3D Printing Designs: Octopus Pencil Holder

This book will cover the very basic but essential techniques you need to model an organic and functional object for 3D printing using Blender. Starting with pen and paper and then moving on to the computer, you will create your first project in Blender, add basic geometric shapes, and use techniques such as extruding and subdividing to transform these shapes into complex meshes. You will learn how modifiers can automatically refine the shape further and combine multiple shapes into a single 3D printable model.

By the end of the book, you will have gained enough practical hands-on experience to be able to create a 3D printable object of your choice, which in this case is a 3D print-ready octopus pencil holder.

Who this book is written for

If you have basic knowledge of Blender and 3D printing and are interested in printing your first object, then this book is for you.

What you will learn from this book

- Get to know the guiding principles required to create 3D printer-friendly models
- Understand material characteristics, printing specifications, tolerances, and design tips
- Master the art of modifying basic shapes with Blender's powerful editing tools: extrude, loop cuts, and other transformations
- Learn techniques of editing complex meshes, smoothing, combining shapes, and exporting them into STL files for printing

Joe Larson

In this package, you will find:

- The author biography
- A preview chapter from the book, Chapter 1 'Octopus Pencil Holder'
- A synopsis of the book’s content
- More information on 3D Printing Designs: Octopus Pencil Holder
Joe Larson is one part artist, one part mathematician, one part teacher, and one part technologist. It all started in his youth when he worked on a Commodore 64, doing BASIC programming and low-resolution digital art. As technology progressed, so did Joe’s dabbling, eventually taking him to 3D modeling while in high school and college, and he temporarily pursued a degree in computer animation. He abandoned this field for the much more sensible goal of becoming a math teacher, which he accomplished when he taught 7th grade math in Colorado. He now works as an application programmer.

When Joe first heard about 3D printing, it took root to his mind, and he went back to dust off his 3D modeling skills. In 2012, he won a Makerbot Replicator 3D printer in the Tinkercad/Makerbot Chess challenge with a chess set that assembles into a robot. Since then, his designs on Thingiverse have been featured on Thingiverse, Gizmodo, Shapeways, Makezine, and other places. He currently maintains the blog http://joesmakerbot.blogspot.in/, documenting his adventures.
3D printers have arrived! Complex and beautiful objects are available at the touch of a button in our schools, libraries, or even our homes. If you have a 3D printer, learning how it works and how to design for it is the best way to be a part of this new industrial age. And the best part is that it doesn't cost a penny.

This book will teach you the things you need to know about 3D printers. Then, you will use the robust and free software, Blender, to follow step-by-step instructions through a planned project. This book is a part of a series of projects that will help you acquire the tools, techniques, and skills you need in order to make your own projects to print yourself on a 3D printer near you and share them with others online to print around the world.

What this book covers
The project in this book, octopus pencil holder, involves simple selection techniques that are unique to edit mode, modification commands in edit mode, and applying modifiers to soften and combine shapes. This technique alone can be used to create an unlimited number of cool things, once mastered.
Octopus Pencil Holder

3D printing makes it easy to combine forms and functions. Why have just a pencil holder when you can have a pencil holder that looks like, say, a cute octopus? This project is an excellent starting project because it demonstrates a simple but versatile modeling technique that involves editing a simple mesh and smoothing it in order to go into more detail.

This project will involve simple selection techniques that are unique to the Edit Mode, modification commands in the edit mode, and applying modifiers to soften and combine shapes. This technique alone can be used to create unlimited cool things once mastered.

In this book, we will cover the following topics:

- Planning the project
- The first basic shape
- Smoothing the mesh with modifiers
- Bending the tentacles
- Flattening the bottom
- Renaming objects
- Adding a pencil cup
- Adding a face
- Finishing touches
Planning the project

A pencil holder is basically a cup with a sturdy base that can be used to hold objects taller than itself, such as pens, pencils, and other items that might otherwise clutter up a desk. A cute cartoony octopus’ tentacles will provide the perfect base and prevent the cup from tipping over.

