

Laboratory Teaching Manual 1

SCIE 1005
Integrated Science Laboratory

Hong Kong Baptist University
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Faculty of Science

Department of Computer Science

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Integrated Science Laboratory

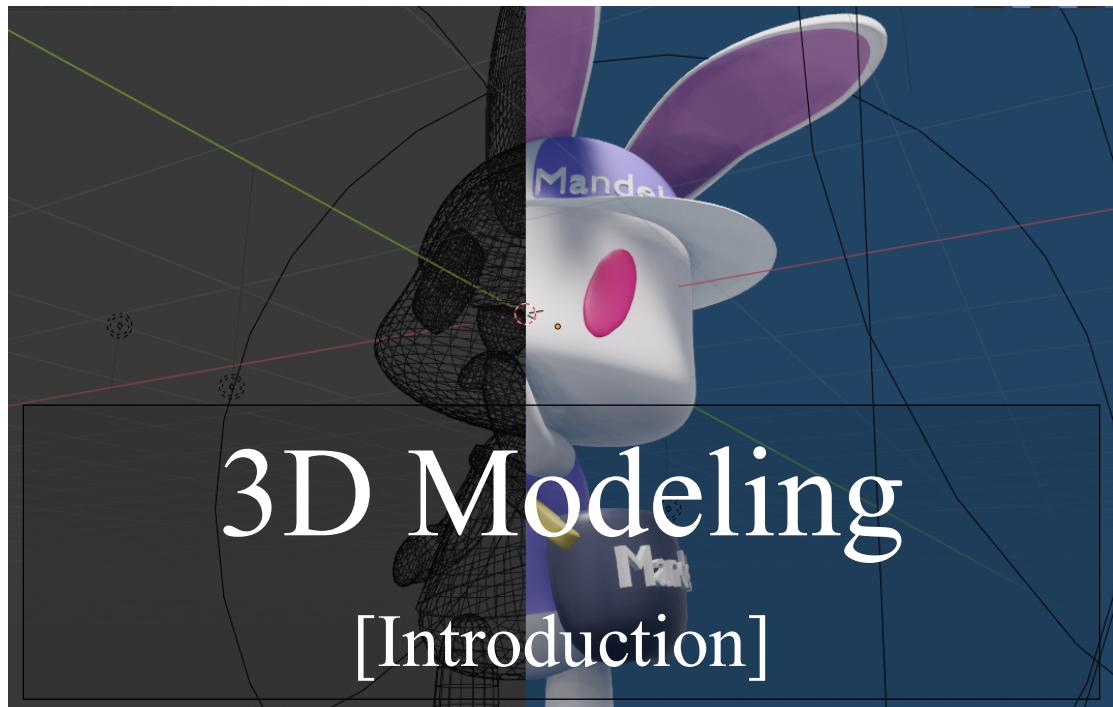
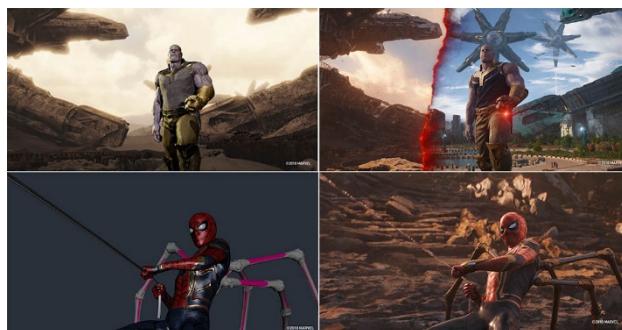
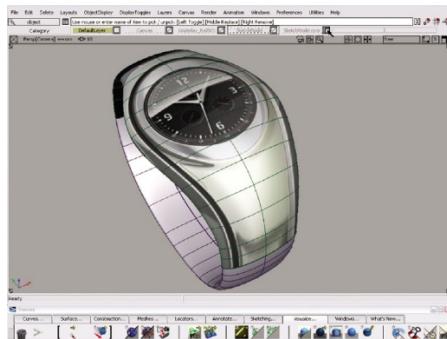


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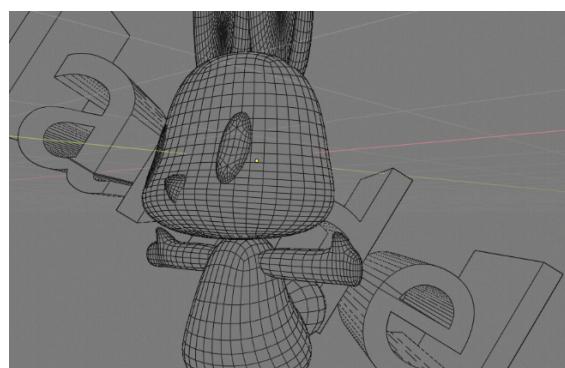
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Introduction

3D modeling is widely used in different areas including product design, packing design, advertisement, movies, cartoons, video games, etc. 3D models can be generated by using 3D scanners or created manually by using 3D editor software.



In computer graphics, 3D modeling is the process of developing a 3D model. A 3D model consists of a collection of vertices, edges, faces and mesh in 3D space – two vertices form an edge; three or more edges form a face; faces form a mesh; meshes form an object.



A 3D model can be used for producing a physical object using 3D printing technology nowadays. 3D printing is very similar to inkjet printing, but the “ink” is another material. The 3D printer does not only print on a flat surface. It prints objects in successive layers of material. The objects printed by the 3D printing can be the previews that help designers to adjust and improve their designs. Some companies even produce their products using the 3D printing technique directly.



The 3D printed house

Source: <https://www.cnet.com/videos/we-visited-the-first-3d-printed-house/>



The 3D printed food

Source: <https://www.digitaltrends.com/cool-tech/3d-printed-food-waste-upprinting/>

The plastic 3D printer uses plastic as “ink” to print 3D objects. It becomes cheaper (less than 10 thousand Hong Kong dollars) and smaller (desktop size). It allows us to print 3D plastic objects at home.

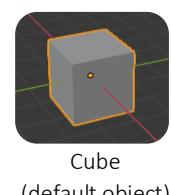
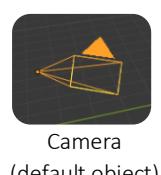
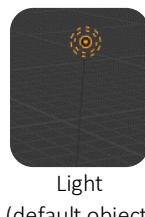
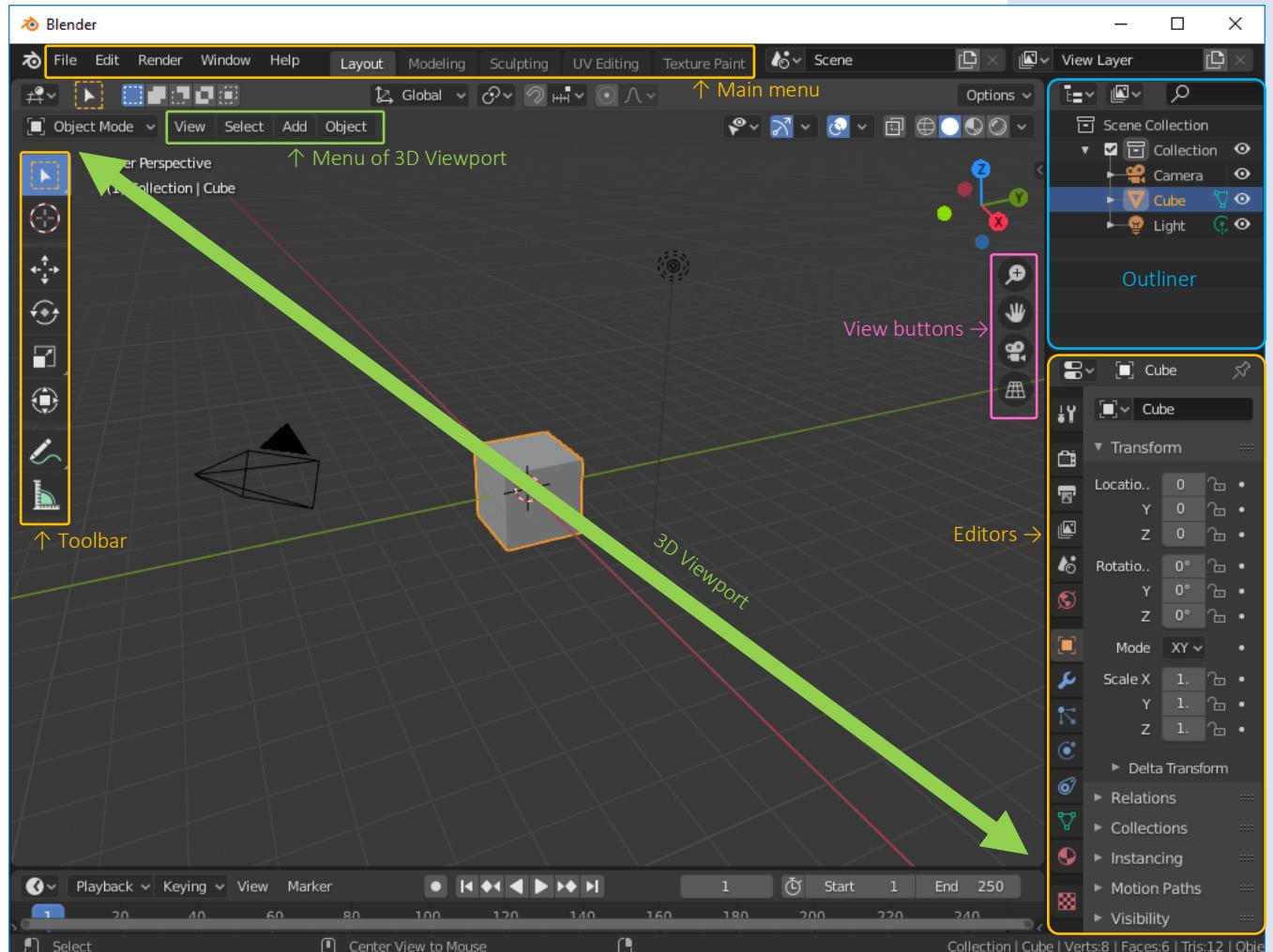


