select: -Rectangle Type: Center -Direction: One side -Operation: New body Select the top plane Click on the origin point Create a box that is: -Length: 500mm -Depth: 400mm -Height: 425mm	

	Set additional settings appear in the window: -Faces (Length, width, height): 6 -Symmetry: Mirror (Check Length and width)	
Remove edges	Click on any section of the edges highlighted in the right (double-click to select the entire loop). Press "del" key to delete them. Repeat to delete edges in the other two directions.	
Shape the box	In the View Cube in the upper right corner, select Front Go to Modify>Edit Form Set selection filter to "edge" Select edges as needed to curve the shape of the box. Use the Orbit's side handles (highlighted in red in the right illustration) to scale them in a single direction.	

	Use the Orbit's arrows to move the edges. Repeat process from other views/directions to apply a rounder shape in all sides.	
Create tube frame	Select a set of edges to define the shape of the frame (see sections highlighted in blue). Go to Create>Pipe In the "sections" tab: -set diameter to 10mm -set display mode to smooth In the "segments" tab: -set density to "fewer"	
	Click "Finish Form" to convert the bodies to B-Rep models and go back to the Solid environment.	

4.2 Seat Cushion		
Create seat body	Go to Create>Create Form to enter the Form (T-Splines) environment In the browser, look for the base box created earlier. Right-click and select "move/copy"	
	In the Move/Copy window, select "Create Copy" Use the Orbit cursor to move the copy up. Hide the frame and base box (look for them in the browser and click on the "eye" icon).	
