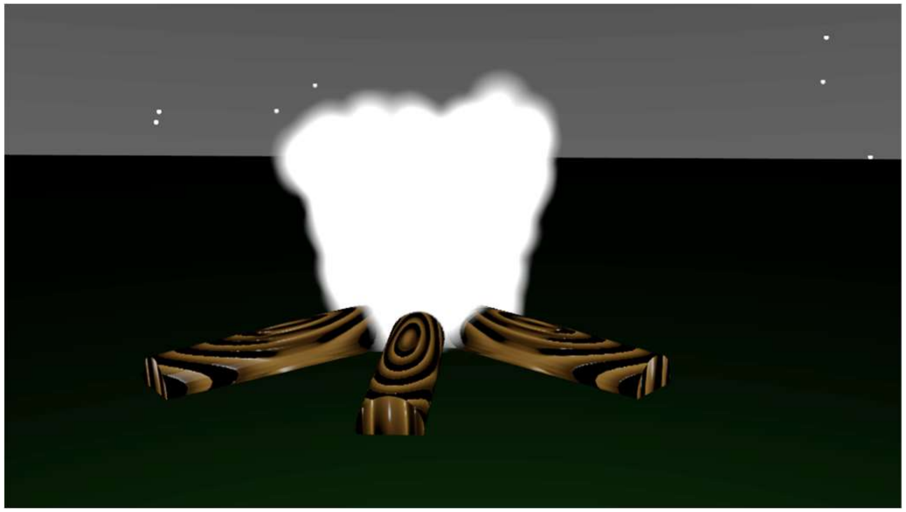
Camp Blender

http://cs.oregonstate.edu/~mjb/blender



Oregon State University

Mike Bailey

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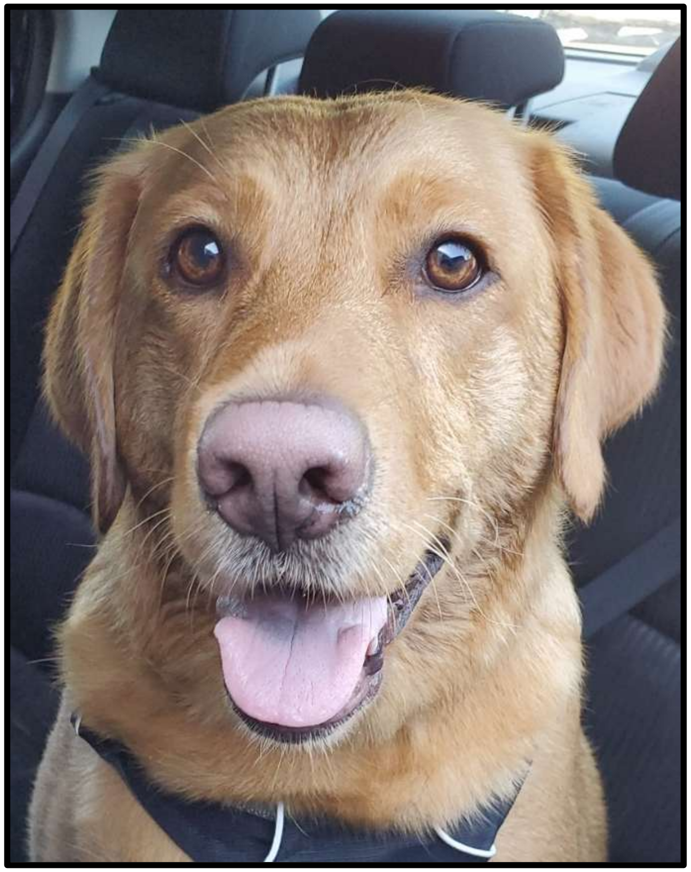
For Those of you on Zoom, I Apologize in Advance for the Barking You Might Hear in the Background ☺



They mean well, but delivery vans are just too-tempting a bark-target…

Handy Blender Shortcuts

Shortcut	What it Does
LMB	Select something
Shift-LMB	Add something else to the selection
MMB	Rotate the scene
Shift-MMB	Pan the scene
Shift-spacebar	Bring up the transformation menu
Scroll Wheel	Zoom in and out
Tab	Toggle between Object Mode and Edit Mode
Control-Tab	Bring up Mode **pie menu**
` (back quote)	Bring up View **pie menu**
a	Select all
Click in empty space	Unselect all
Alt-a	Unselect all
Shift-a	Bring up the Add menu
Escape	Get you out of almost anything (including stopping a render or an animation)
b, c	Box or circle select
C	Center the scene (good if you are lost in 3D)
Shift-d	Duplicate
e	Extrude (in edit mode)
F3	Search
g	Grab (translate) an object

Handy Blender Shortcuts

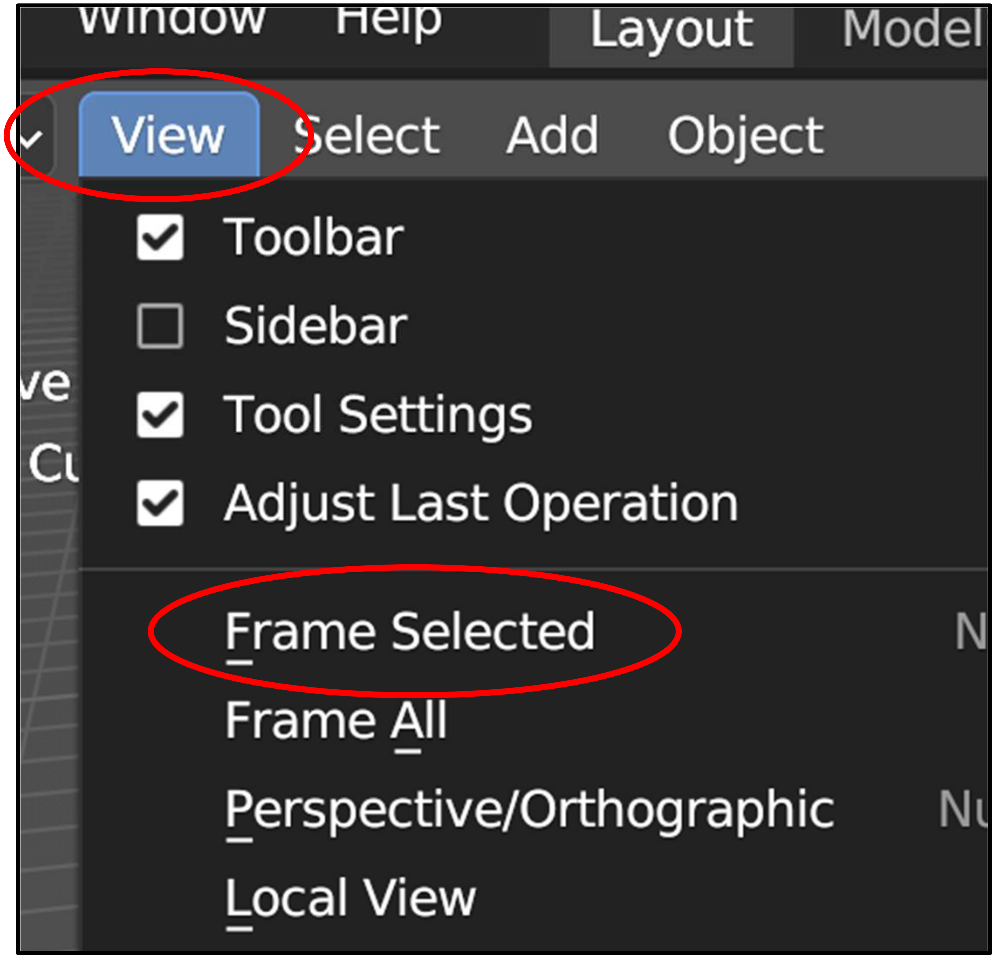
Shortcut	What it Does
Shift-g	Group
i	Insert a keyframe
Control-j	Join 2 or more objects
m	Send object to a collection (layer)
n	Toggle the Sidebar menu
Shift-n	Recalculate normals
p	Partition (only in edit mode)
Control-p	Establish a parent-child relationship (the last object selected will be the parent)
Alt-p	Destroy a parent-child relationship
Control-Alt-q	Toggle quad viewing
r	Rotate an object
s	Scale an object
Shift-s	Pie menu for using the 3D Cursor
Spacebar	Start / Pause an animation
t	Toggle the Object Tools menu
x	Delete whatever is selected
z	Bring up a display mode **pie menu**
Control-z	Undo
Alt-z	Toggle x-ray mode
Control-Shift-z	Redo
F12	Render a scene image
F11	Return to the interactive scene

Not Exactly a Shortcut, but Really, Really Useful

If you would like to be able to rotate the entire scene around a particular object, click on the object and then select:

View → Frame Selected

You can also hit the period (**.**) on the number pad on the keyboard.



A Recommendation

If you don't have one already, I *strongly, strongly, strongly* recommend that you get a 3-button mouse for use with Blender.

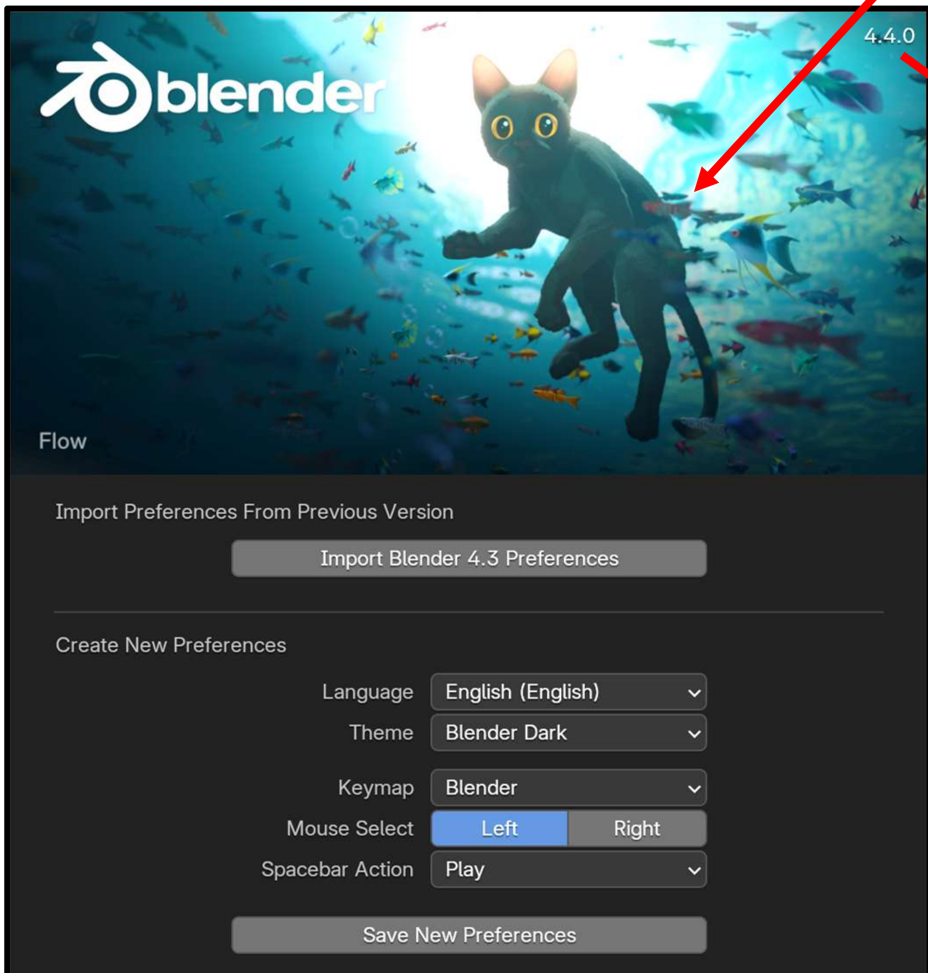
The middle button is both a push-button and a scroll wheel.

Blender makes liberal use of all 3 buttons and the scroll wheel.

You can get by with a 2-button mouse, but your Blender life will be considerably easier and more productive with a 3-button mouse.

What is Blender?

Blender is a *free* program that lets you do professional-looking 3D modeling, rendering, and animation. This, not this. ☺



Note: The version number changes often. These notes have been written against Blender version **4.4**

Blender likes to change elements of its user interface every new version. It is recommended that you have 4.4 installed on your own system to match these notes!