Blender

Blender is a free, popular, and powerful tool for creating the 3D model and 3D animation. In this lab, we will discuss how to use it. First, you need to download and install Blender in your computer.

<https://www.blender.org/download/>

The following is the main user interface of Blender:

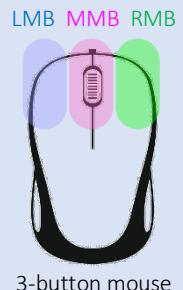


Operation Method of Blender

Prerequisites

To make your learning smooth, you need to know the basic mouse operations in advance. The following are the basic mouse operation terms:

- LMB = Left Mouse Button
- MMB = Middle Mouse Button (wheel)
- RMB = Right Mouse Button
- Click = press and release LMB
- Double-click = Click twice rapidly
- Right-click = press and release RMB
- Drag = hold LMB and move the mouse



Viewport

In Blender, we watch the objects inside the scene (3D virtual world) through the viewport. The viewport is not like a TV programme shown on television. It allows us to rotate and move the view. Therefore, we can watch the objects from different angles.

Rotate the View

Imagine that a cube, just like the default object shown at the center of the viewport, has total of six faces. We can see some faces through the viewport, but its rear faces cannot be seen. So, we rotate the view to see the other faces.



View rotator

The **View Rotator**, shown on the top-right corner of the viewport, is used for rotating the viewport. We can rotate the view by dragging it. You may use MMB to get the same effect – hold MMB and move the mouse to rotate the view.

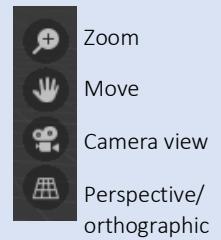
The color circles shown in the view rotator are preset viewpoints. With these viewpoints, we can change the view rapidly.

	Right viewpoint – View the left side of the object. shortcut: Numpad3
	Left viewpoint – View the right side of the object. shortcut: CTRL+Numpad3
	Front viewpoint – View the front side of the object. shortcut: Numpad1
	Back viewpoint – View the rear side of the object. shortcut: CTRL+Numpad1
	Top viewpoint – View the top side of the object. shortcut: Numpad7
	Bottom viewpoint – View the bottom side of the object. shortcut: CTRL+Numpad7

Zoom and Move the View

We can also make use of the zoom and move functions to change the view. There are four view buttons on the right-hand side of the viewport. The first one is used for zooming, the second one is used for moving. To zoom and move the view, you only need to drag these two view buttons.

You may use MMB to get the same effects – scroll MMB to zoom in and out; hold SHIFT and MMB and then move the mouse to move the view.



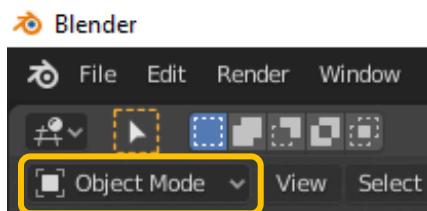
Camera View

We can switch between the camera view and normal view by clicking the third button. The camera view just like we look at the object through the default camera. We will make use of it later in this lab.

Object Interaction Modes – Object Mode and Edit Mode

Blender provides many types of objects. Most of them are used for creating 3D models. **Mesh** is a commonly used type. The default **Cube** belongs to the mesh type. For building a 3D model, we may make some simple editing (move/rotate/scale) to the meshes. But that is not enough for building more complicated models. We need to change the shapes of the meshes by moving the vertices.

For simple editing, we do it in the default object interaction mode – “Object Mode”. For changing the shapes of the meshes, we do it in the “Edit Mode”. We can switch the object interaction mode by using the combo box located at the top-left corner of the viewport. Next, we discuss how to edit objects in the object mode and edit mode respectively.

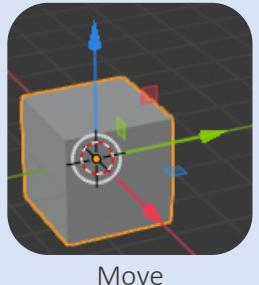
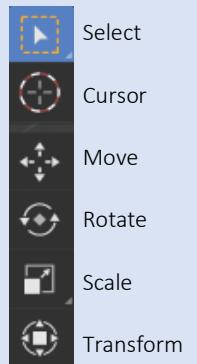
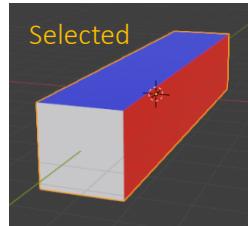
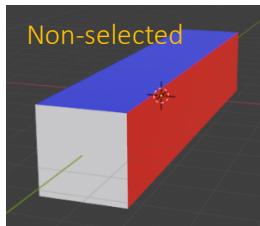


Editing Object in Object Mode

A toolbar shows on the left-hand side of the viewport, which provides tools for editing the objects.

Select Object

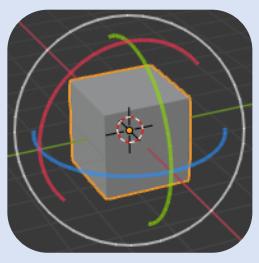
To select an object, we use the “Select” tool and then click an object. To select multiple objects, we select objects by using **CTRL+Click**. Or, hold **LMB** and move the mouse to select objects. We can also press **A** to select all objects. The selected objects are highlighted with the orange outlines.



Move

Move Object

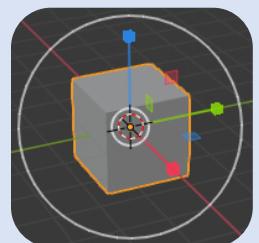
The “Move” tool is used for moving the selected object(s). We drag the arrows to move the objects along the axes. Or, we drag the little planes to move the objects over the specific planes.



Rotate

Rotate Object

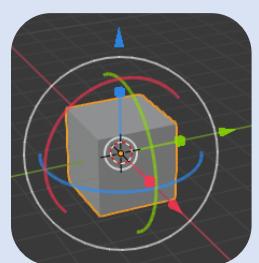
The “Rotate” tool is used for rotating the selected object(s). We drag the arcs to rotate the object(s) along the axes. Or, we drag the outer circle to rotate the object(s) basing on the current view.



Scale

Scale Object

The “Scale” tool is used for resizing the selected object(s). We drag the small cubes to resize the object(s) along the axes. Or, we drag the small planes to resize the object(s) on the specific planes. We can also drag the circle to resize the object(s), the width, height, and depth of the object(s) will be changed in the same scale rate.



Transform

Transform Object

The “Transform” tool combines the functions of the “move”, “rotate”, and “scale” tools.

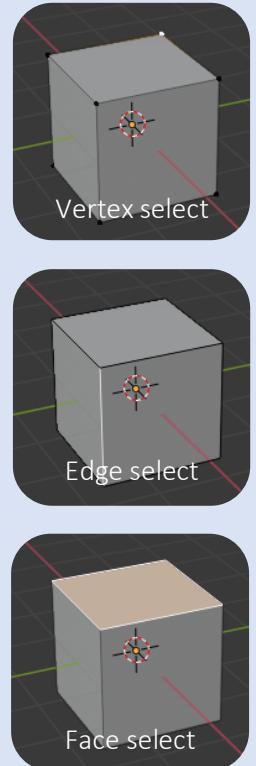
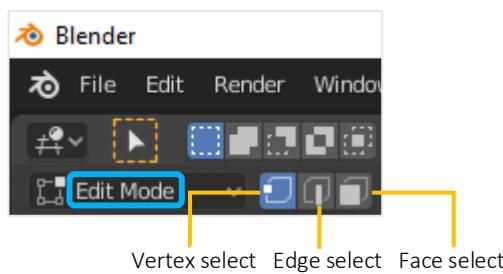
Setting Cursor

The “Cursor” tool is an advance tool. In this lab, we will not discuss it.