	Select and delete the bottom portion of the box.	
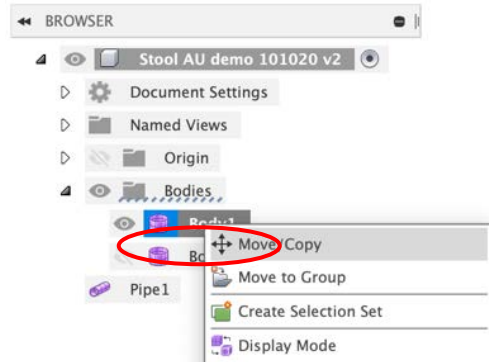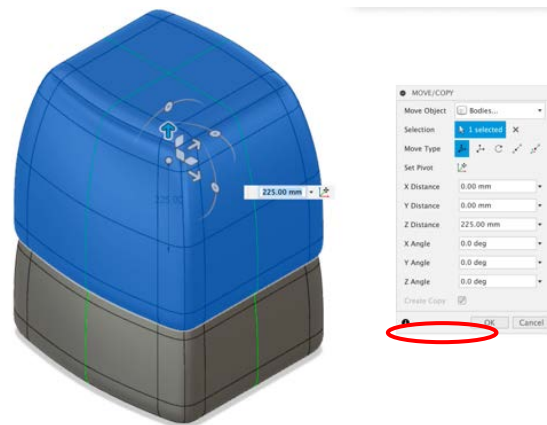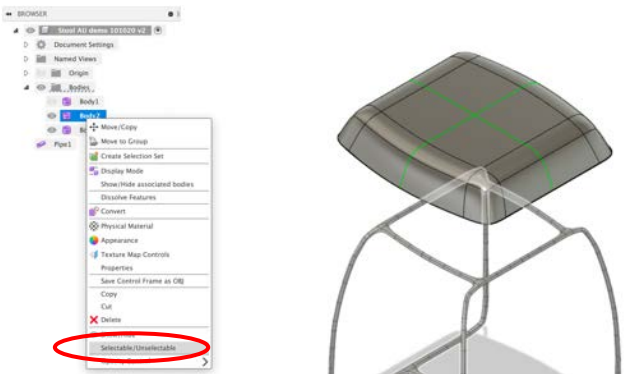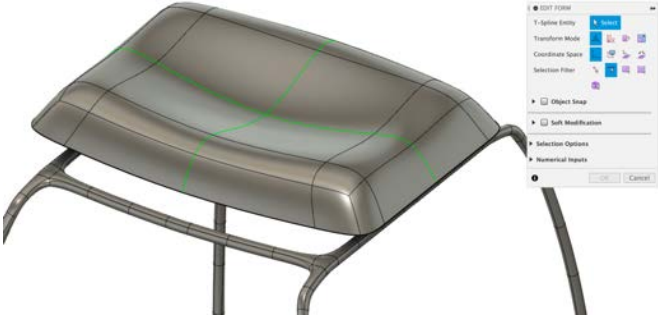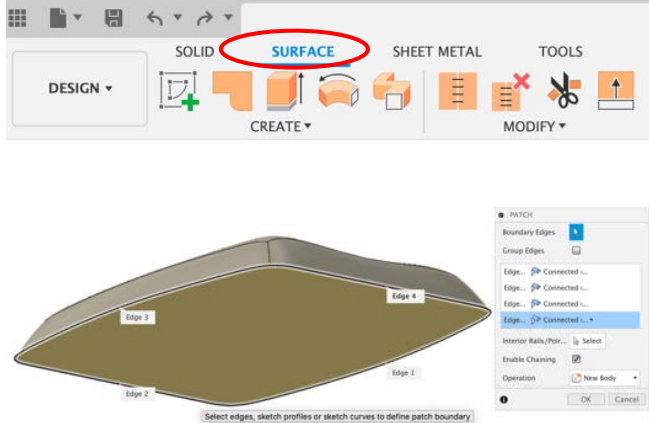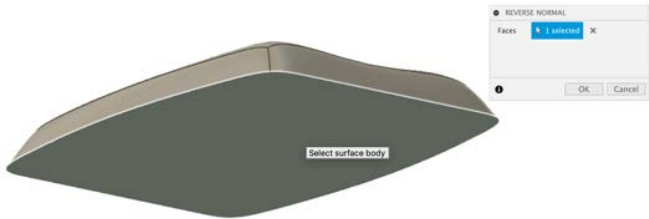
	In the browser, make the tubing frame visible (by clicking on the "eye"). Right-click on label of the frame, it and make it "unselectable"	
	Go to Modify>Edit Form Edit the shape of the cushion to make it: -wider than the frame -shallower than the frame -add more curvature at the top Use "Finish Form" to convert the body and move it to the Solid environment.	
Turn the cushion into a solid	In the top tabs, change from "Solid" to "Surface" Go to Create>Patch Select the bottom open edge of the seat to patch it.	
	Go to Modify>Reverse Normal, and select the new face to match it to the upper section. Go to Modify>Stitch, and select both surfaces to stitch them together and turn the body into a solid.	
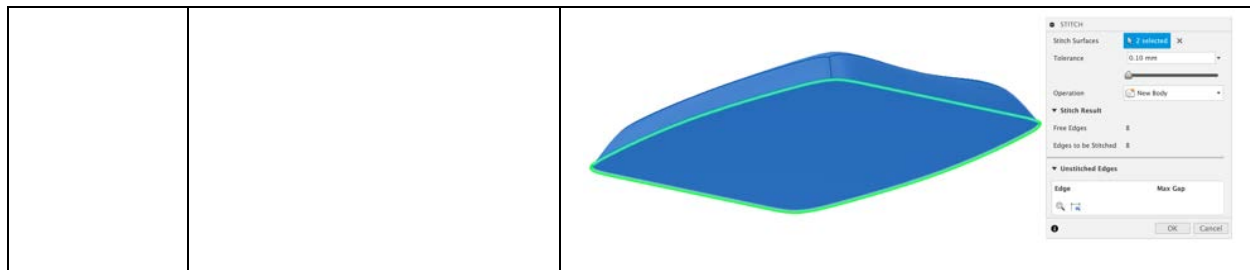
4.3 Cushion's base		
Create cushion's base	Go to Create>Ruled Surface Select the bottom edge of the cushion and set to: -Distance: 10mm -Angle: 65 deg	
	Create a second ruled surface from the bottom edge, set to: -Distance: 60mm -Angle: 120 deg	
	Go to Construct>Offset Plane, select the top plane and set the offset plane 410mm above. Go to Modify>Split Body and set: -Body to split: bottom ruled surface -Tool: offset plane	
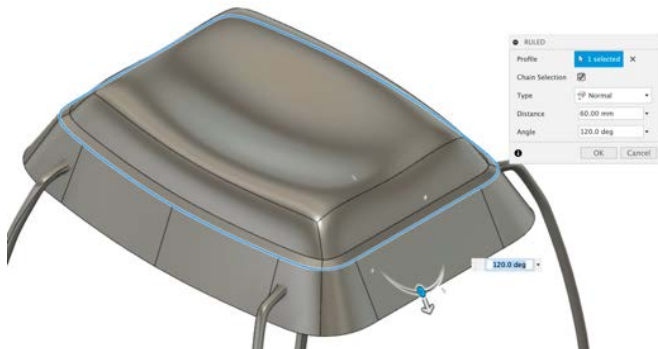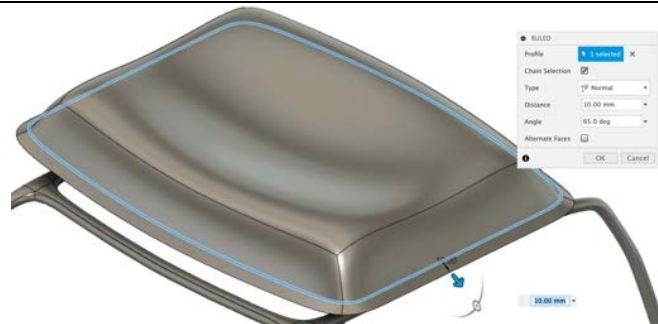
| | In the browser, find the label for the bottom section of the ruled surface. Righ-click and select "Remove" | |
| | Hide the top cushion.