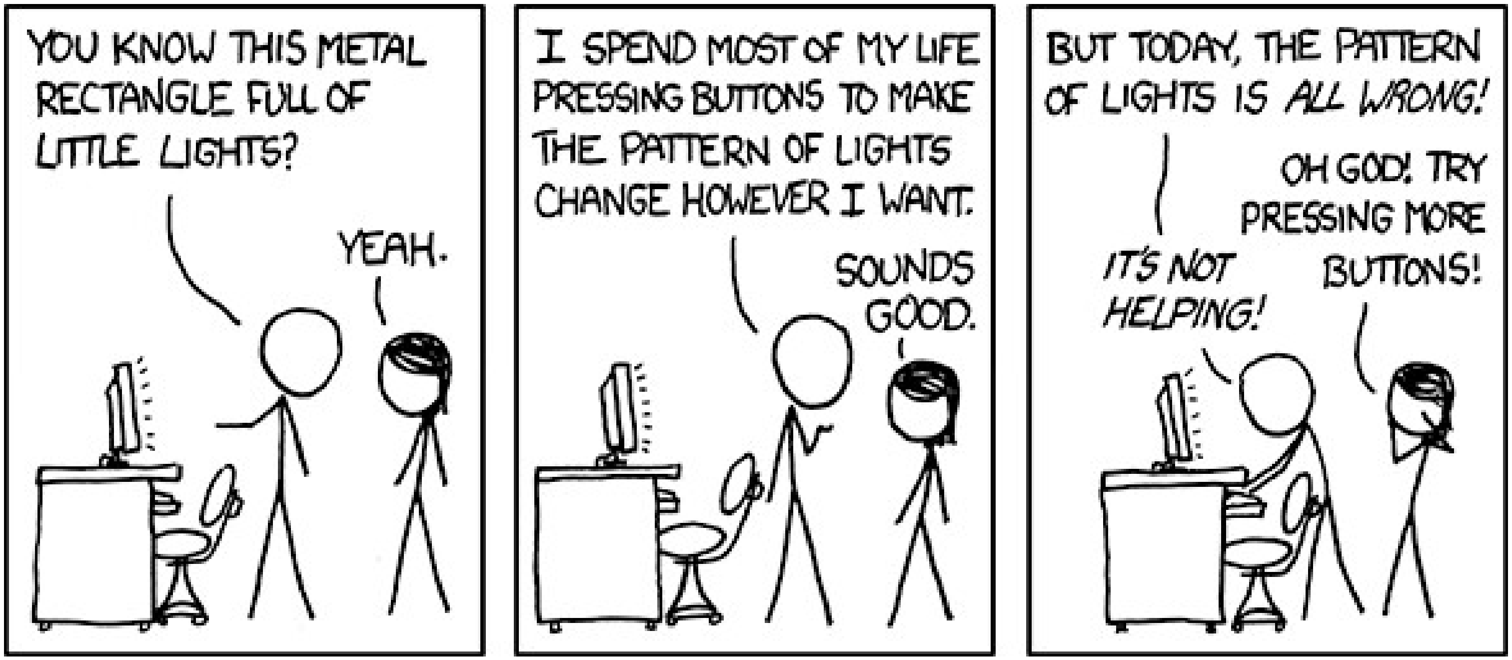
You can get Blender for yourself by going to: **http://www.blender.org**

Flow – an award-winning Blender-animated movie

Winner of the 2025 Academy Award for
Best Picture

See:
https://en.wikipedia.org/wiki/Flow_(2024_film)

Why Do We Have These Notes?



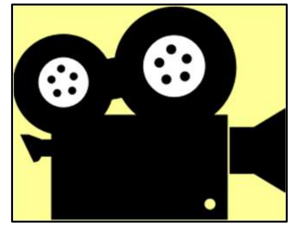
http://xkcd.com

Blender has thousands of buttons you can press. It is difficult to understand them all. These notes are here to show you what certain combinations of buttons do in order to learn them, and to remind you later when you've forgotten.

In these notes, what do these icons mean?

cloth.blend

worldtex.bmp



cloth.mp4

They tell you that if you go to our notes web site:

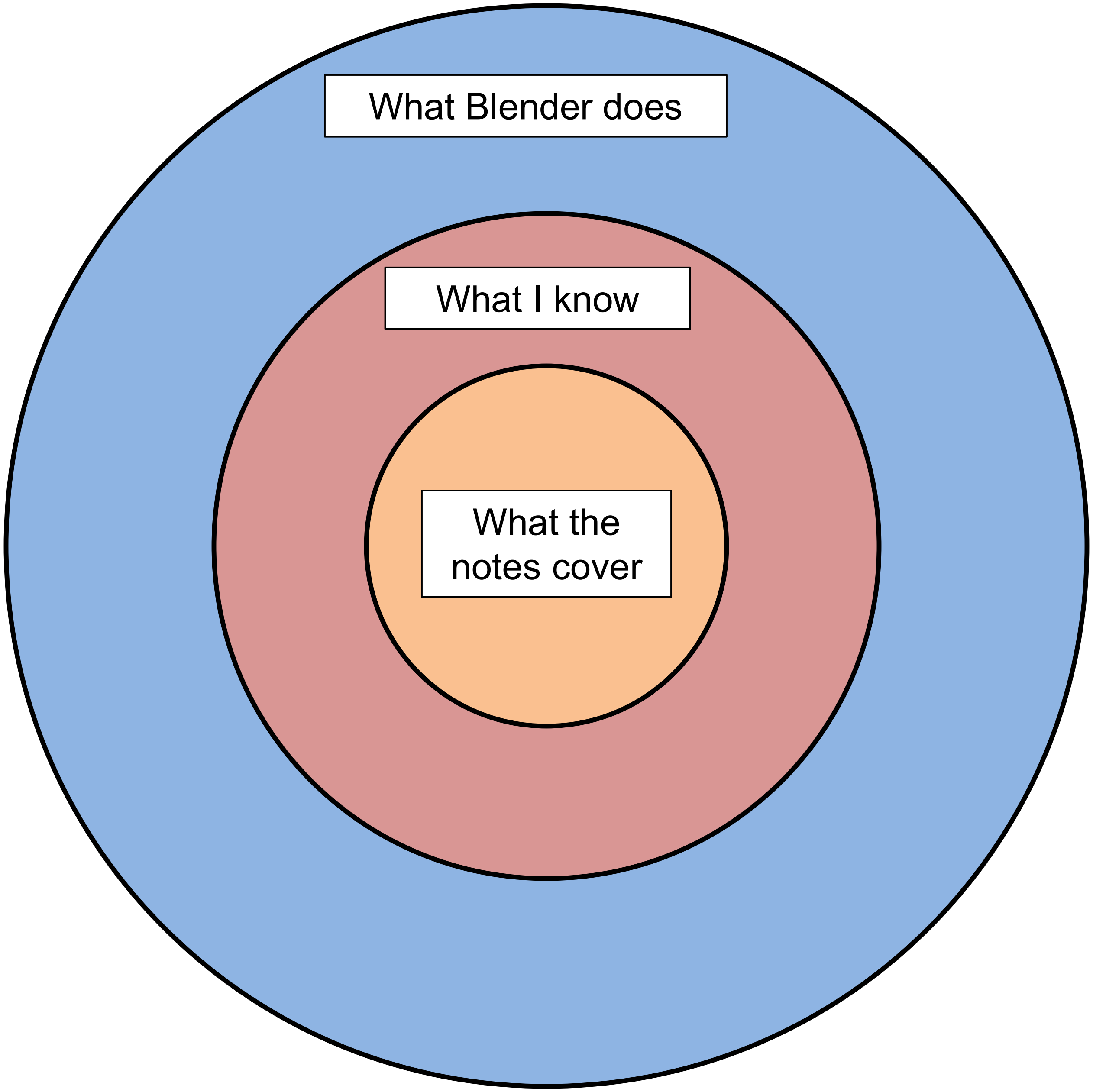
http://cs.oregonstate.edu/~mjb/blender

you will find Blender input files (*.blend), texture map files (*.bmp), and animation movie files (*.mp4).

You can read a .blend file right into Blender (**File** → **Open**) so that you can experiment with these examples without having to first create them yourself.

You can play an .mp4 movie file right from your browser so that you can see how these examples look without having to run Blender at all.

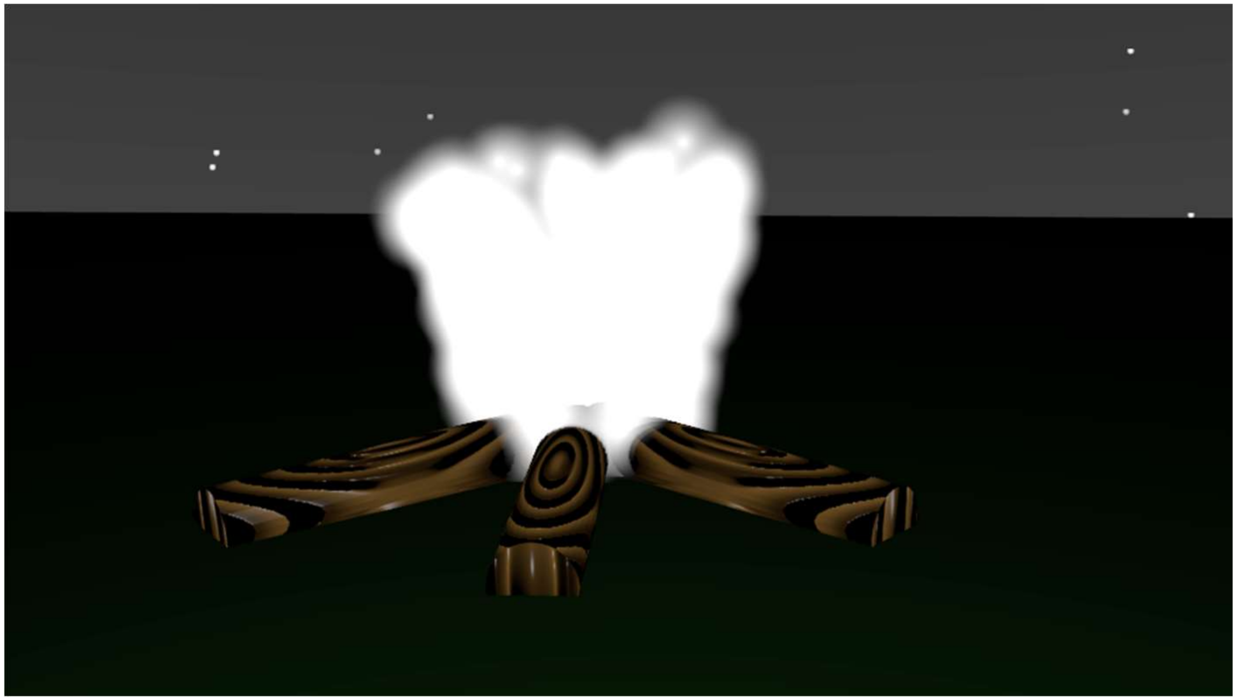
A warning about me and the Notes



What We Will Cover in these Notes

1. Navigating the screen layout
2. Viewing in 3D
3. Moving things around in 3D
4. Modeling, I
5. Appearance, I
6. Modeling, II
7. Rendering
8. Particle Systems
9. Physics Animation
10. Appearance, II
11. Vertex Sculpting
12. Vertex Painting
13. Keyframe Animation
14. 3D Printing
15.Stereographics
16. References