Editing Object in Edit Mode

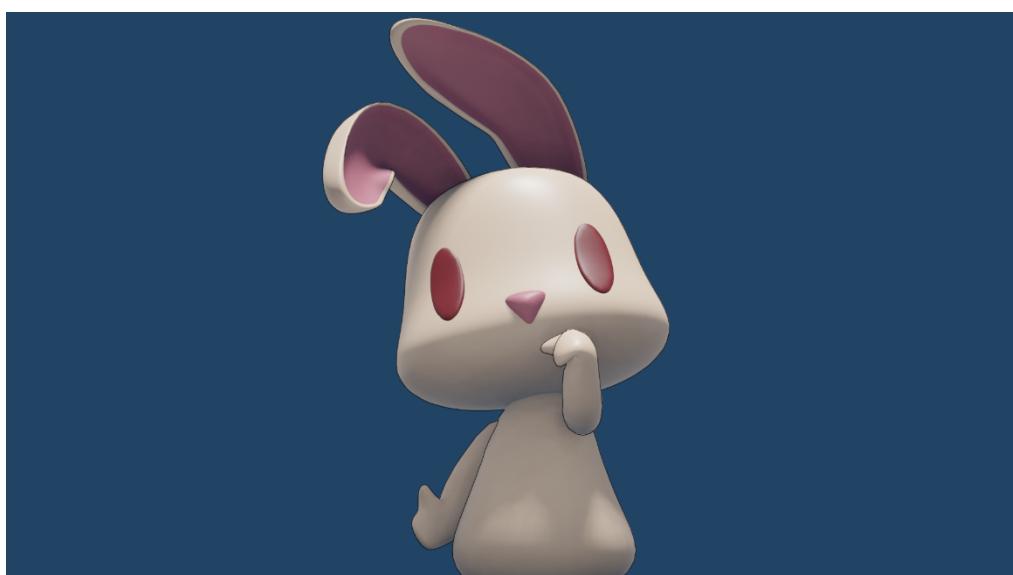
Assume that a cube is selected, and Blender is switched to “Edit Mode”. You will see that some additional markers (points) are added on the cube. These markers represent vertices. Because the cube is a mesh that consists of vertices, edges, and faces. By moving the vertices, the shape of the object will be changed.

We may edit edges or faces instead of the vertices. There are three buttons next to the combo box of the object interaction mode.



Besides, more tools are added to the toolbar. You can see that the six tools we discussed still be in the toolbar. Their usages are the same as in “Object Mode”, but the participants are the selected vertices/edges/faces instead.

Creating 3D Model



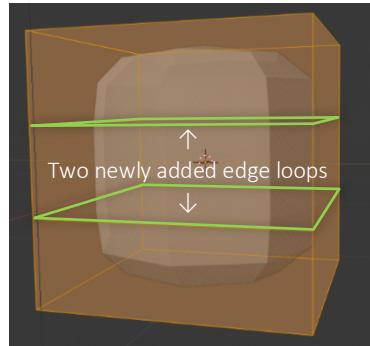
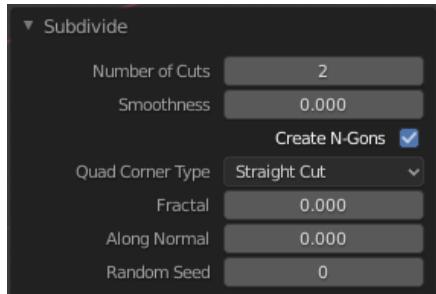
After understanding Blender’s user interface and its operation method, we now are going to create a 3D rabbit. The rabbit consists of different parts – head, body, legs, and arms. Let’s complete the parts one-by-one.

Adding Head

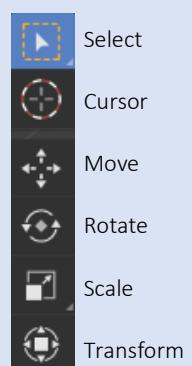
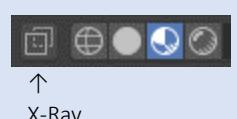
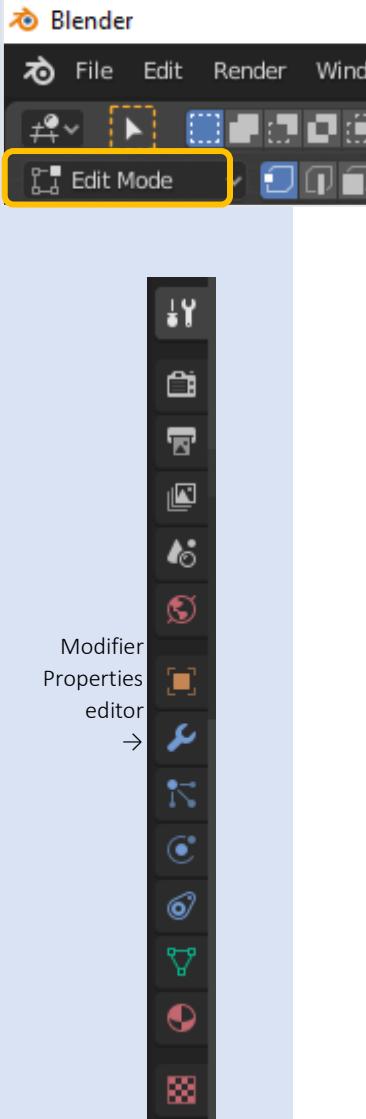
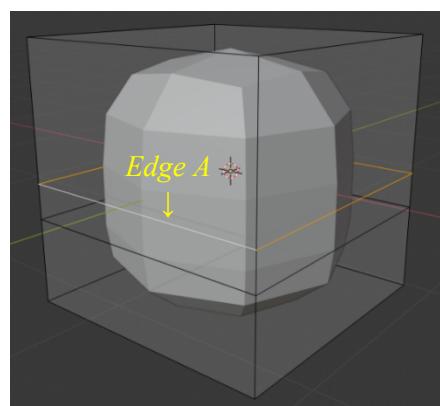
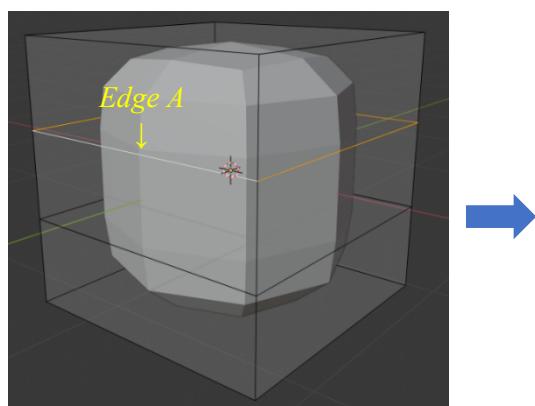
The rabbit head can be separated into a few parts including head core, eyes, nose, and ears. Let's follow the steps below to create the rabbit head.

Head Core

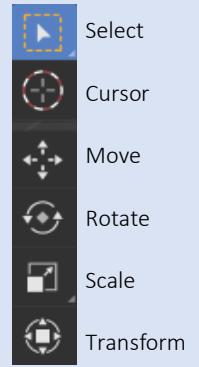
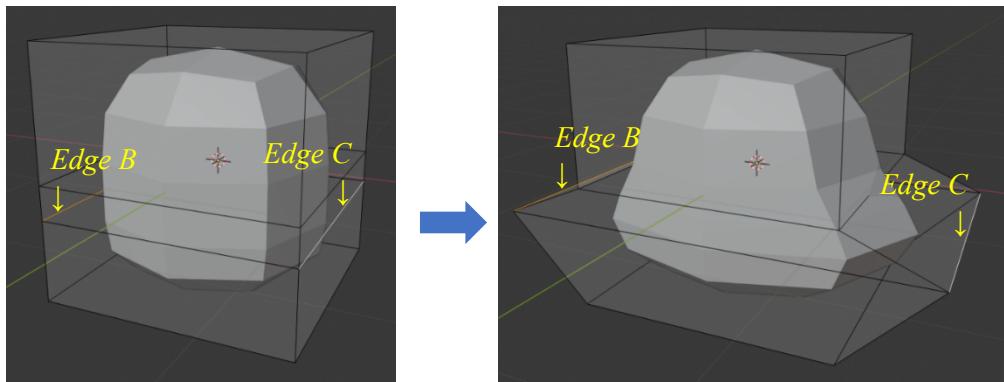
1. Click menu “File” > “New” > “General” to create a new document.
2. Click the cube to select it and switch to “Edit Mode”.
3. Go to the “Modifier Properties” editor, click “Add Modifier” and select “Subdivision Surface”.
4. Enable “X-Ray” and switch to “Edge select”.
5. Select all **vertical** edges and then click the menu “Edge” > “Subdivide”.
6. In the “Subdivide” pop panel (*shown in the bottom-left corner*), change “Number of Cuts” to 2.