Use "Patch" to close the top and bottom sections of the cushion frame.

Use "Reverse Normal" to set all surfaces in the same direction.

Use "Stitch" to connect all surfaces and turn them into a solid body. | |

5 Stand Mixer step-by-step tutorial

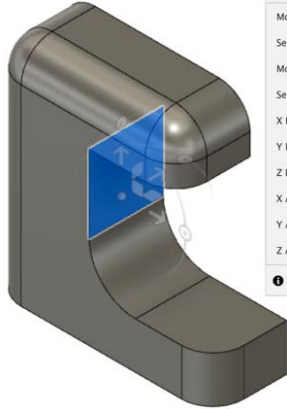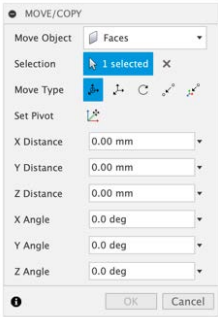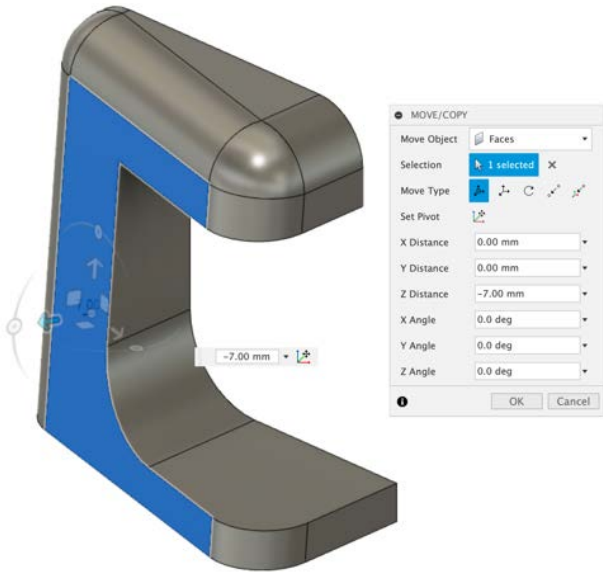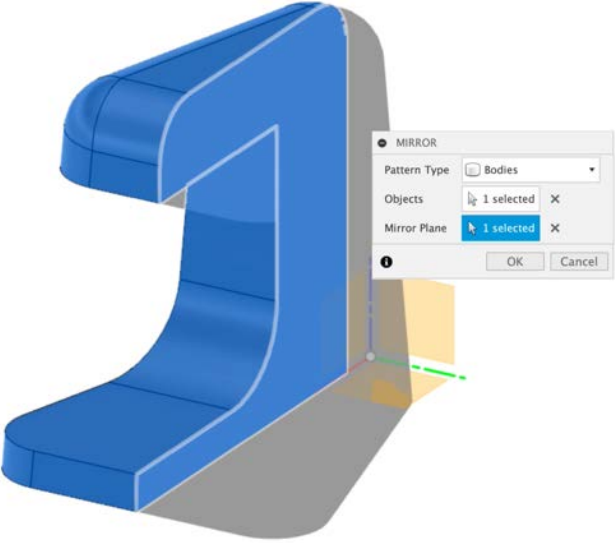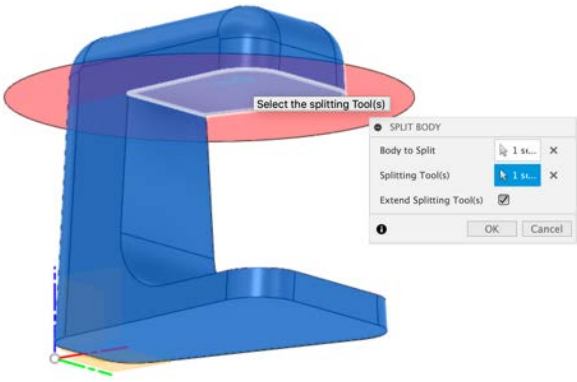| 5.1 Basic shape		