1. Navigating the Screen Layout



Full Screen Layout

View Control

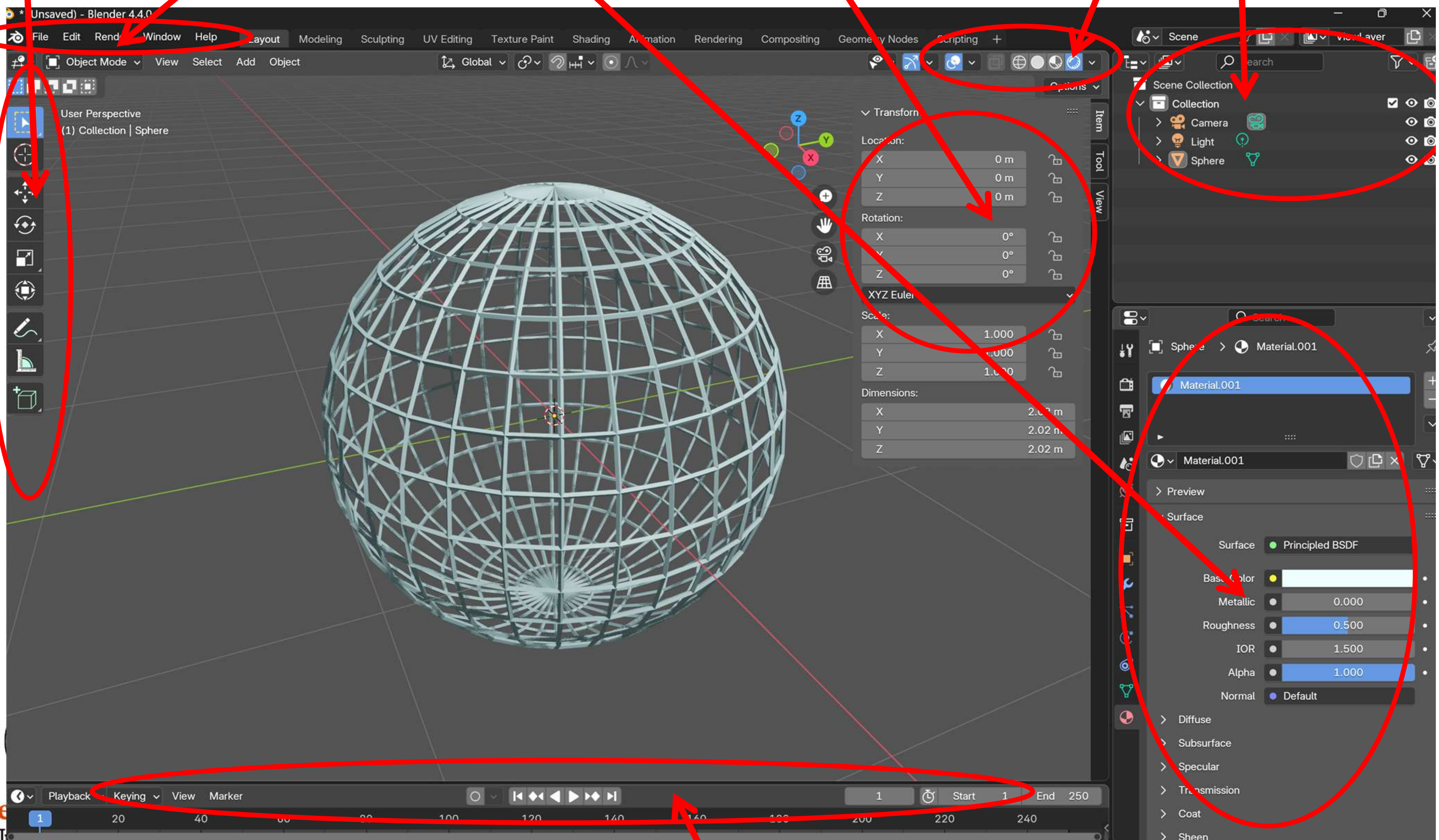
Object Tools ('t')

Main Menu

Property-specific Options

Object Properties ('n')

Outliner



Animation Controls

The Object Tools Menu

Select

Cursor

Move

Rotate

Scale

Transform

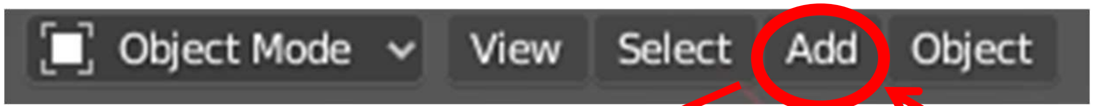
Annotate

Measure

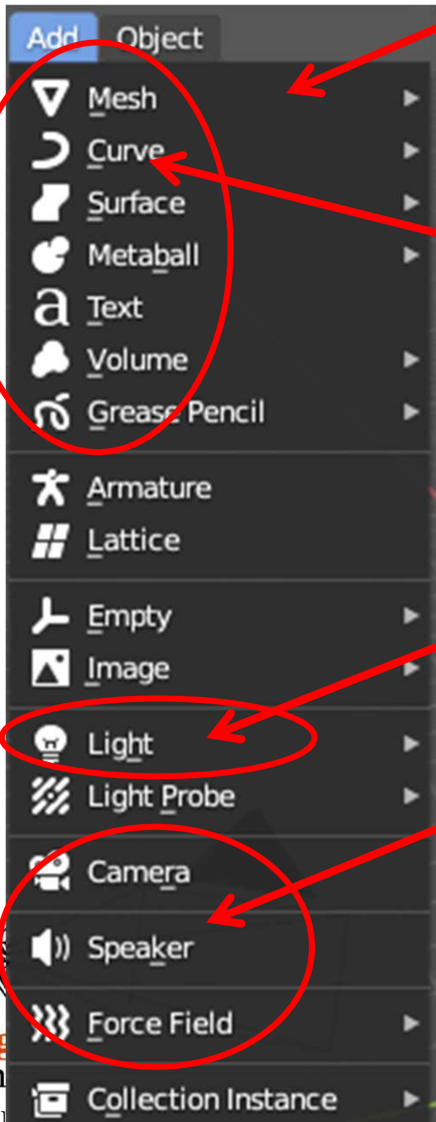
Add Cube

Toggled on and off with the ‘t’ key

The Add Menu



This is the Add tab – you will spend a lot of time here!

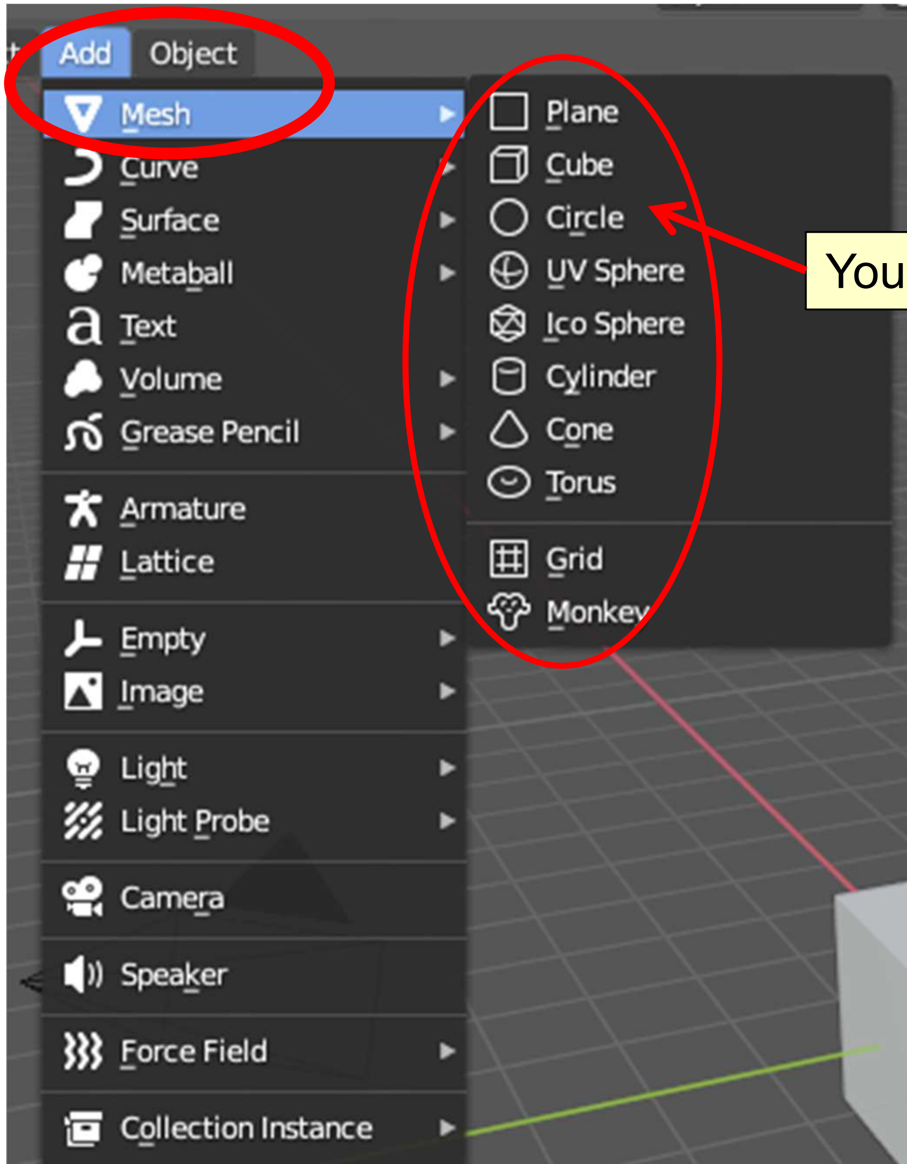


Create geometry

Create lights

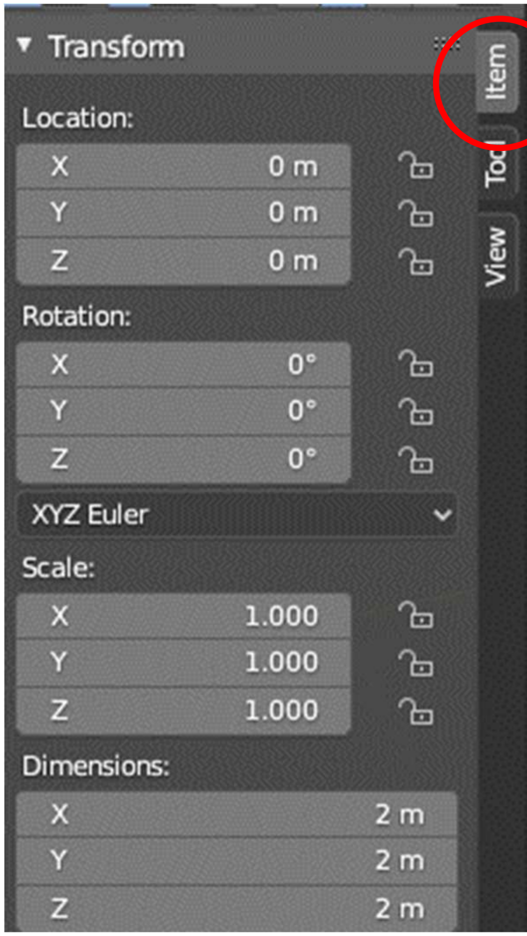
Create other cool stuff

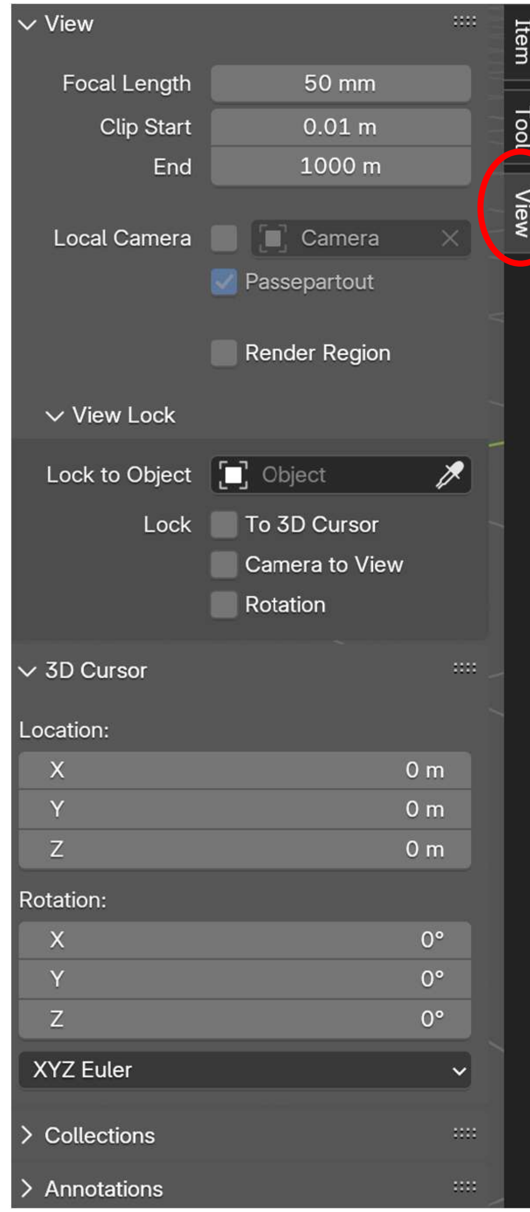
The Add→Mesh Menu



You will *especially* spend a lot of time here!