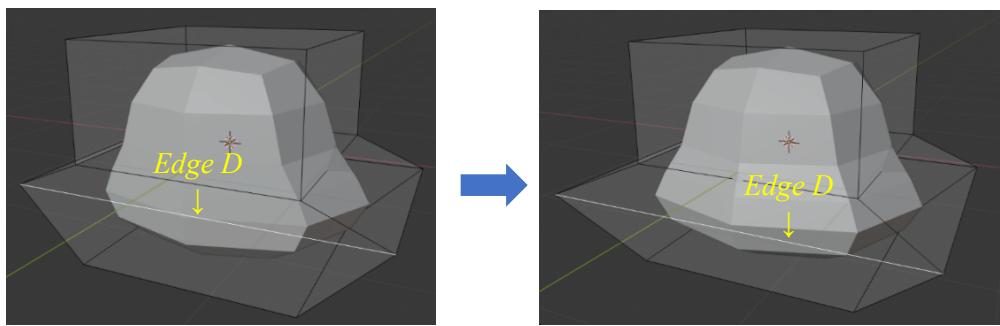
7. Disable “X-Ray”.
8. Click the menu “Select” > “None” to deselect all.
(*you may click the empty area to deselect all*)
9. Hold ALT and click Edge A to select the edge loop. Then, move the selected edges down a bit.



10. Select Edge B and Edge C. Then, scale them along X-axis.



11. Select Edge D and move it along Y-axis.



12. Go to the “Modifier Properties” editor.

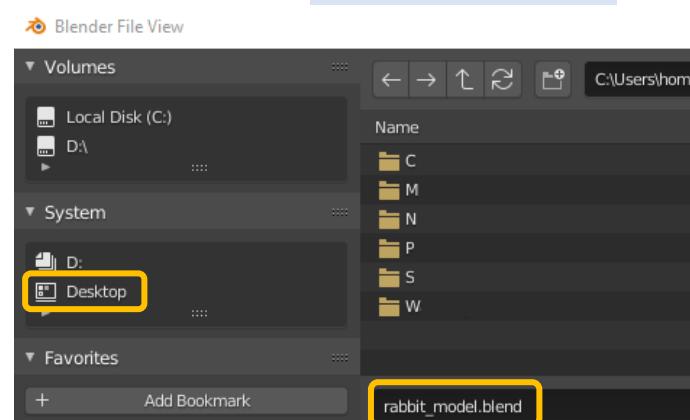
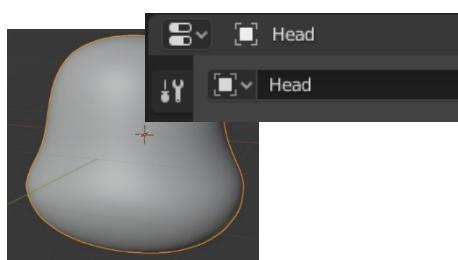
13. Change “Render” and “Viewport” of the “Subdivision Surface” modifier to 3.

14. Press A to select all the edges. Click menu “Face” > “Shade Smooth”.

15. Move the edges for further adjustment.

16. After the adjustment, switch back to “Object Mode”.

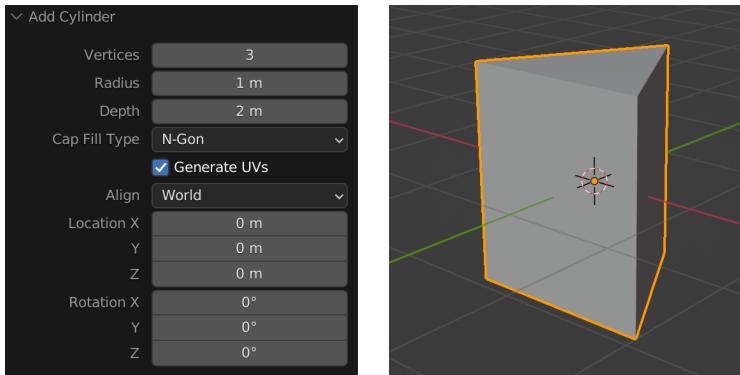
17. Go to the “Object Properties” editor, change the name to “Head”.



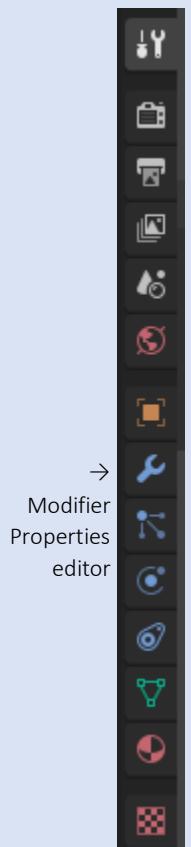
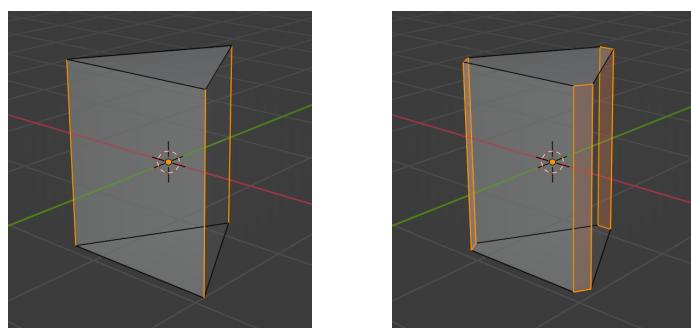
18. Press CTRL+S to save your work to the desktop and name it “rabbit_model.blend”.

Nose

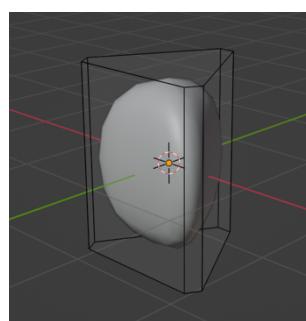
1. Add a new cylinder by clicking the menu “Add” > “Mesh” > “Cylinder”.
2. In the “Add Cylinder” pop panel, change “Vertices” to 3.



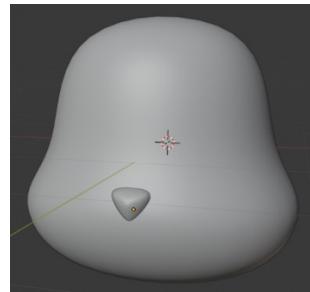
3. Move it along Y-axis and put it in front of the head.
4. Make it smaller using the scale function.
5. Switch to “Edit Mode”.
6. Select all vertical edges. (*You may enable the X-ray function to make the selection easier*)
7. Then, click the menu “Edge” > “Bevel Edges” and move the mouse to adjust the level of the bevels. Then, press the LMB to confirm.



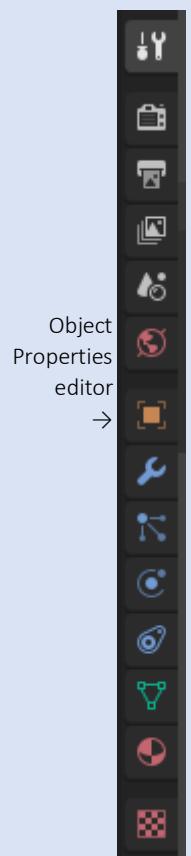
8. Go to the “Modifier Properties” editor and add a “Subdivision Surface” modifier. Change “Render” and “Viewport” to 2.
9. Select all edges, click the menu “Face” > “Shape Smooth”.



10. Switch back to “Object Mode”.
11. Rotate it -90° along X-axis.
12. Go to the “Object Properties” editor, rename it to “Nose”.
13. Adjust the width and height of the nose. Then, put it on the head properly.