The hole in the cup should be roughly cylindrical, and about 40-50 mm wide at the base. The whole thing should stand at least 80 mm tall. And, of course, it needs a cute and friendly face; something like this:

The basic shape

Let’s get ready; it’s time to get to work:

1. Open Blender, select everything (A) in the default scene and clear (X) the scene:
2. Next, add a cylinder and an object to the scene. For this, add (\textit{Shift} + A) a new object by navigating to \textbf{Mesh} | \textbf{Cylinder}:
3. Immediately after adding the cylinder and before clicking on anything else, in the Tool Shelf operator, add parameters for Add Cylinder and change the number of Vertices from 32 to 8. Change the Radius field to 25 and the Depth to 15:

![Octopus Pencil Holder](image)

**Editing the basic shape**

This project is going to take advantage of several powerful editing tools that Blender provides. The first one is going to be the Extrude operator. Extruding takes its name from the process of creating things in real life, but in 3D modeling, extruding takes a selected part of an existing model and creates new geometry on the edge of the selected parts so that the original can be moved away but remain attached to where it came from. The result is a new shape that can then be edited.
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Extruding is a very powerful tool that's used to alter the shape of an object and create new faces that can be extruded themselves:

1. Enter **Edit Mode** (*Tab*) and switch to face the **Select Mode** (*Ctrl + Tab*):

![Select Mode](image)

2. Deselect all faces (*A*). Then, select one of the vertical sides of the cylinder.

3. Extrude it either by navigating to **Mesh | Extrude | Region** in the **3D View** menu or pressing *E* on the keyboard.
4. Extrude the face about 40 mm by moving the mouse or typing 40 on the keyboard:

5. Press Enter or click on the select mouse button to complete the Extrude action.

Like all actions in Blender, if a mistake is made in the process of extruding, press Esc or click on the right mouse button to cancel the action. If a mistake is made after this, undoing the action with Ctrl + Z is always possible.

6. Then, scale the face (S) down to about 20% (0.2) in order to create a tentacle:
7. Repeat the extruding and scaling process with the other seven vertical faces of the cylinder to create all eight tentacles:
8. Select the top face of the cylinder and extrude (E) it about 30 mm:

9. Then, scale (S) it up just a little bit to make the head bulbous:
10. Extrude ($E$) the top again—this time, about 20 mm and—and scale ($S$) it in order to give the top a more rounded shape:

Now, the cylinder has been changed into something more of an octopus-like shape. And it was mostly accomplished with the Extrude command, a truly powerful tool used to modify the shape of an object.
Smoothing the mesh with modifiers

This blocky octopus is fine for editing, but it needs to be much smoother for the final result. Fortunately, there’s a way to increase the smoothness of the model while retaining the simple geometry, which is easy to edit. This is done by adding a Subdivision Surface modifier to the object:

1. To add a Subdivision Surface modifier, click on the Modifiers tab in the Properties panel (the one that looks like a wrench):

2. Click on the Add Modifier button, and in the menu that appears, choose Subdivision Surface from the list:
With the **Subdivision Surface** modifier, the shape looks much smoother. While in the edit mode, it's clear that the original geometry is still there and acts as sort of a cage that defines the shape of the smoothed mesh. As long as the modifier isn't applied, the simple geometry can be kept for editing.

Changing the **View** setting in the modifier will affect how smooth the mesh will be. Higher values will create more complex geometry that will look smoother, but they will slow down the computer more. There comes a point where increasing this setting won't have any noticeable effect. Generally, it's best to keep this setting high enough to have a good effect on the shape but low enough to not slow down the computer.

3. For now, set **View** to 2; then, the object will look like what's shown in the following screenshot:

This isn't the final form, but it will get better. If looking at the smoothed mesh while working on the simpler mesh is confusing, the modifier can be temporarily turned off by pressing the eyeball icon on the modifier.
Bending the tentacles
Now, it's time to begin adding some details to the tentacles and give the model some personality.

Before moving ahead, let's take a look at another powerful tool when editing meshes, which is called **loop cut** or **loop subdivide**, which will be used while bending the tentacles. Loop cut adds points in the middle of an edge and all around a portion of the geometry. These points can then be transformed. Loop cut only works with edges or vertexes' select mode and will automatically switch modes when using them.

To perform a loop cut, execute the following steps:

1. Navigate to **Mesh** | **Edges** | **Loop Subdivide** from the **3D View** menu, or press **Ctrl + R**.
2. Then, move the mouse pointer near an edge, and the loop cut suggestion will be suggested.
3. When the loop cut is where desired, click on the select mouse button or press **Enter**. At this point, the loop isn't set and can still be slid back and forth in order to decide an exact location.
4. When it is where desired, press **Enter** or the select mouse button again in order to finish the operation. At any time, the operation can be canceled by pressing the right mouse button or pressing the **Esc** key.
5. Now that we know how to perform a loop cut, let's go for why we are here, that is, bending the tentacles.
6. While still in the edit mode, switch to the vertex edit mode (**Ctrl + Tab**). Add a loop cut (**Ctrl + R**) to one of the tentacles. Place the cut at the default location in the middle of the tentacle:
7. After setting the loop cut, change the operator settings at the bottom of Tool Box and then change **Number of Cuts** to 2:
8. Deselect all points (A) and select the points at the end of the tentacle. Rotate (R) the points around the z axis (Z) and move (G) them along the x and y axes (Shift + Z) to bend the tentacle a bit:

9. Expand the selection (Ctrl + NumPad + the (+) sign). Again, rotate (R) the selection around the z axis (Z) and move (G) it along the x and y axes (Shift + Z) to bend the tentacle a bit more:
10. Expand the selection again. Rotate (R) and move (G) the tentacle, being careful to constrain the movement:

11. Check your tentacle. Adjust your view and make sure that from the front or side views, the twisty tentacle is still on the same level as the other tentacles and not twisted up and down. If it isn't, then your movements weren't constrained properly:
Octopus Pencil Holder

12. If not correct, then undo *(Ctrl + Z)* your movements and try again. There’s a way to ensure that the movements are constrained properly. You can do this easily by doing all your transformation while in the top view (NumPad 7). It may be necessary to select points in the *Wireframe view* *(Z)* to get all the points and not just the ones on top.

13. Move to the next tentacle and cut it through loops. This time, while the loop location is being displayed, before clicking on the mouse or pressing *Enter* the first time, try to press the 2 key to quickly change the number of cuts to 2. This is a shortcut method that can be used optionally instead of changing the parameters after the cut:

14. Work around, cutting, selecting, moving, and rotating each tentacle. Give each one a different twist, being careful not to overlap them. If the tentacles overlap, the model won't print properly when exported:
Your octopus doesn't need to look exactly like this. Make it your own. When all the tentacles have been detailed, it should look much more like an octopus.

Some 3D printers won't be able to print this model if it's too big, so keep those tentacles tucked in and don't let them fly too far. The smaller 3D printer build areas are about 150 mm or 6 inches across. If the total width of your model is more than that, you'll need to think about the printer you're designing this for.

**Flattening the bottom**

A friendly 3D print needs to have a solid, flat base. There is more than one way the bottom of a model can be flattened. For one, the geometry can be edited to be flat. Alternatively, a floor object can be created and cut out of the object using a Boolean modifier. Since this project is using the subdivision surface modifier, editing the geometry can be complicated. So, the floor method will be used in this project.
Octopus Pencil Holder

Looking at the model from the front orthographic view (NumPad 1 and NumPad 5), it's clear that the parts of the tentacles that sit below the x and y axes (the red or green line depending on the view) is where the model needs to be cut off in order to create a flat, printable base:

So, let's get started:

1. First, exit the Edit Mode (Tab).
2. Ensure that the 3D cursor is at the 3D View origin point (Shift + C).
   Then, create a cube (Shift + A) by navigating to Mesh | Cube:
3. The cube cannot be seen in the solid view because it's completely inside the octopus, so with the cube still selected, switch to the local view (NumPad /) to view the cube by itself:

The cube is half above and half below the origin. Fortunately, there's an easy way to create a floor and ensure that no matter how it's scaled, the top remains on the XY plane.
4. In the **Edit Mode** (*Tab*), with all points selected (which should be selected by default; *A* is the hotkey if they're not), move (*G*) along the *z* axis (*Z*) by 1 unit (*-1*).

5. Then, exit the **Edit Mode** (*Tab*) and scale (*S*) the cube. Note that the top remains on the *XY* plane. This is because object transformations are made in relation to the object's origin. When the points were all moved in the **Edit Mode**, the origin wasn't affected. So now, when scaling the top, because it's in line with the cube's origin, it remains on the same plane:
6. Exit the local view (NumPad/) and scale (S) the cube until it covers the bottom of the octopus body:
In the **Solid** view \((Z)\), it may look like the octopus has a flat bottom, but in the **Wireframe View**, \((Z)\), it is clear that the cube is only hiding the bottom part. For the final model, the bottom needs to actually be flat:

7. Select the octopus body again, and in the **Modifier** tab, add a Boolean modifier:
The Boolean modifier has the option of combining the selected object with another object in a number of ways; **Intersect**, **Union**, and **Difference**. **Union** joins the two objects, so that they become one. **Difference** cuts the second object out of the first, and **Intersect** leaves only the part where the two objects overlapped. Boolean is a powerful tool and it's good to be aware of how to use it.