The Sidebar Panels





Toggled on and off with the **‘n’** key

The Blender Interface Widgets

If Blender shows you something that looks like this …

… you are expected to click a button to put yourself in a particular mode

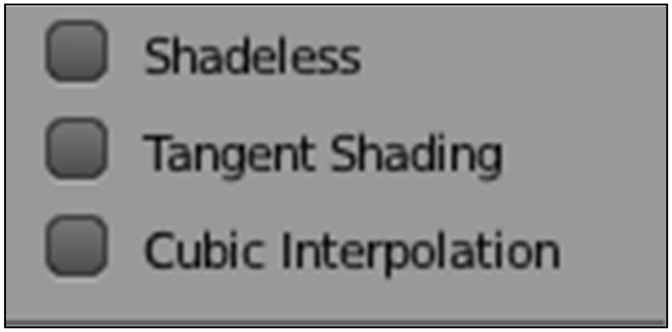
The Blender Interface Widgets

If Blender shows you something that looks like this …

… you are expected to click in the box to bring up something else, like this

The Blender Interface Widgets

If Blender shows you something that looks like this …



… you are expected to turn features on and off by clicking in **all or none** of the checkboxes

If Blender shows you something that looks like this …

… you are expected to make a choice of ***just one*** of these options

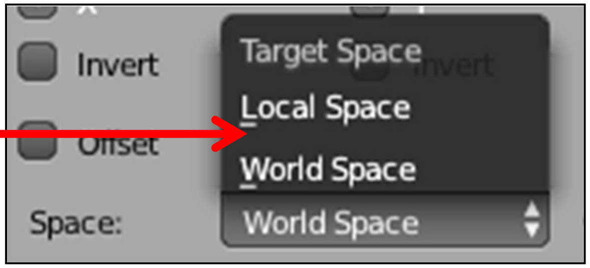
The Blender Interface Widgets

If Blender shows you something that looks like this …

… you are expected to either left-click in the box and (keeping the left button down) drag the mouse left-right like a slider, ***or*** single-click in the box and type in a new value

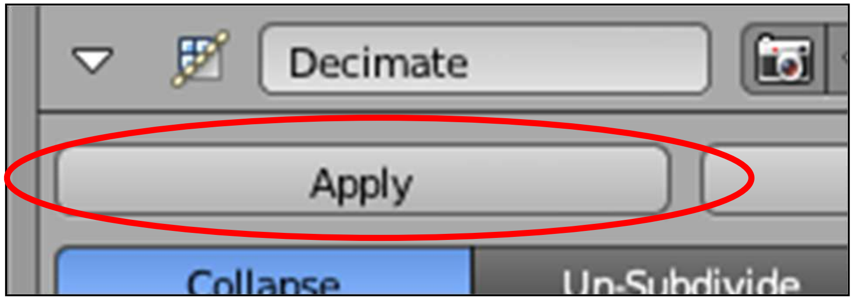
If Blender shows you something that looks like this …

… you are expected to click in the box and then select from the resulting list



The Blender Interface Widgets

If Blender shows you an "Apply" button …



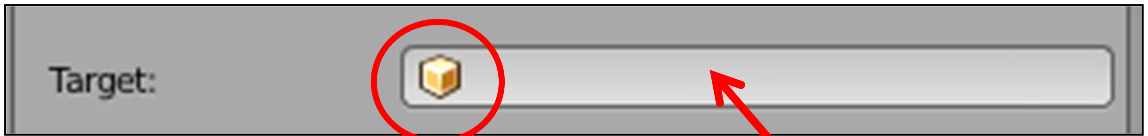
… it means that you can click this button to get rid of your original model and replace it with a model that has the edits you have just made

If Blender shows you this icon (with or without the word "Open" …

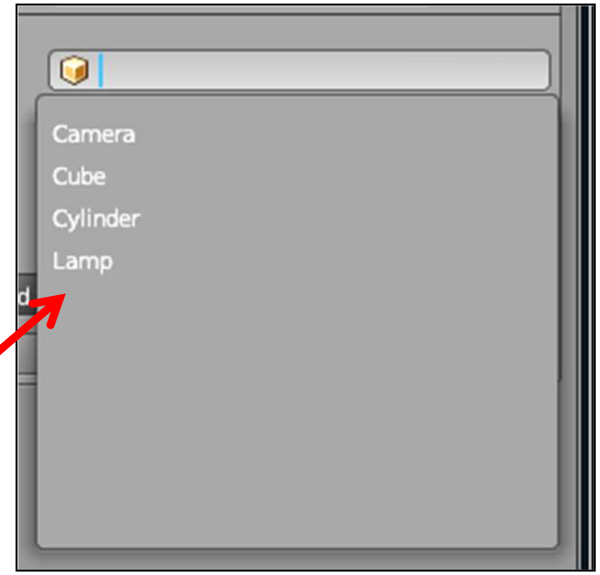
… it means that you can click this button to open a file

The Blender Interface Widgets

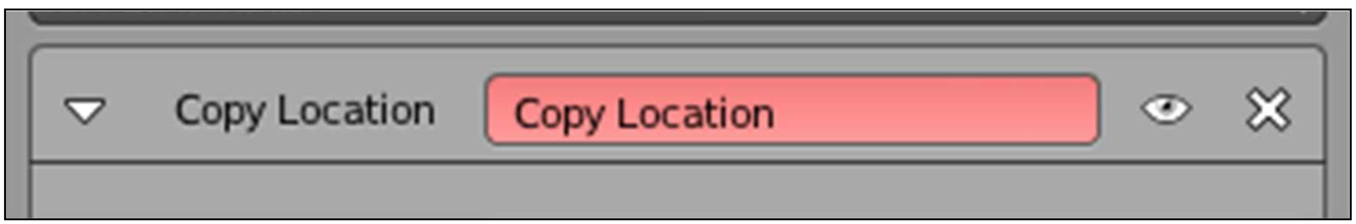
If Blender shows you something that looks like this …



… you are expected to click in the box and select from a list of other **objects** in the scene



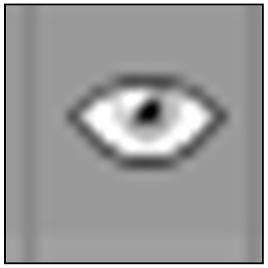
If Blender shows you something that looks like this …



… the red color is telling you that you haven't yet entered enough information in this panel

The Blender Interface Widgets

If Blender shows you something that looks like this …

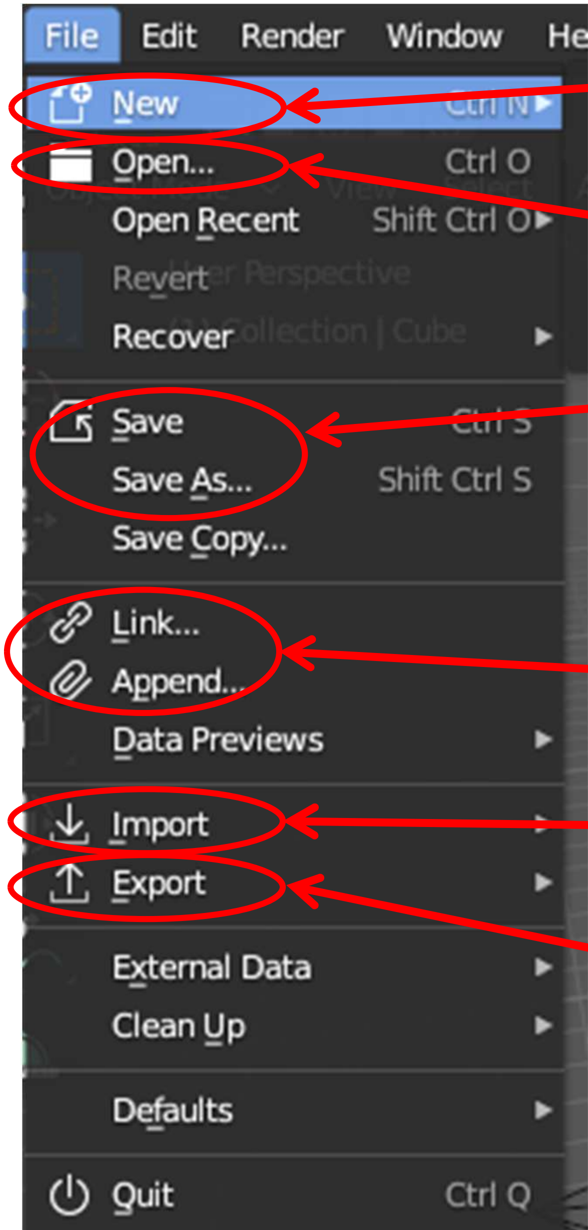


… it allows you to hide and unhide something (the Outliner is where you use this most often). Hiding an object is useful for decluttering your scene.

Hint #1: If you no longer want an object in the scene, hiding it for a while before deleting it is usually a smart idea. It is surprising how often you need something not long after you deleted it. ☹

Hint #2: If you hide something, don't forget that you have hidden it. It is pretty freaky to be certain that you once created something, but now you can't find it anywhere in the scene. ☺

The File Menu



Start a new Blender scene (thus closing the scene you currently have open)

Open a previously-created Blender scene (thus closing the scene you currently have open)

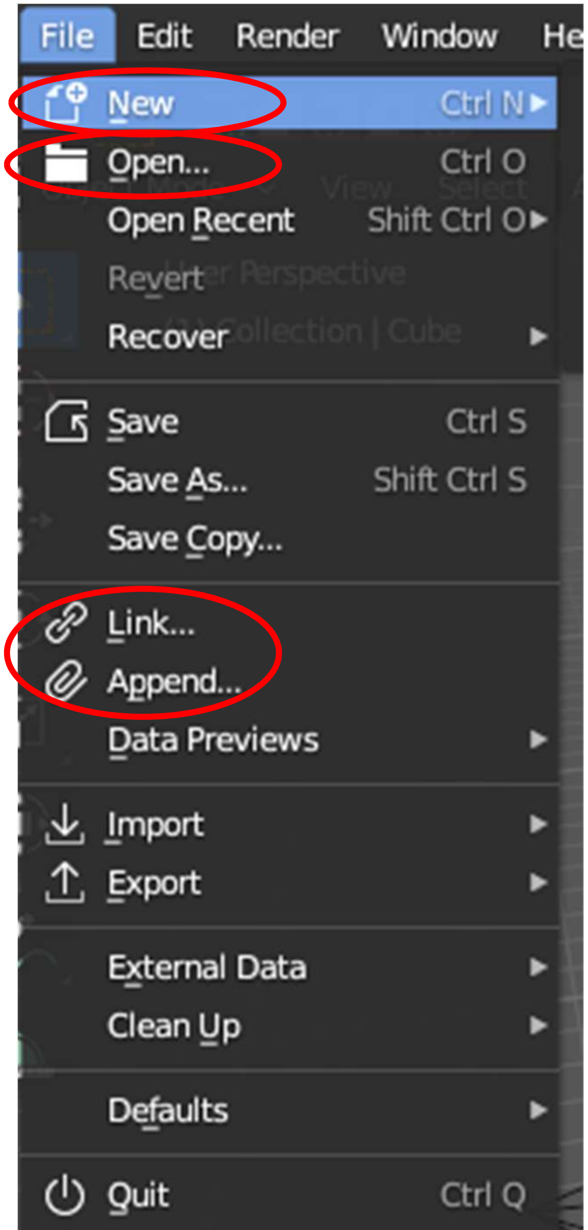
Save the current scene in a file

Bring elements from another Blender file into this scene

Bring an image or object in from somewhere else

Send an image or object to somewhere else

The Difference Between New, Open, Link, and Append



New closes the scene you currently have, then initiates a new Blender scene.