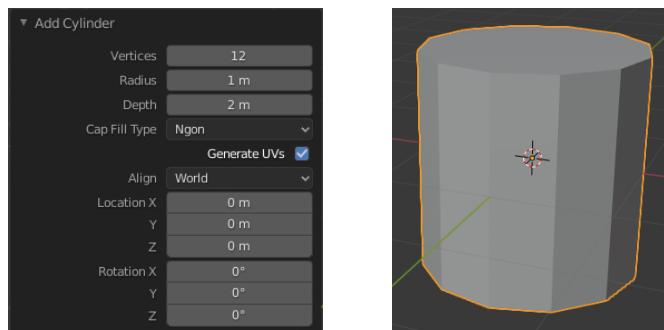


14. Press **CTRL+S** to save.

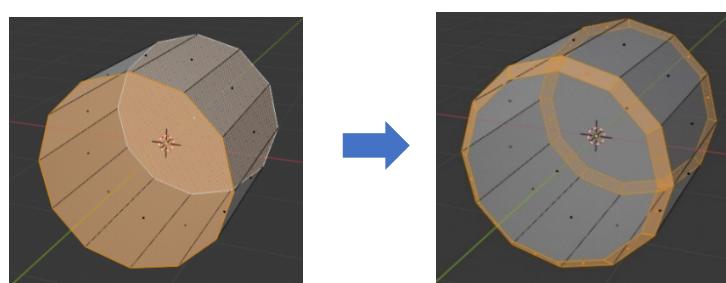


Eyes

1. Click menu “Add” > “Mesh” > “Cylinder”.
2. In the “Add Cylinder” pop panel, change “Vertices” to **12**.



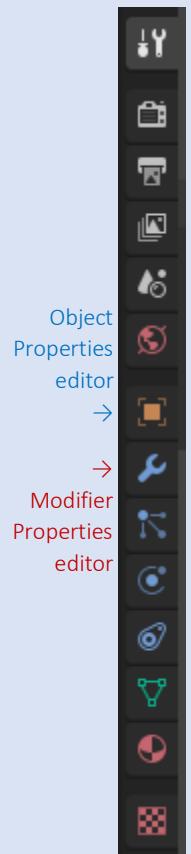
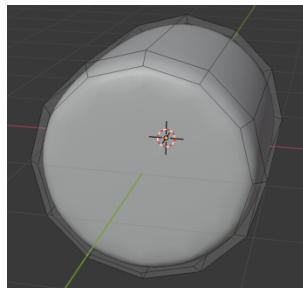
3. Rotate the cylinder 90° along X-axis by pressing **R** > **X** > **90** > **Enter**.
4. Switch to “Edit Mode”.
5. Switch to “Face select” and select the front and rear faces.
(You may enable the X-Ray function to make the selection easier)
6. Click menu “Edge” > “Bevel Edges”. Move the mouse to adjust the rate of the beveling. Then, press the LMB to confirm.



7. Go to the “Modifier Properties” editor and add a “Subdivision Surface” modifier. Change “Render” and “Viewport” properties to 2.

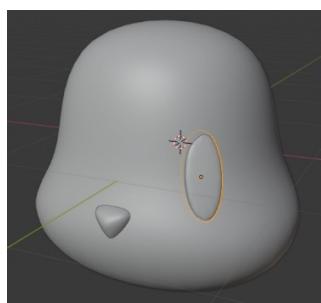
8. Press A to select all.

9. Click menu “Face” > “Shade Smooth”.



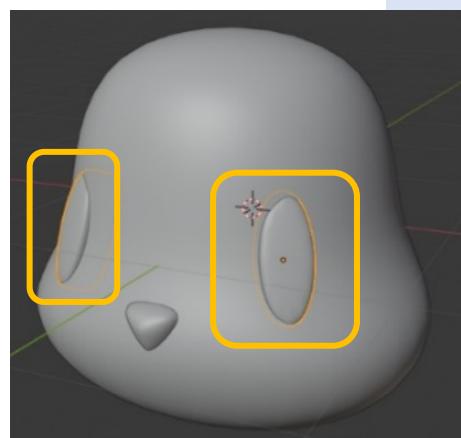
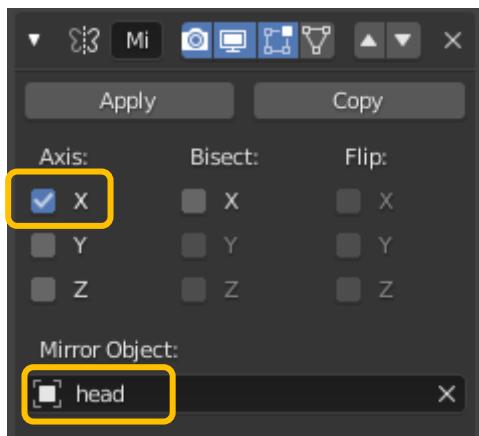
10. Switch back to “Object Mode”.

11. Adjust the width, height, and angle. Then, put it on the head properly.



12. Go to the “Modifier Properties” editor, add a “Mirror” modifier.

13. Change “Mirror Object” to “Head”. Now, the eye is mirrored on X-axis based on the head. The rabbit has two eyes.

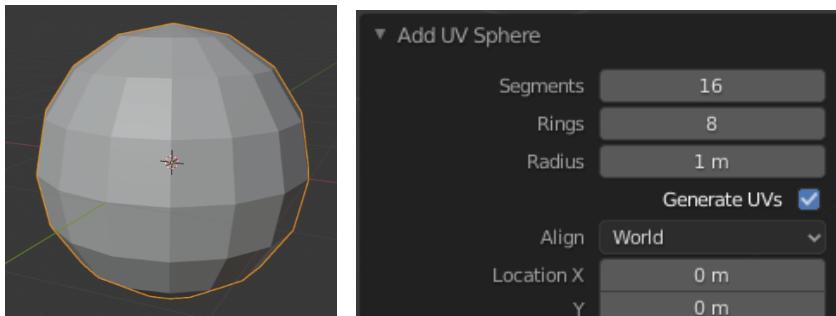


14. Go to the “Object Properties” editor and rename it to “eyes”.

15. Press CTRL+S to save.

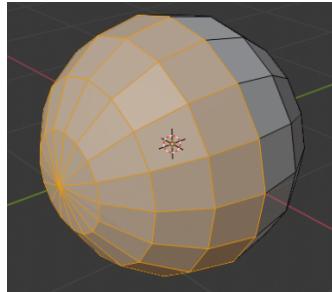
Ears

1. Create a Sphere by clicking the menu “Add” > “Sphere”.
2. In the “Add Sphere” pop panel (shown on the bottom-left corner), change “Segments” to 16 and “Rings” to 8.

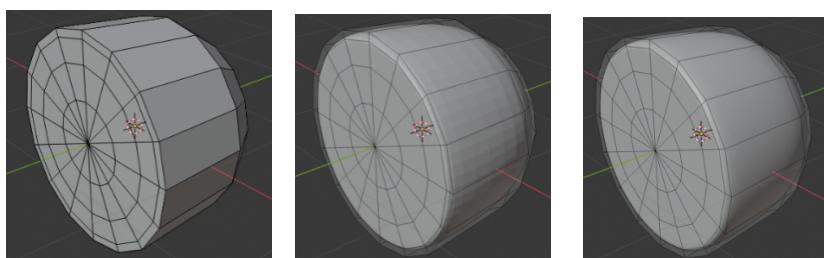


3. Rotate it 90° along X-axis.
4. Switch to “Edit Mode”.
5. Select the front half of the sphere.

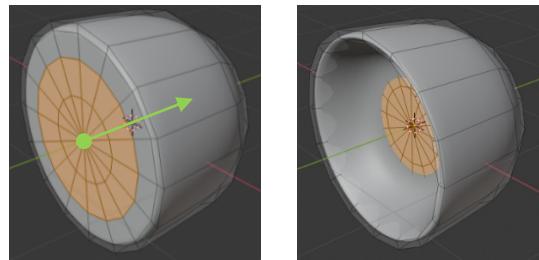
(*You may switch the viewpoint to right and enable X-Ray. This setting may make the selection easier*)



6. Press S > Y > 0 > Enter to make the selected area become a flat plane.
(*Use the scale function to align the selected faces using Y-axis. The Y values of all vertices on the selected faces are changed to the same*)
7. Go to the “Modifier Properties” editor, add a “Subdivision Surface” modifier.
8. Change “Render” and “Viewport” to 2.
9. Select all faces and click menu “Face” > “Shade Smooth”.



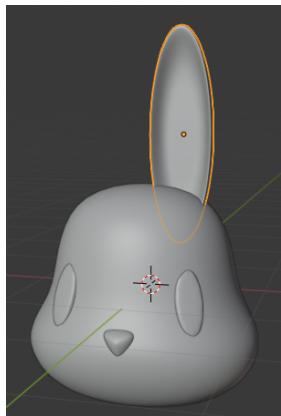
10. Select the center part of the plane side and move it to make a hollow.



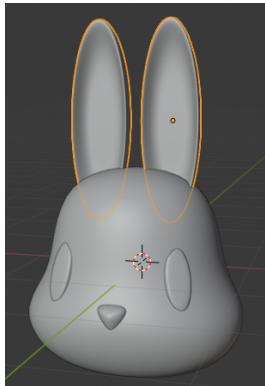
11. Switch back to “Object Mode”.

12. Adjust the width, height, and thickness to make it look like a rabbit ear.

13. Put it on the head properly.



14. Go to the “Modifier Properties” editor, add the “Mirror” modifier and select the head as the mirror object.



Material
Properties
editor
→

15. Rename it to “ears”.

16. Press CTRL+S to save.

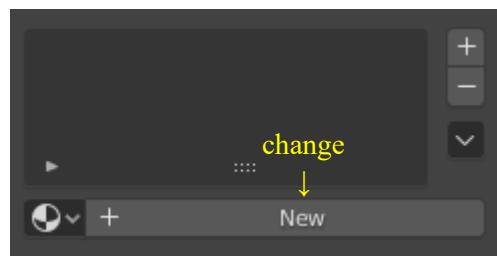
Fine-tune

1. Select one of the objects and switch to “Edit Mode”. Adjust the edges.
2. Repeat for other objects.
3. Press CTRL+S to save.