Create base shape	Make sure you're in Design>Solid environment. Go to Create>Box. Select the top plane. Create a box with dimensions: -Length: 360mm -Width: 120mm -Height: 360mm	
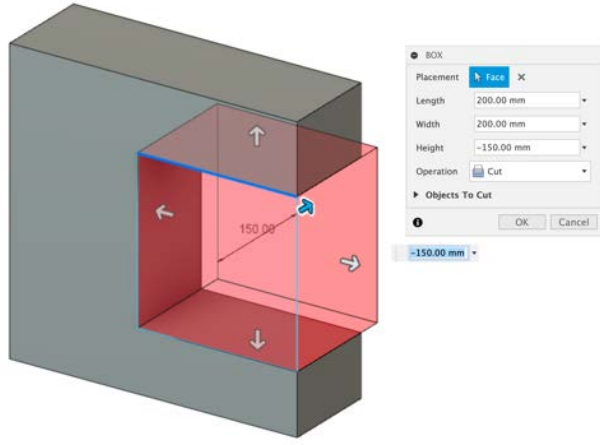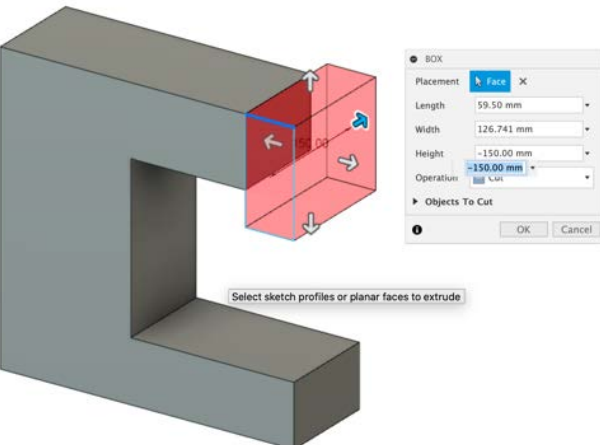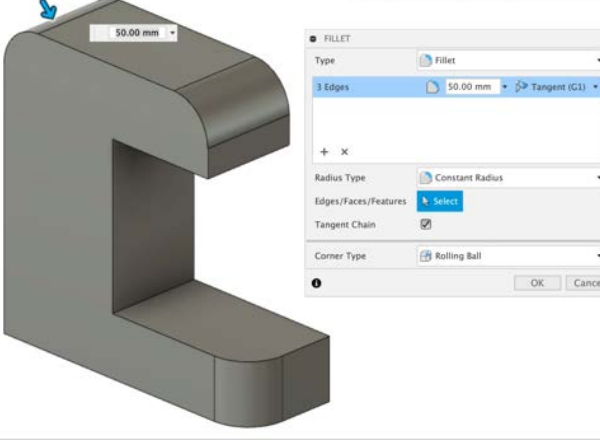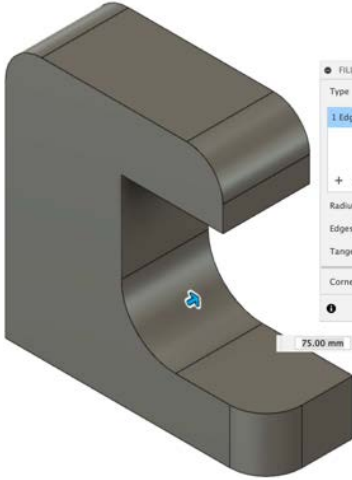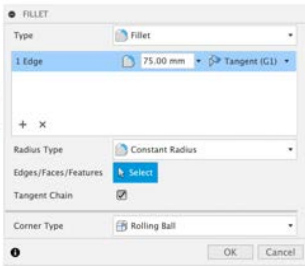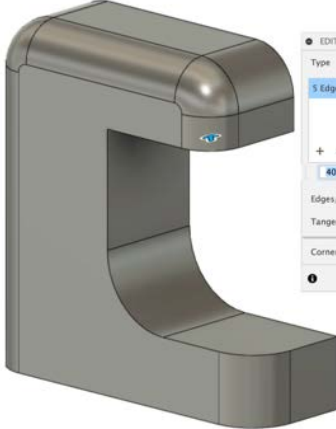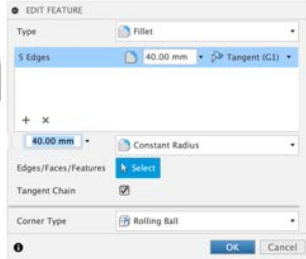
| | Create two more boxes from the side of the first box. Set their operation to "cut."