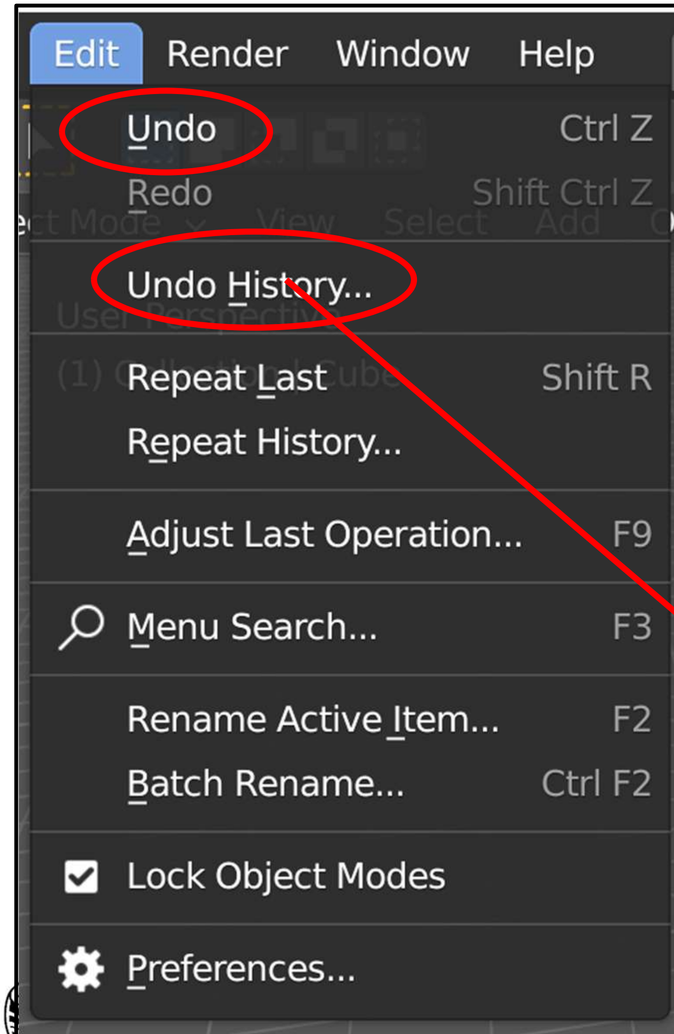
Open closes the scene you currently have, then reads in a previously-stored Blender scene.

Append leaves the scene you currently have open, and adds elements of a previously-created scene into it.

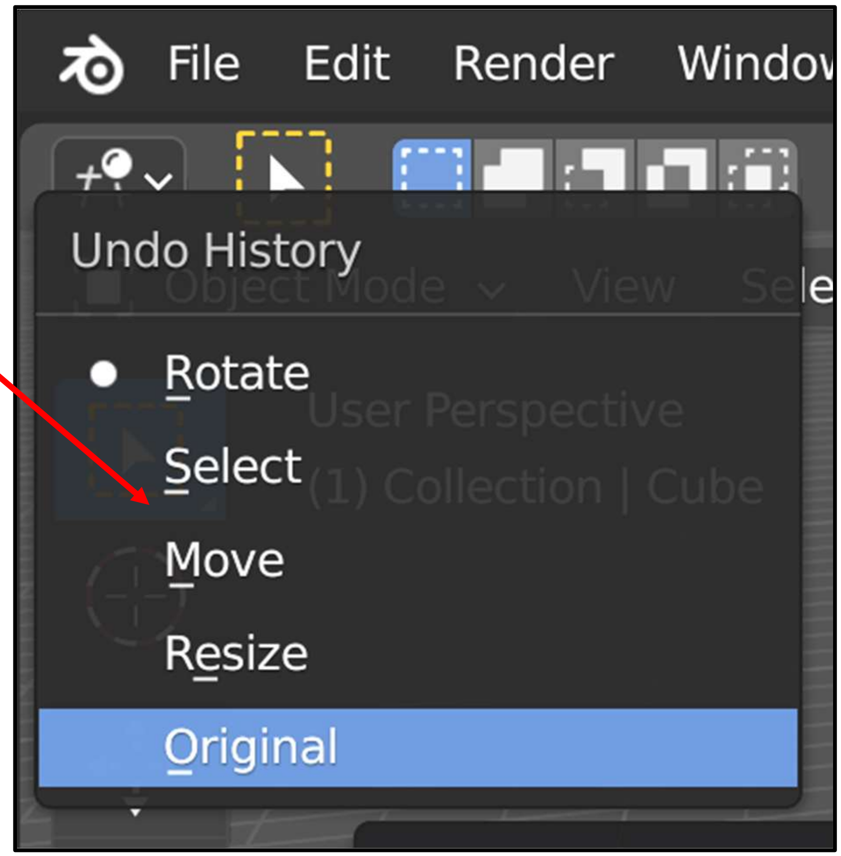
Link is like Append, but every time you open the scene again, it will look at the file you are Linking from to see if changes have been made, and if so, will bring those into the scene instead of the first ones.

The Edit Menu

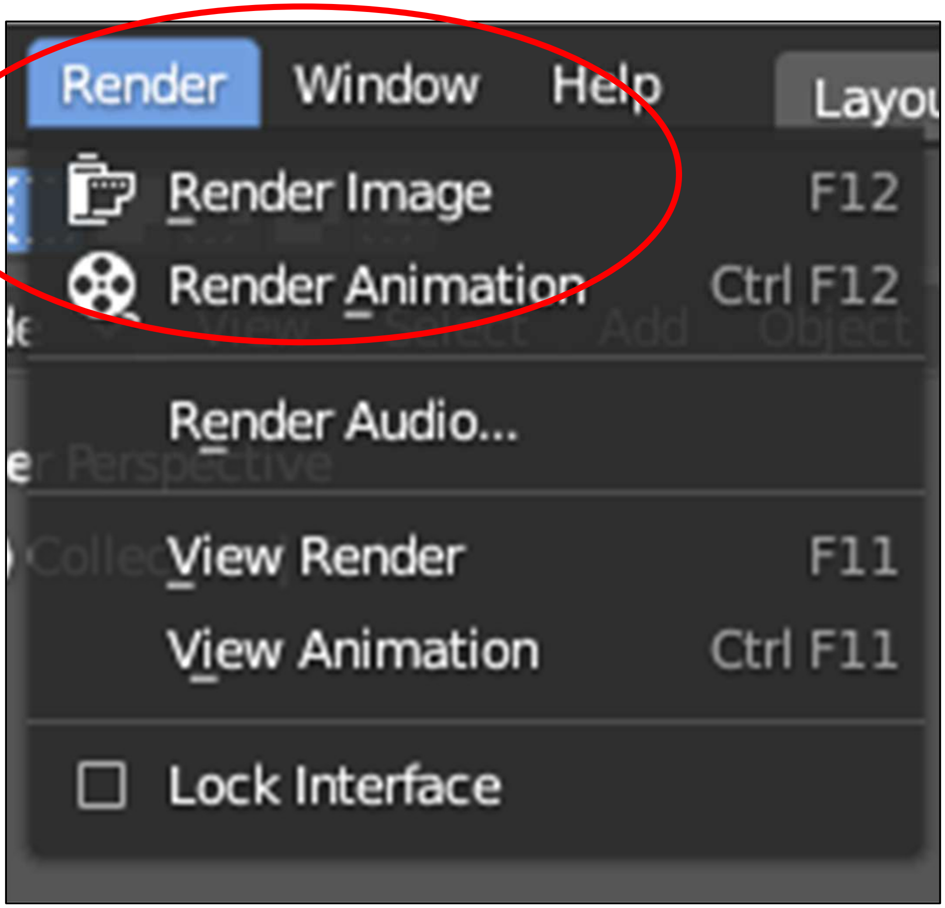
Control-Z or **Edit→Undo** are two of your best friends!



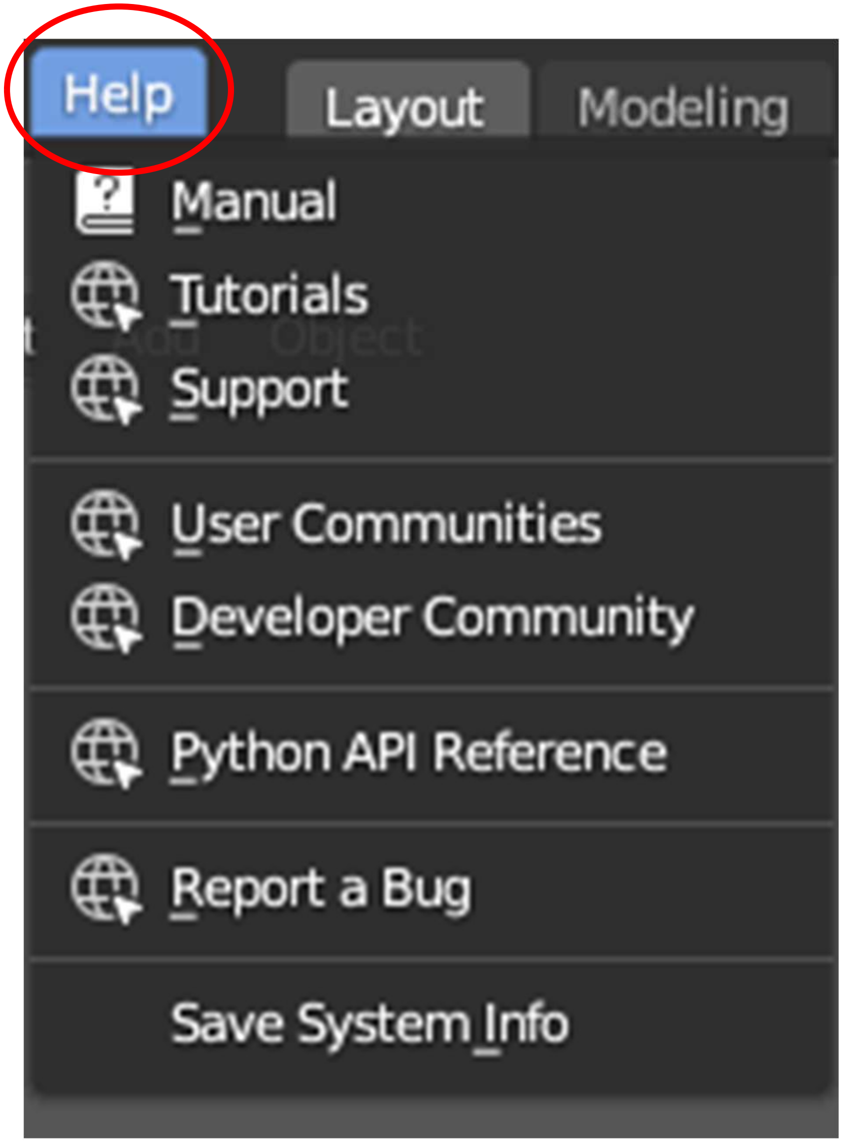
You can also select **Undo History** and go back in time to several commands ago