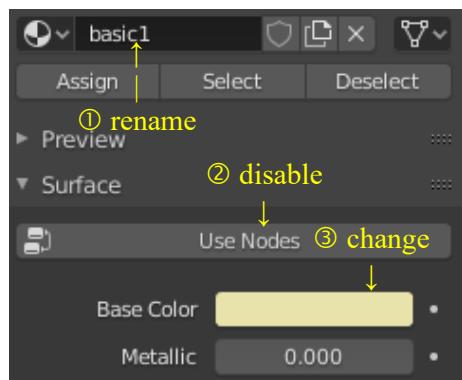
Materials (Changing Colors)

Now we need to change the colors for the objects.

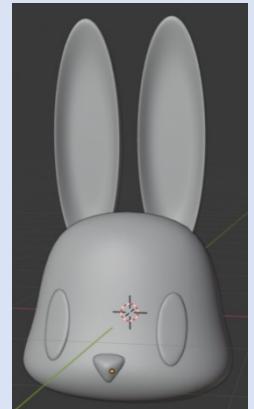
1. Preview the materials by pressing Z > “Material Preview”.
2. Select the head and go to the “Material Properties” editor.
3. If there is no material, click the “New” button to add new material and rename it to “basic1”.



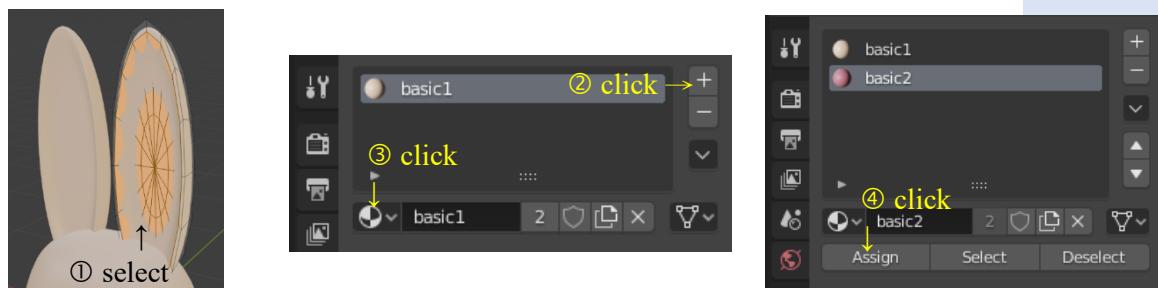
4. If there is a material named “Material”, rename it to “basic1”.
5. Disable “Use Nodes” (click it to change its color to grey).
6. Click the color box of the “Base Color” and change the color to your favorite color.



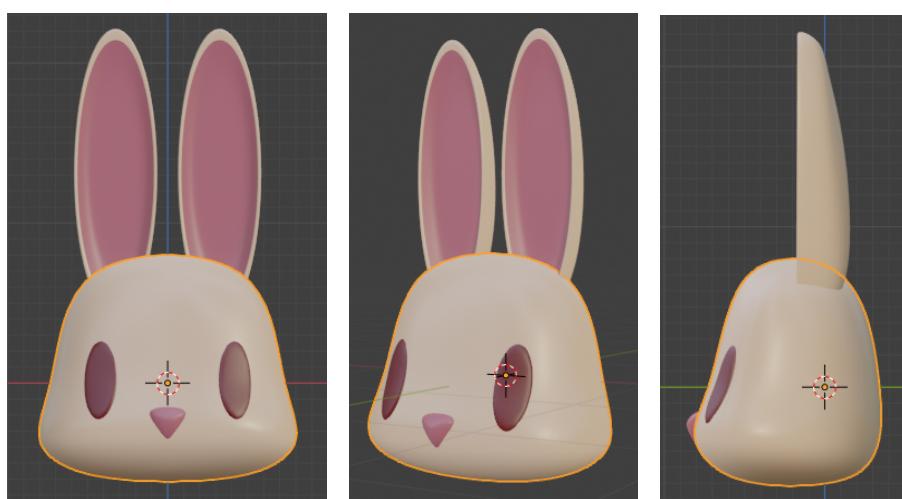
7. Select the eyes and add a new material named “eyes” using the “Material Properties” editor.



8. Select the nose and add a new material named “basic2” using the “Material Properties” editor.
9. Select the ears and go to the “Material Properties” editor. Click the “+” button to add new material. Use the “Material” button to select “basic1”.
10. Now, the color of the entire ears is changed to “basic1”.
11. Click the “+” button again and use the “Material” button to select “basic2”.
12. Switch to “Edit Mode”, select the hollow. Go to the “Material properties” editor, select “basic2” and then click “Assign”.

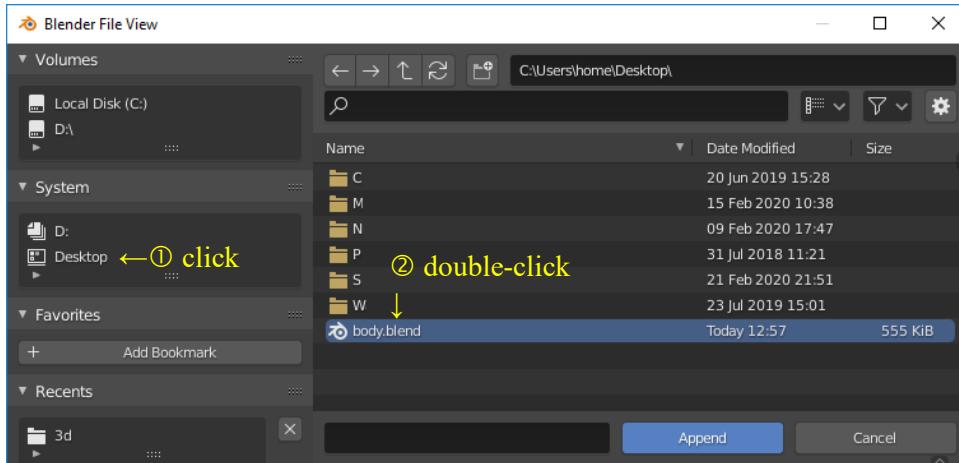


13. Now, the color of the selected areas is changed to “basic2”.
14. Press CTRL+S to save.

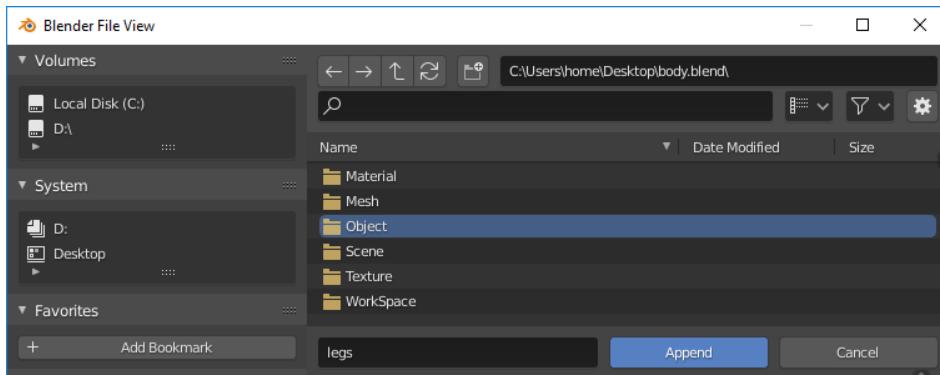


Adding Body (using Append Function)

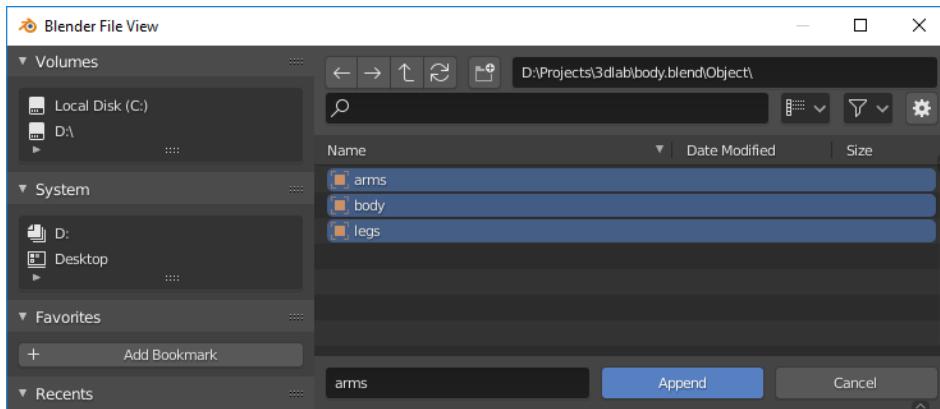
1. Download *body.blend* from Moodle and save it to *Desktop*.
2. In Blender, click the menu “File” > “Append”.
3. In “Blender File View” window, click “Desktop”, and double-click *body.blend*.