Their dimensions are not essential at this point. The important thing is to create a shape that resembles a "C", with the top section shorter than the bottom one. | |
| | Go to Modify>Fillet

Select these corners:
-top back
-top front
-bottom outer side

Set radius to 50mm | |

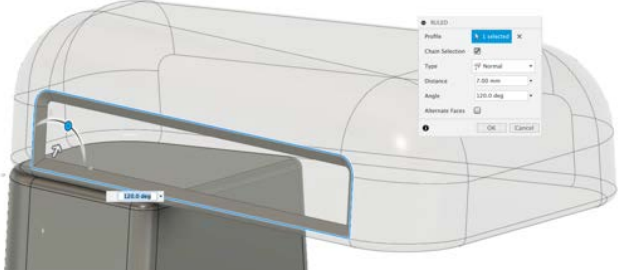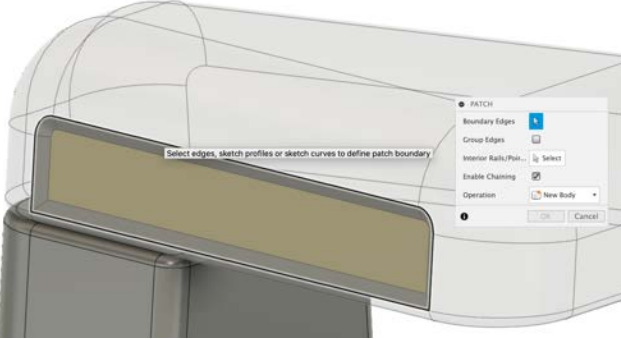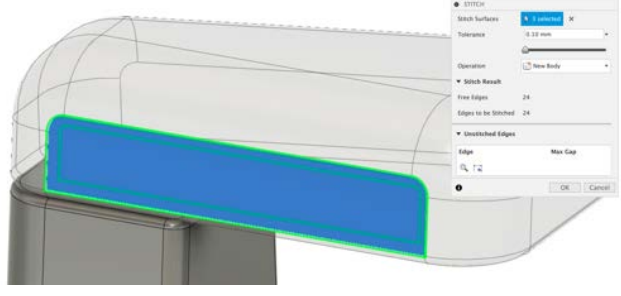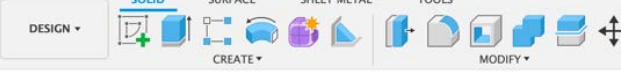|	Go to Modify>Fillet Select the bottom inner corner, and set radius to 75mm.	
	Go to Modify>Fillet Select the side edge that extends from the top to the back of the box, and set radius to 40mm.	
	Go to Modify>Move/Copy Set "Move Object" to Face. Select faces in the body to move them, in order to refine the shape/proportions of the body. Move the faces by pulling from the arrows in the Cursor Orbit.	