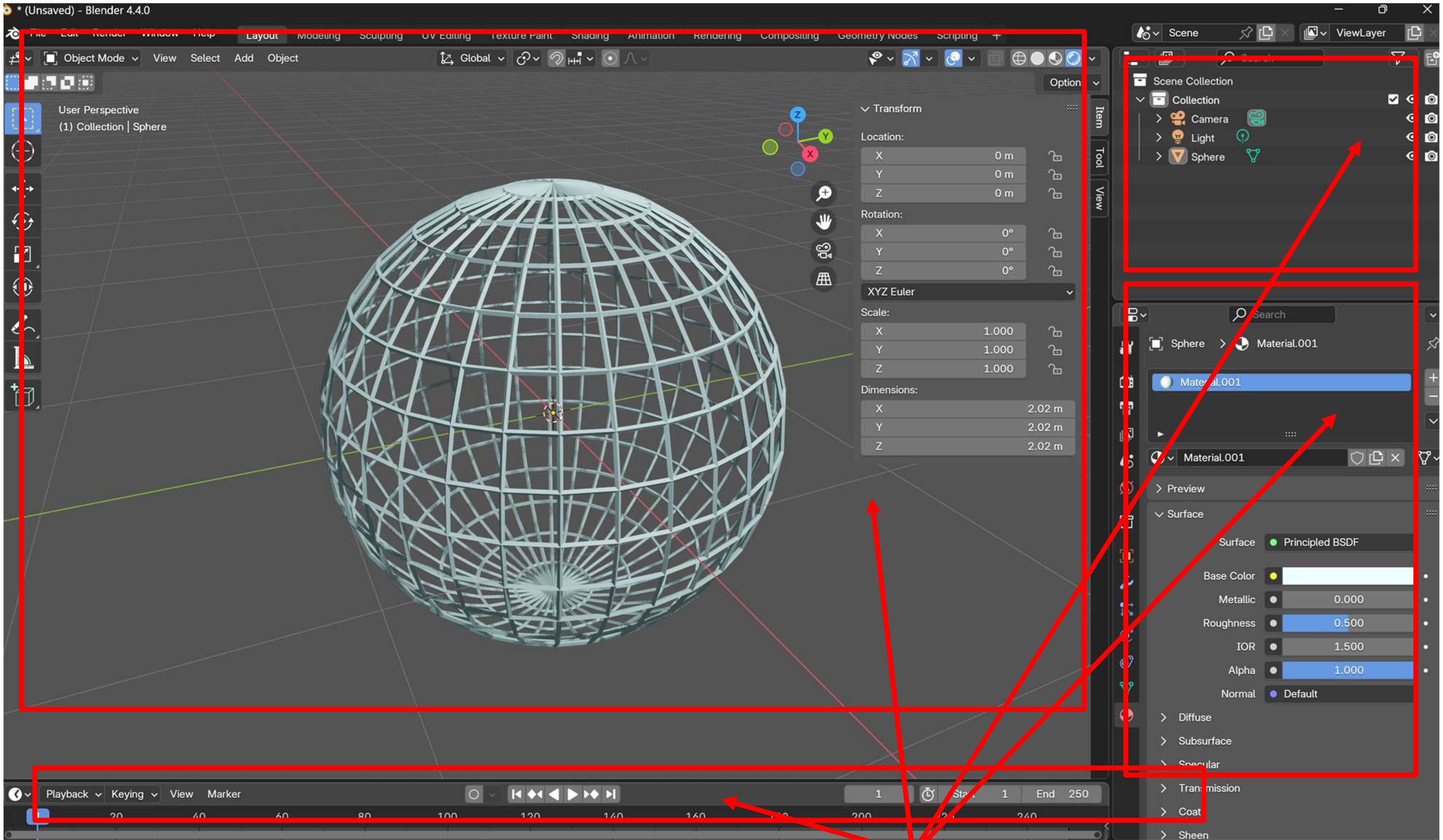
The Render Menu



The Help Menu

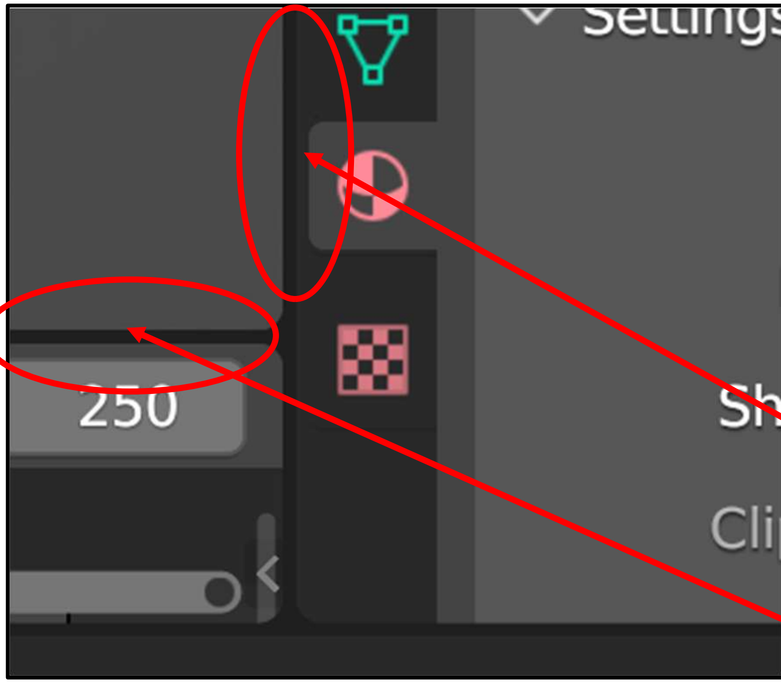


Blender Windows



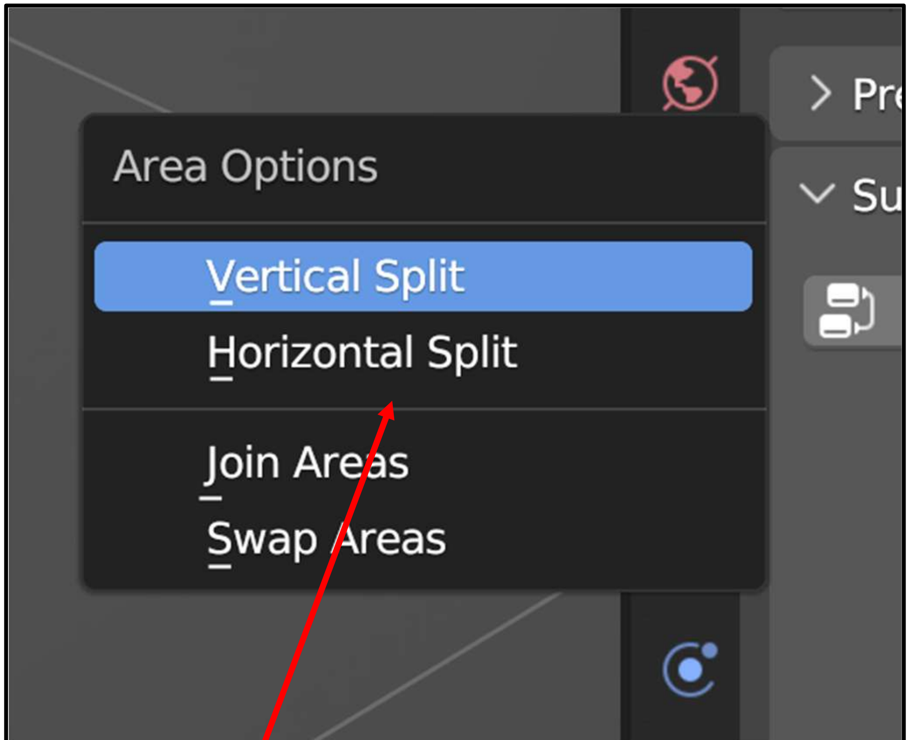
When Blender launches, there are four sub-windows visible. But Blender has 23 Possible sub-window types that you can bring up and change the size of.

Changing the Border Line on Blender Windows



To change a sub-window boundary, **left-click** on the horizontal or vertical border line, wait for the cursor to change to a double-arrow, then move the mouse up/down or left/right.

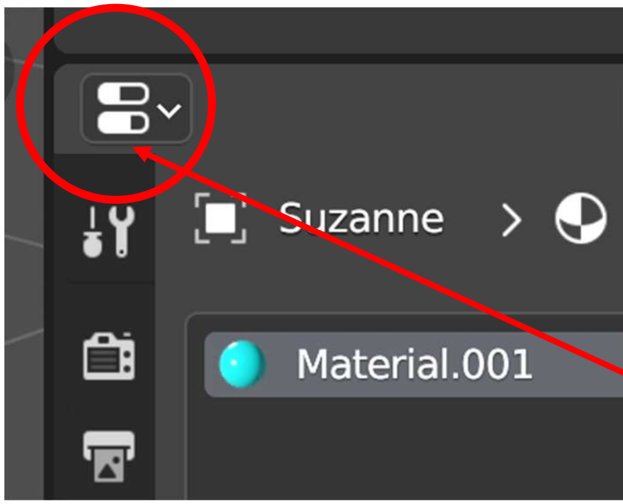
Adding a New Blender Window



To change a sub-window boundary to create a new window, hover over the boundary, wait for the cursor to change to a double-arrow, then **right-click**. This menu will pop up. Select **Vertical Split** or **Horizontal Split** and move the mouse up/down or left/right. This will create a copy of a Blender sub-window that you already have.

Changing the Type of a Blender Window

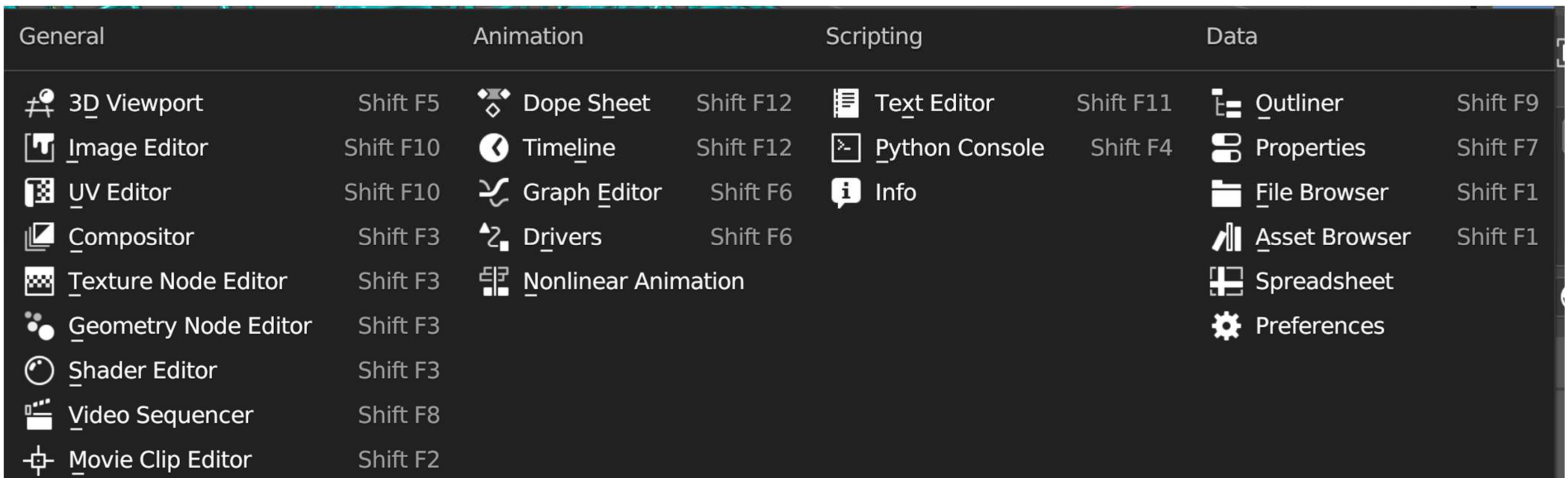
"This will create a copy of a Blender sub-window you already have."
Well, what good is that?



Blender sub-windows have a type, designated by the icon in the upper-left corner.