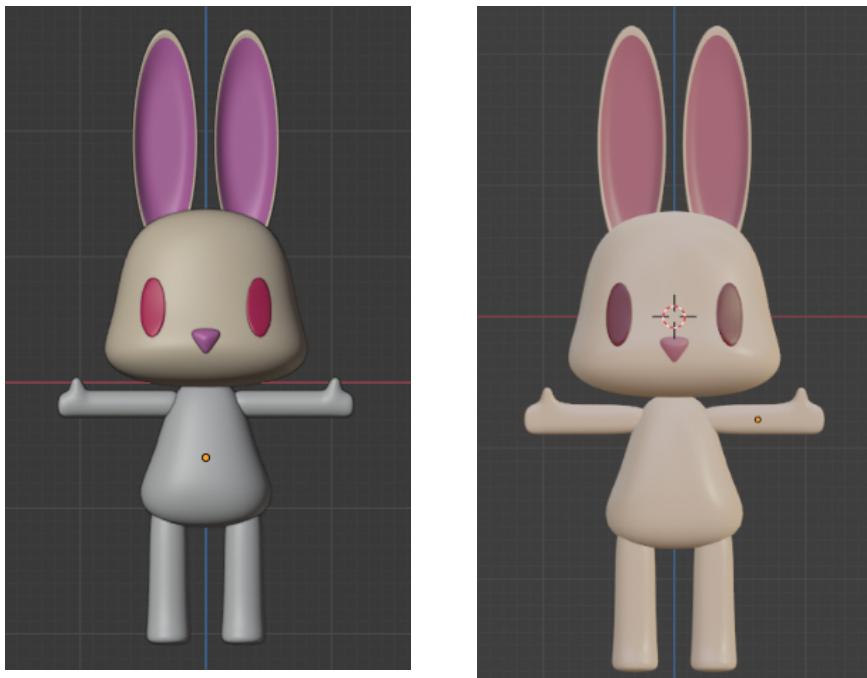
4. Then, double-click “Object”.



5. Use CTRL+Click to select “arms”, “body”, and “legs”. Then, click “Append”.



6. Move the body to the appropriate positions. You may edit each parts to fit the head.
7. Then, change the materials for the body.
8. Press CTRL+S to save.



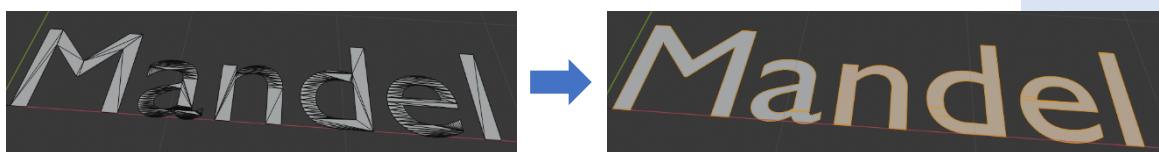
Submission

Submit your *rabbit_model.blend* file to Moodle using the submission box named “Submission Box of 3D Modeling Lab 1”.

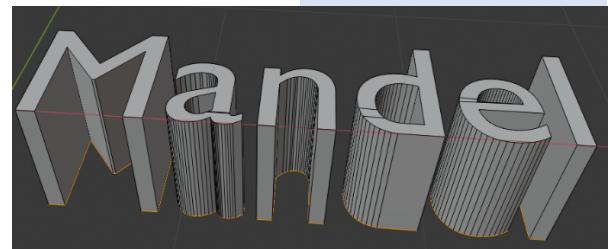
Supplementary

Adding 3D Text

1. Click menu “Add” > “Text”.
2. Switch to “Edit Mode” and type your name.
3. Switch back to “Object Mode”.
4. Click menu “Object” > “Convert to” > “Mesh ”.
5. Switch to “Edit Mode” again. You can see that it becomes a mesh just like the rabbit.
6. Select all edges and press X and select “Limited Dissolve”.
7. Now, the edges and faces of the text are simplified.



8. Click menu “Mesh” > “Merge ” > “By Distance”. Change the merge distance to “**0.03 m**”.
9. The number of vertices is reduced.
10. Click menu “Face” > “Extrude Faces”. Move the mouse to adjust the height of the extruded faces. Then, press LMB to confirm.

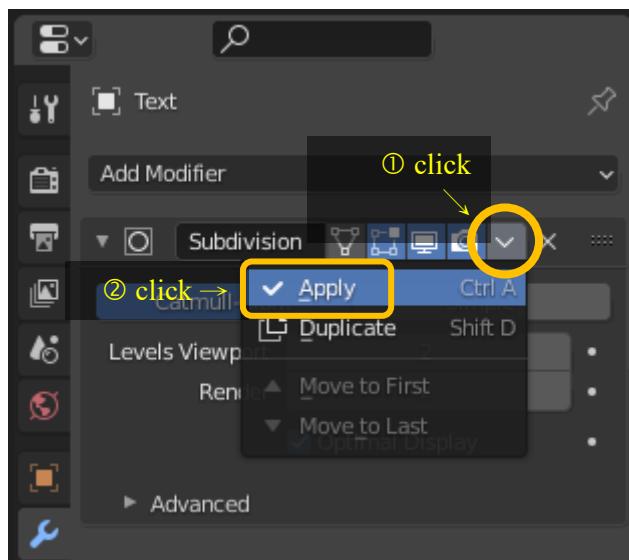


11. Apply material(s) to your name.
12. Switch back to “Object Mode”. Move your name close to the rabbit.
13. Press CTRL+S to save.



Applying all Modifiers

1. Switch to “Object Mode”. Then, click the menu “File” > “Save Copy” to save a copy named *rabbit_model_backup.blend*. Now, you have a backup file. If there is any unrecoverable problem in your original file, you can use the backup to replace it.
2. Select the head, go to the “Modifier Properties” editor.
3. On the “Subdivision” modifier section, click “V” and select “ Apply”.



4. Repeat the step on all modifier sections.
5. Do the same things for the ears, eyes, body, arms, and legs.
6. Press CTRL+S to save.

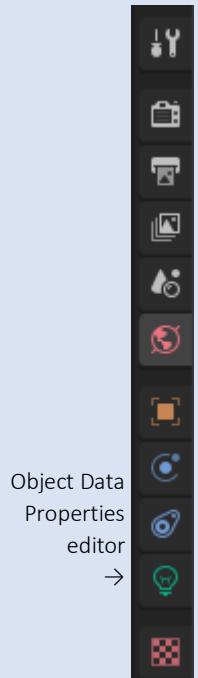
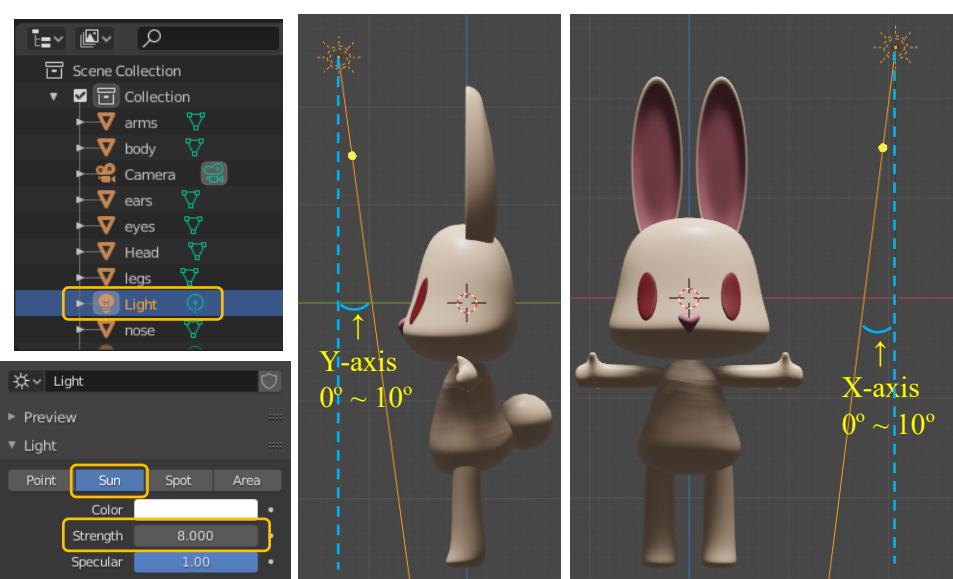
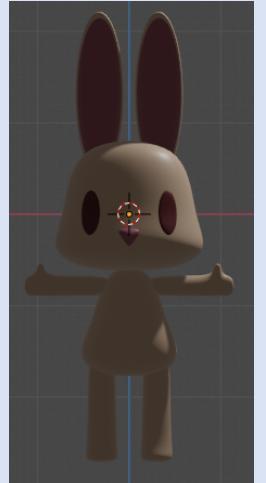
Confirming Rotation & Scale

1. Switch to “Object Mode”. Select all objects by pressing A.
2. Click menu “Object” > “Apply” > “Rotation & Scale”.
3. Press CTRL+S to save.