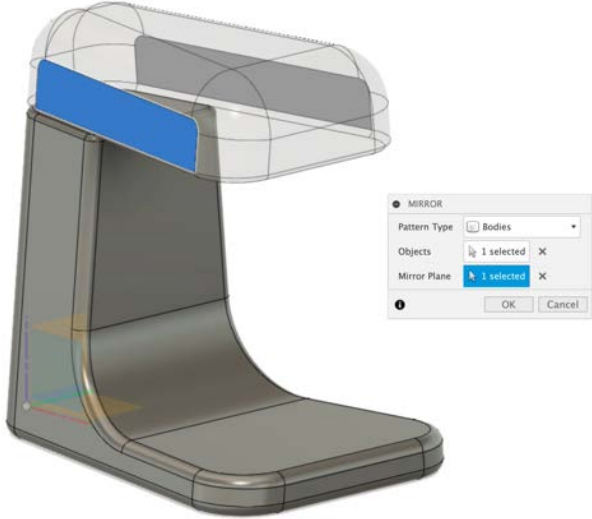|		
	Continue using "Move/Copy" to add a tapered angle to the side of the body. Adjust the angle by using the curved slider in the Cursor Orbit.	
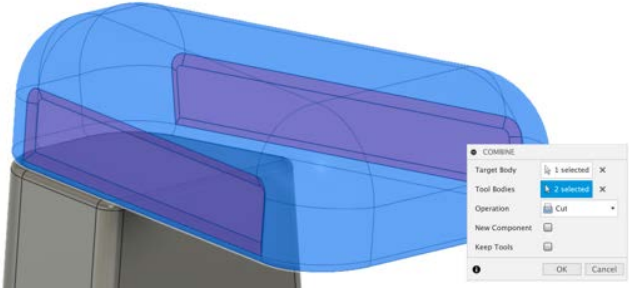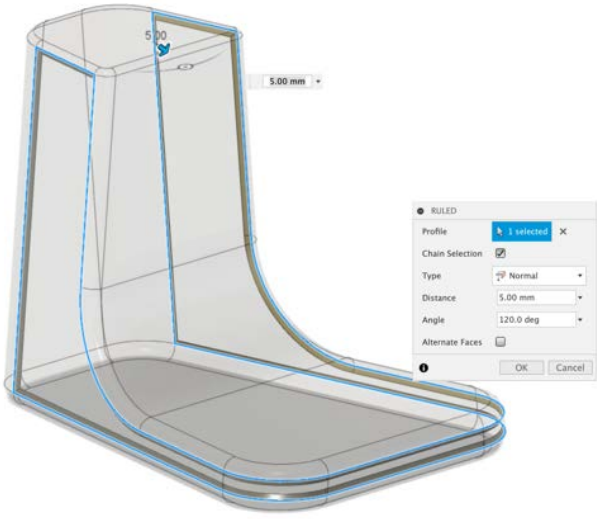
	Go to Create>Mirror Set type to Bodies. Select the body, and use that side that is straight as mirror plane.	
	Go to Modify>Combine Select the base body as "Target" and the mirrored body as "Tool" Set operation to "Join"	

5.2 Divide body into parts and add details		
	Go to Modify>Split Body Select the body and use the bottom flat face of the upper section as splitting tool. Now there are a base and upper bodies.	

	Go to Modify>Fillet Select the upper and lower edges in the front of the base, and set radius to 10mm.	
	Go to Modify>Fillet Select the edges that connect the base and upper bodies.	
	Move to "Surface" environment Go to Browser and right-click on the upper body's label. Go to Opacity control and change to 50%	

	Go to Create>Ruled surface Select the edges side's flat section, and set: -Distance: 7mm -Angle: 120deg	
	Go to Create>Patch Select the inner edge of the ruled surface to patch it. Repeat the process for the outer edge. Use Modify>Reverse Normal to adjust any surface that needs its normal flipped.	
	Go to Modify>Stitch Select all three surfaces to stitch them together and convert into a solid body.	
	Change environment to "Solid" Go to Create>Mirror Use these settings: -Pattern: bodies -Objects: ruled body -Mirror Plane: XY	

	Go to Modify>Combine. Set settings to: -Target: upper body -Tools: both ruled bodies -Operation: cut	
	Using the steps for the upper body as reference, create a ruled surface in the base body that extends along the side and front sides.	

	Create a second ruled surface that extends outwards: -Distance: 10mm -Angle: 180deg	
	Using the steps for the upper body as reference, add the following features: -Patch the outer and inner edges -Reverse normal as needed -Stitch all surfaces together -Cut the base body	

	Additional components can be added to the mixer by creating cylinders, boxes and T-Splines forms, in ways similar to the steps above.	