The following screenshot shows the three ways to combine selected objects with other objects:

1. Change the **Operation** value of the Boolean modifier to **Difference**. Click on the **Object** text field and choose **Cube** from the list that pops up:
2. Now the octopus body actually has a flat bottom that's suitable for 3D printing. This can be confirmed in the Wireframe view (Z):

The Boolean modifier is one of the most important tools in Blender that's used to create 3D printable objects. However, it can also be one of the most frustrating to use. The Boolean modifier demands that a mesh be clean and free from holes or problems. Even things that aren't obvious while looking at the mesh, such as duplicate points or flipped faces, can cause problems with the Boolean operation. If your Boolean operation isn't working, here are a few steps you can perform in order to try to fix it:

1. In the Edit Mode, select all the points (A), and in Tool Shelf (T), locate the Remove Doubles button in the Tools tab and click on it.
2. With all points still selected, switch to the Shading/UV tab, locate the Recalculate button, and click on it:
3. Now, exit the **Edit Mode**, and the Boolean modifier may work in many cases. If these fixes don't make the Boolean modifier work, then the best option may be to start over again, making sure that you perform all the steps correctly.

### Renaming objects

Now that there is more than one object in the scene, leaving the objects’ names as the names of the basic shapes they started as can be confusing, especially when other objects enter the scene. It's best practice to name objects as something more descriptive. Let's see how to rename an object.

Objects can be renamed in the **Object** tab in the **Properties** panel, the one marked with an orange cube icon, as shown in the following screenshot:
1. Select **Octopus Body** in 3D View (or **Cylinder** in the Outliner panel). In the Objects menu, click on the **Name**, currently **Cylinder**, and change it to **Octopus Body**:

![Octopus Body](image)

2. Now, select the cube, and in the Objects menu, change its name to **Floor**.

3. Since the floor has served its purpose, in order to avoid it getting in the way or getting accidently transformed, hide it from the view by selecting it, and then, in the 3D View menu, navigating to **Object** | **Show/Hide** | **Hide** or pressing **H**. The object is still in the outliner view but hidden in the 3D view:

![Floor](image)
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Hidden objects can be unhidden by navigating to **Object | Show/Hide | Show All**, pressing $Alt + H$, or pressing the eye icon next to the object in the **Outliner** panel.

**Adding a pencil cup**

The octopus model looks appealing so far, but it can be functional as well. The plan for this project was a cup holder, so it needs to have the shape changed so that things can be put inside it:

1. To start, temporarily turn off the subdivision surface modifier by locating the **Subsurf** modifier in the **Modifiers** tab and clicking the eye icon in it. Now, the simplified geometry is easier to work with:
2. Go to the **Face Select** mode (**Ctrl** + **Tab**) in the **Edit Mode** (**Tab**). Now, select the topmost face of the octopus:

![Octopus Pencil Holder](image)

3. Switch to **Wireframe** (**Z**) and the **Front Ortho** view (**NumPad 1**) and extrude (**E**) the top face into the body. Stop just a little above the red x axis line:
It may be necessary to scale (S) the bottom of the cup a little so that it fits inside the body.

After scaling the body will look this:
Now, the shape is generally right for a pencil holder. Turn the subdivision surface modifier back on by clicking on the eye icon in the **Subsurf** modifier in the **Modifiers** tab. You'll notice that the cup bottom is a bit too round to be a space-efficient cup:

In the **Edit Mode**, edges can be marked with **Crease** to indicate to the **Subsurf** modifier that they should be sharpened.

5. With no points selected (A) in edge or point, select the mode (**Ctrl + Tab**), hold down **Alt** on the keyboard, and select and click on one of the edges around the top lip of the cup in order to select all the points in a loop around the top of the mug:
6. From the 3D View menu, navigate to Mesh | Edges | Edge Crease or press Ctrl + E on the keyboard. Move the mouse pointer up or down in order to increase or decrease the amount of crease applied to the edge until it looks good:
7. Hold Alt and select and click on one of the edges at the bottom of the cup to loop and select all the points around the bottom of the cup. It may help to switch to the Wireframe mode (Z) or temporarily turn off the Subsurf modifier:

8. This time, set the crease value by finding the Mean Crease setting in Properties (N). This setting can be any decimal number between 0.0 (off) and 1.0 (maximum). Click on the setting and enter 1, and then press Enter to set the value. Now, the bottom of the cup is flat:
This sort of edge creasing is a powerful way to control the Subsurf modifier. Note that the bottom of the cup is still circular even though the original mesh is an octagon. Subsurf smoothens out the other edges even if it's told to crease others. It's very smart!
Adding a face

Functionally, the design is complete, but it's the little details that really make it. This little octopus would be much cuter with a face:

1. To start making a cute face, make sure the **Edit Mode** is off (**Tab**) and make sure the 3D cursor is at the origin (**Shift + C**). Now, create a circle (**Shift + A**) by navigating to **Mesh | Circle**:

2. The circle is hidden inside the octopus, so with the circle still selected, switch to the local view (**Numpad /**). Since this circle will become the face, it's good to name it **Face** using the same method to rename the object as the one used earlier.

   The circle is a flat object that has no face and is just a ring of points and lines. That's easy enough to fix:
3. Switch to the **Edit Mode** (Tab). Now, with all the points or edges selected (A) from the 3D View menu, navigate to **Mesh | Faces | Make Edge/Face** or press F on the keyboard:
Octopus Pencil Holder

The Make Edge/face command attempts to make a connected face from the selected vertices or lines. It can be quite intelligent, but if the points are not all flat, the edges may twist unexpectedly.

4. While still in the **Edit Mode**, switch to the top view (Numpad 7), and with all the points still selected, move (G) them to the left of the green y axis:

Duplicating an object outside of the **Edit Mode** creates a new object. However, duplicating points in the **Edit Mode** doesn't technically create a new object. Whatever is selected is duplicated while remaining a part of the same object. Objects in Blender can have many parts to them, all inside the same object.

5. Duplicate (**Shift + D**) all the points and place the duplicated points on the opposite side of the green y axis line:
In this way, objects created while in the **Edit Mode** are just points, lines, and faces added to the existing object, even if they're not connected.

6. While still in the **Edit Mode** (making sure the 3D cursor is still at the origin), add *(Shift + A)* a plane to the face object by navigating to **Mesh** | **Plane**: 
7. Move (G) the plane down along the y axis (Y) about 3 units:

8. Deselect all the points (A) and select the two points at the top of the plane. Then, scale (S) them up about twice in order to create a smiling mouth:
9. The shapes now look like a face but only in two dimensions. To give it the additional dimension required, select all the points (A twice) and extrude them (E) about 4 or 5 units.

10. Exit the Edit Mode (Tab). The face template is now complete, and it just needs to be scaled and positioned.
11. Rotate (R) the face object around the x axis (X) by 90 degrees (90):

12. Exit the local view (Numpad /). The face is hidden inside the body, so move (G) it in the z and y axes (Shift + X) until it's outside the octopus body:
13. In front of the **Ortho** view (NumPad 1), scale the face (**S**) and move (**G**) it in the **z** axis (**Z**) until it's positioned properly:

14. In the side **Ortho** view (NumPad 3), move (**G**) the face along the **y** axis (**Y**) until it's partway into the body:
It may help to use the **Wireframe** view to ensure that the face is deep enough but not too deep. About four or five small squares (or 0.4 or 0.5 real-world millimeters) is perfect. If the face is too deep, it may cut all the way through into the cup space and may create an overhang problem. The top of the mouth will rely on some bridging during printing, and that's okay.

15. Now, select the body, and in the **Modifier** tab, add a **Boolean** modifier. Change the settings of the Boolean modifier to be a **Difference** operation with the **Face Object**.

16. The effect of this new modifier won't be visible immediately, so select the face object and hide it (H):
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Your octopus pencil holder is now complete.

17. Select the body, and in the Info panel menu (at the top of the screen), navigate to File | Export | Stl (.stl) to view the 3D-print-ready octopus holder. Ensure that you choose a directory where you can find the file later in order to send it to the printer:
Finishing touches
Now, the octopus is done, but don't stop here. Use your imagination to make this design your own. Add accessories and personality, change the base shape, and come up with your own design to make this something you'll want to share. Just remember the rules about overhangs in your design and the sky is the limit:

Summary
This project was functional but also cute. The techniques of vertex editing basic shapes in the Edit Mode with extrusion and loop cuts and then using the mesh smooth modifier and Boolean modifier in combination to further modify them can be used to create endless projects of any type and shape. Not all designs need to be cute, but they also don't all need to be purely practical. Combine a practical design with an aesthetic element in order to add personality and really take advantage of what 3D printing can offer.

Happy designing!
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