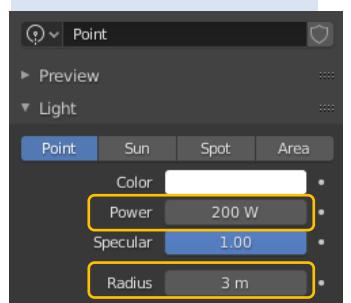
Image Output

Setting Lights

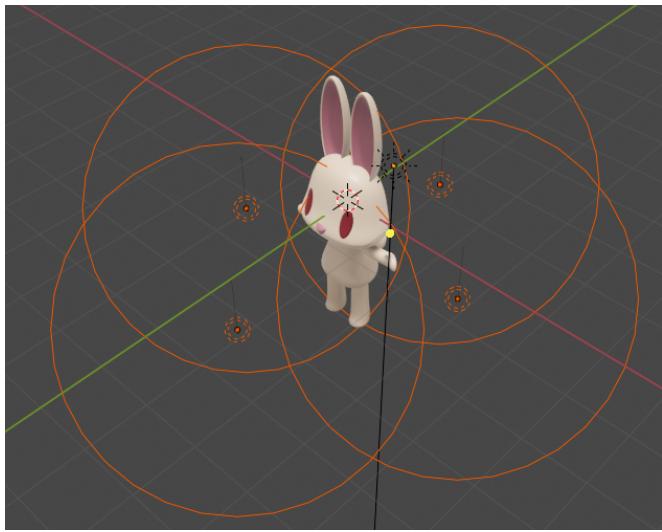
1. Switch to the render preview by press Z and select “Rendered”.
2. You can see that the screen becomes very dark. It is because the default light is not bright enough.
3. Go to the “Outliner” editor, select “Light” and go to the “Object Data Properties” editor. Click “Sun” to change the type of light to “Sun” and the strength to 8.
4. Adjust the angle of the light as follows.
(Note that the position of the sunlight does not affect the result)



5. Click menu “Add” > “Light” > “Point”. Go to the “Object Data Properties” editor and change “Power” to “200 W” and “Radius” to “3 m”.
6. Put the point light in the front of the rabbit.
7. Press D to duplicate the point light. Move the mouse to put the duplicated point light behind the rabbit. Then, press LMB to confirm the position.
8. Repeat the step to put point lights to the left- and right-hand side of the rabbit.



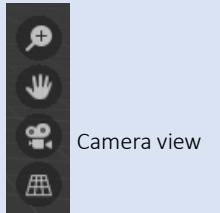
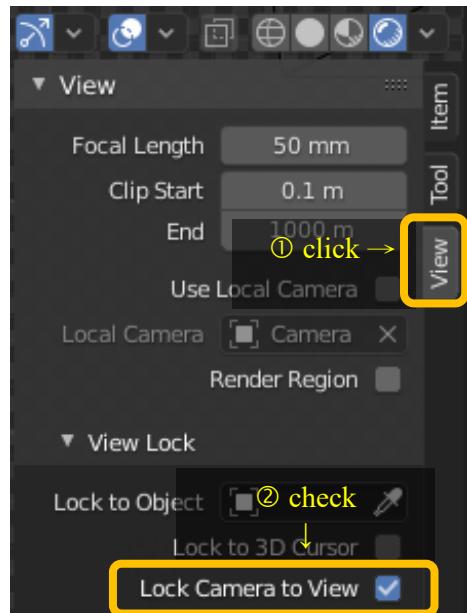
9. Adjust the position of each point light to make a comfortable lighting effect.



10. Press CTRL+S to save.

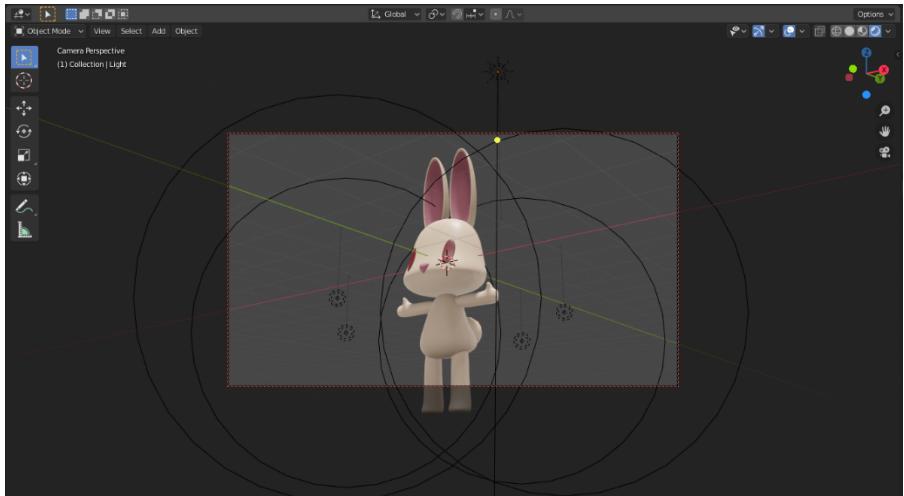
Setting Camera

1. Press N to show the toggle sidebar. Switch to the “View” tab and check “Lock Camera to View”.



2. Press N again to hide the toggle sidebar.
3. Click the “Camera view” button, shown on the right-hand side of the viewport, to switch the view to the camera view.

4. Adjust the view to get a good shot.



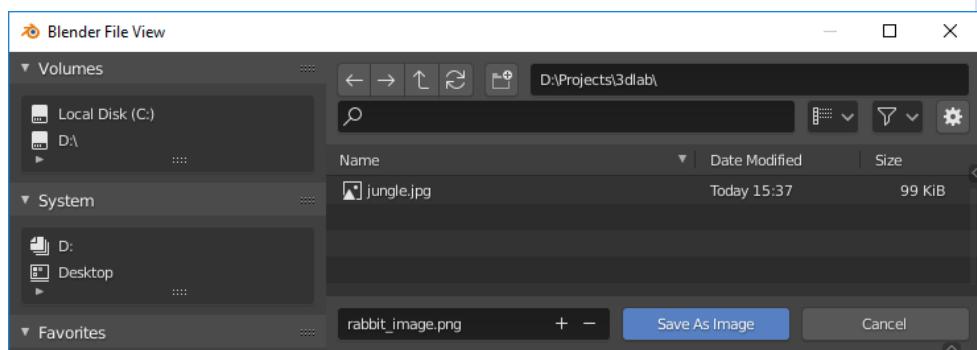
5. Click the “Camera view” button again to switch back to the normal view.
6. Press CTRL+S to save.

Rendering Image and Creating Image File

1. Press F12 to render your model as an image.

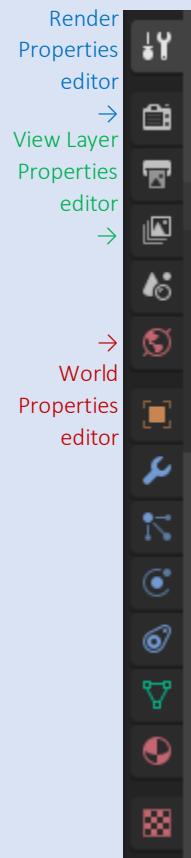
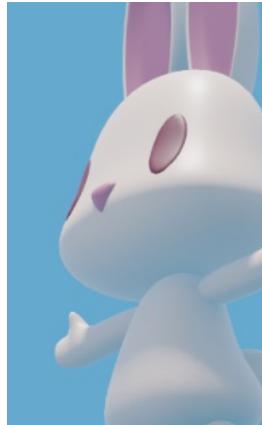


2. Click the menu “Image” > “Save as”.
3. Change the file name to “rabbit_image.png” and click “Save as Image”.



More about Image Rendering

1. The default background color of the image is dark grey. You may change the background color using the following method:
 - i. Go back to the main window.
 - ii. Switch to the “World Properties” editor, expand the “Surface” section.
 - iii. Disable “Use Nodes” and change the color for the “Color” field.
 - iv. Press F12 again to re-render your model.
2. You may change it to transparent by using the following method:
 - i. Go back to the main window.
 - ii. Switch to the “Render Properties” editor, expand the “Film” section and check “Transparent” to set the rendered image background to transparent.
 - iii. Press F12 again to re-render your model.



Adding Freestyle Line

You may also enable the freestyle line on the rendered image, just the outline of the cartoon characters. The following is the procedure to enable the freestyle line:

1. Go back to the main window.
2. Switch to the “Render Properties” editor, and check “Freestyle”.
3. Expand the “Freestyle” section and change “Line Thickness” to “0.5 px”.
4. Switch to the “View Layer Properties” editor, expand the “Freestyle” section and check “Face Smoothness”.
5. Press F12 to re-render your model.
6. The rabbit now looks like a cartoon character.