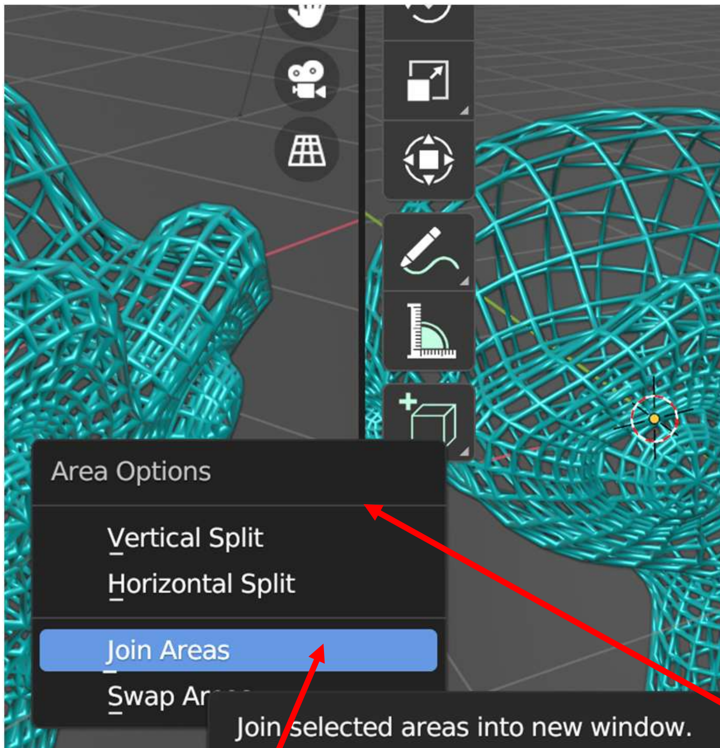
Changing the Type of a Blender Window

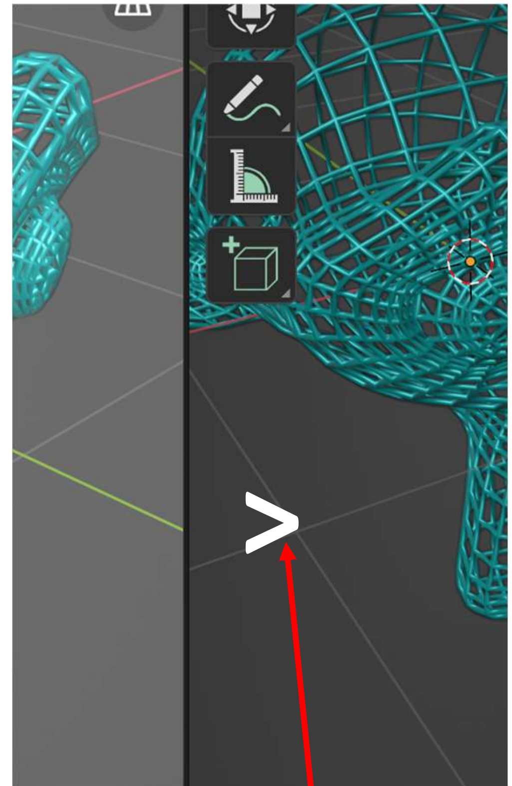
Clicking the down arrow, will bring up the list of the 23 types you can change that sub-window into:



Congratulations! You have now added a new Blender sub-window to your display.

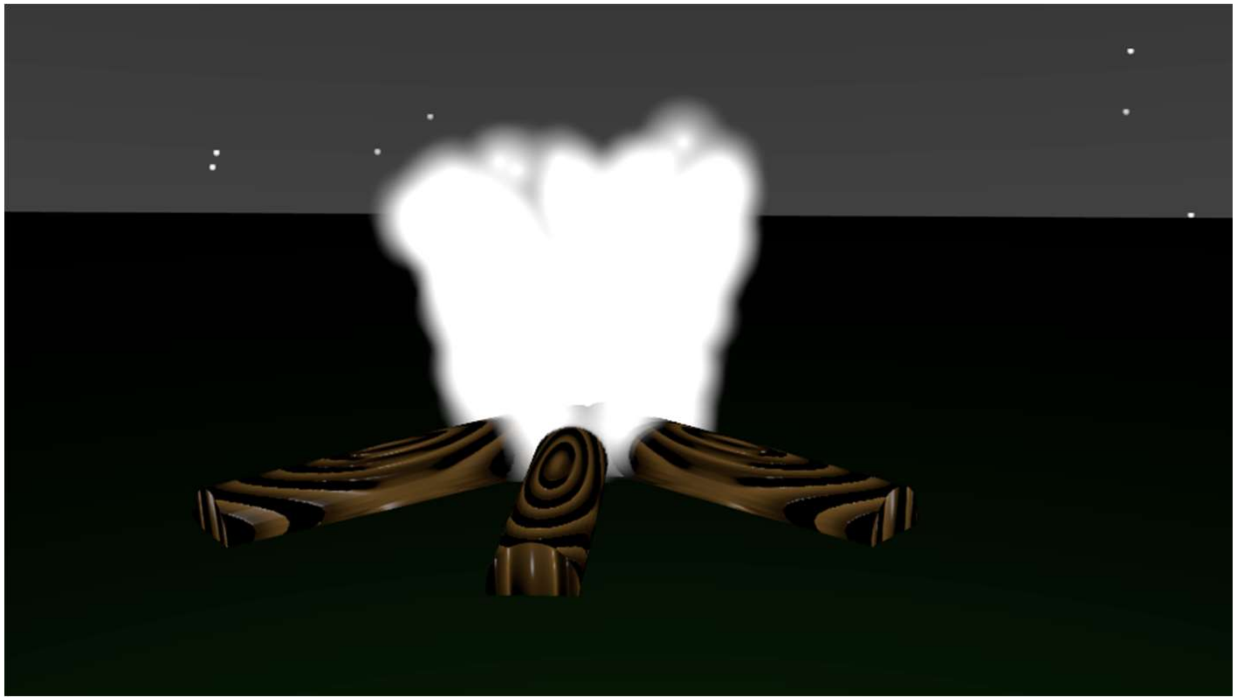
Deleting a Blender Window



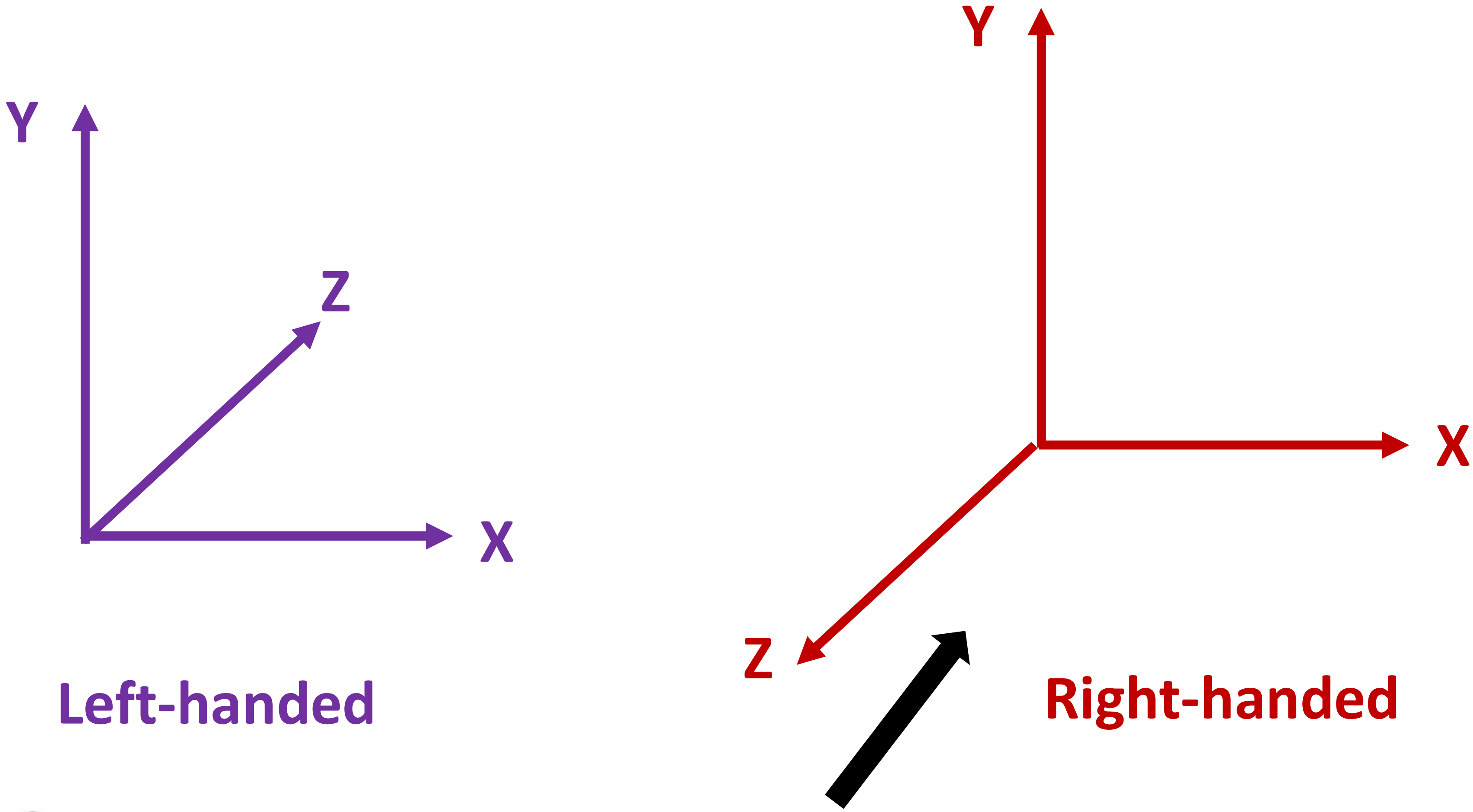


To delete a window, hover over the boundary, wait for the cursor to change to a double-arrow, then **right-click**. This menu will pop up. Select **Join Areas** and move the mouse up/down or left/right. This symbol shows you which window will be eliminated when you click the mouse button.

2. Viewing in 3D

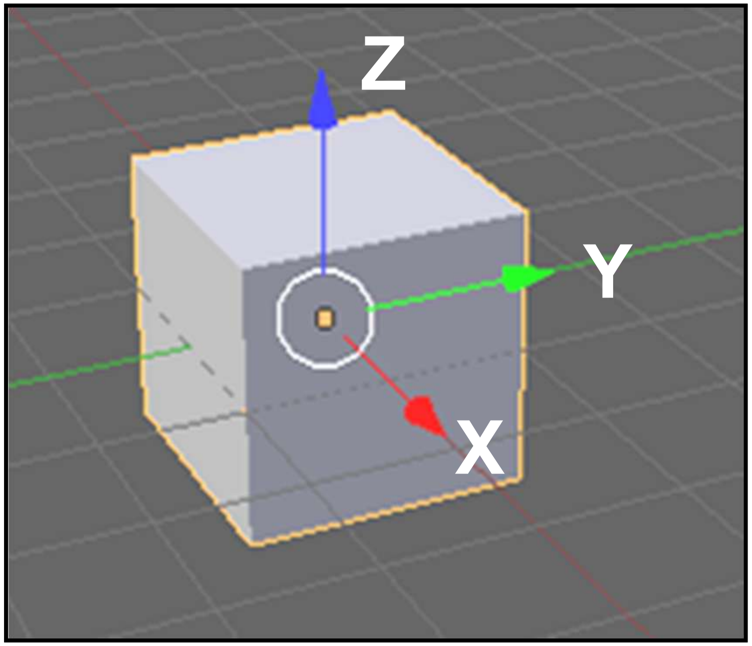


3D Coordinate Systems



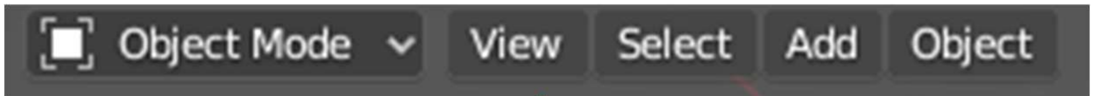
Blender uses this convention

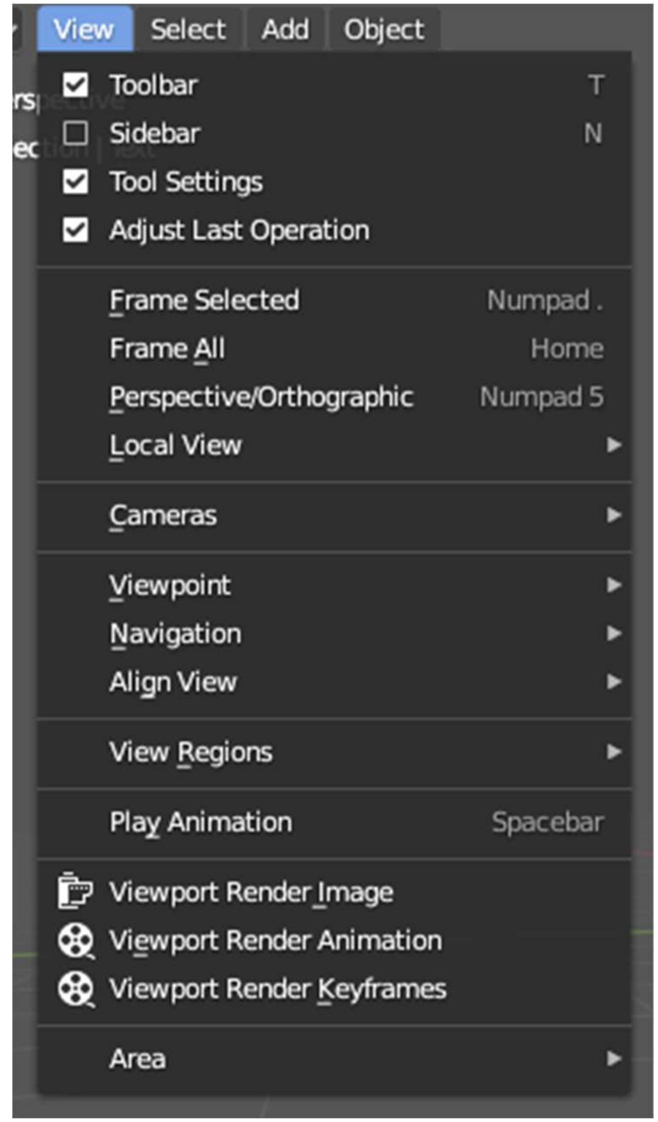
The Coordinate and Viewing System



- Right-handed coordinate system
- **X = Red**
- **Y = Green**
- **Z = Blue**
- Middle mouse button (MMB) – orbit (rotate)
- Shift MMB – pan
- Scroll wheel – zoom
- View → Viewpoint → Left, Right, …
- View → Area → Toggle Quad View
- View → View Perspective/Orthographic

The View Menu





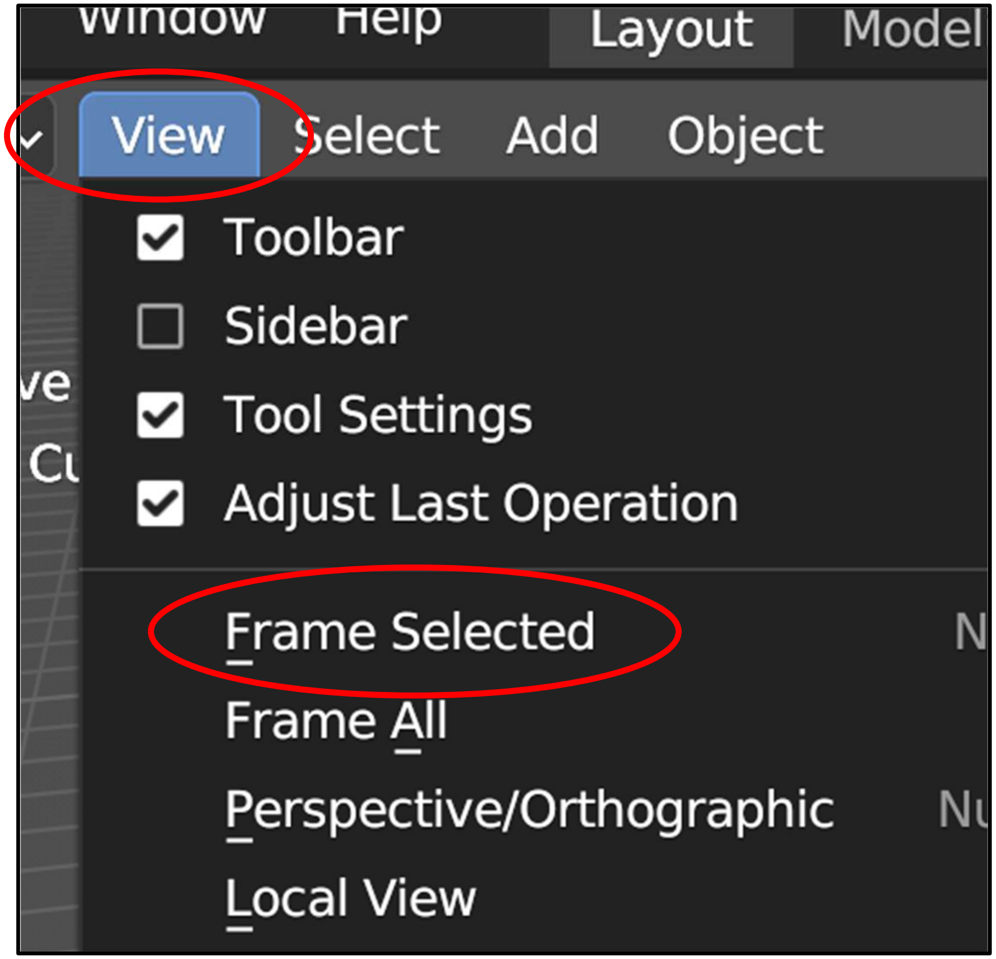
The View Menu gives you access to lots of ways to change how you are viewing the scene

Rotating About a Particular Object

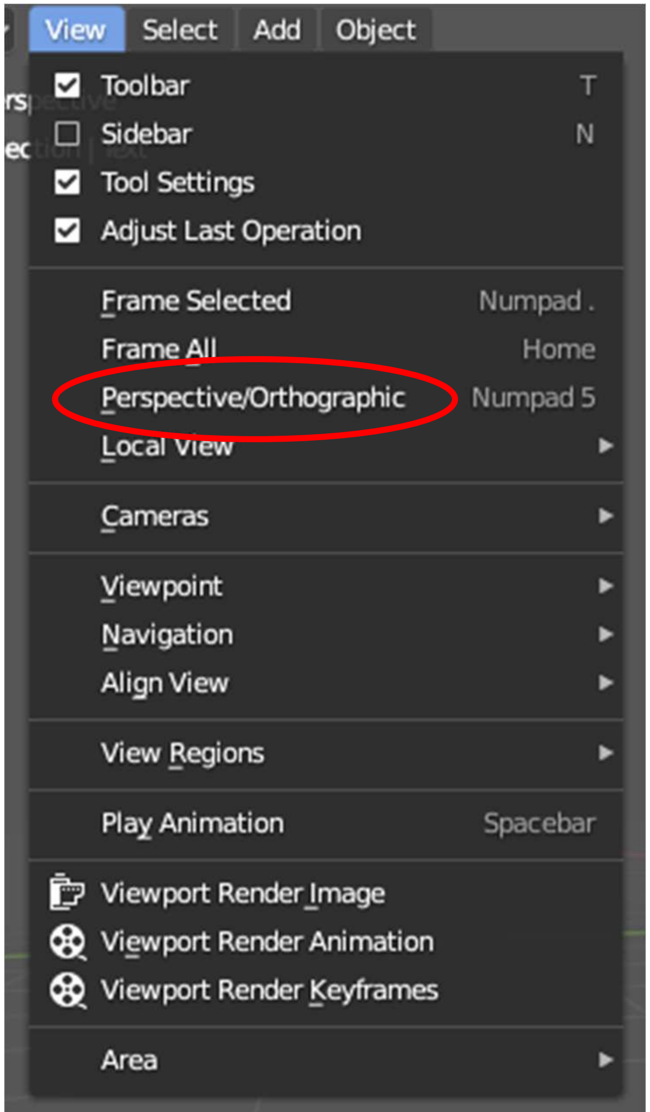
If you would like to be able to rotate the entire scene around a particular object, click on the object and then select:

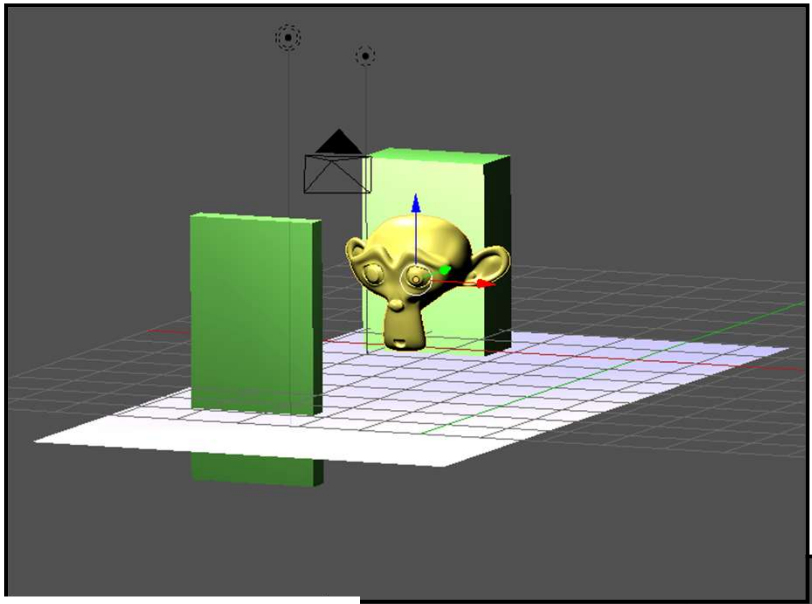
View → Frame Selected

You can also hit the period (**.**) on the number pad on the keyboard.

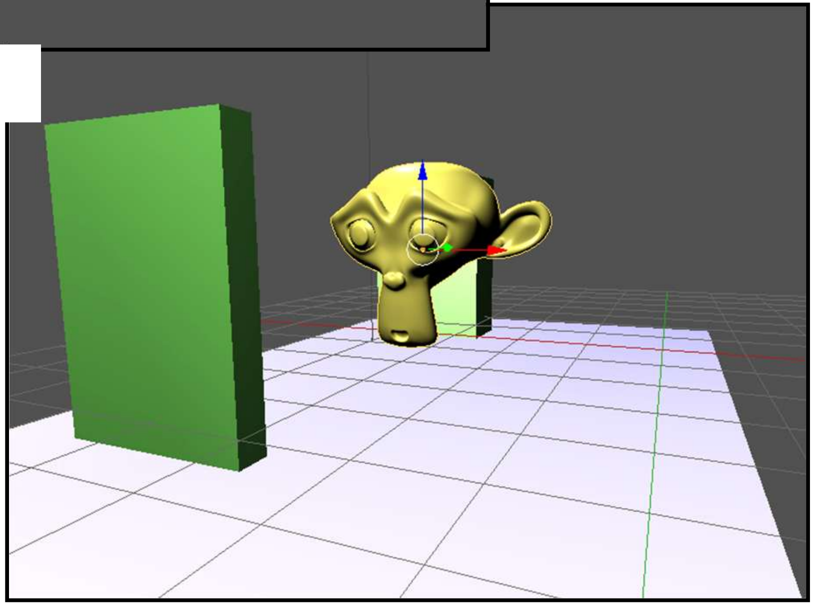


Toggling Between Perspective and Orthographic Views



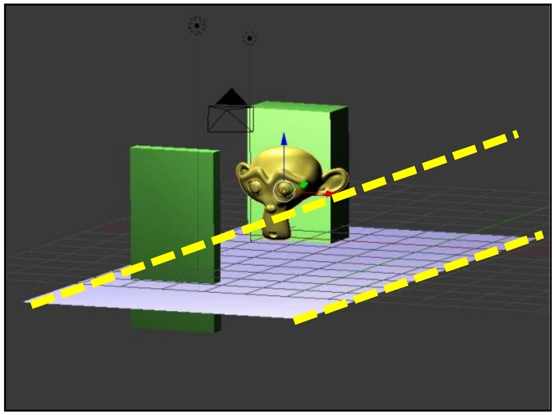


Orthographic

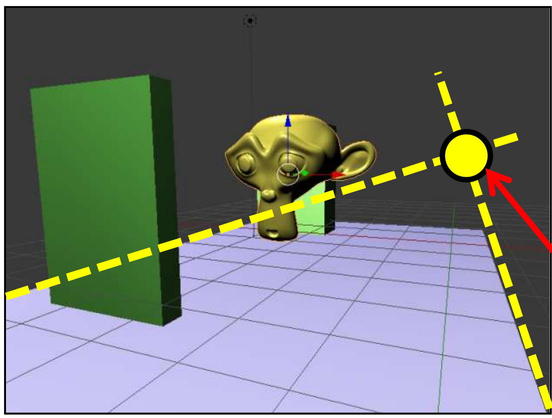


Perspective

Toggling Between Perspective and Orthographic Views

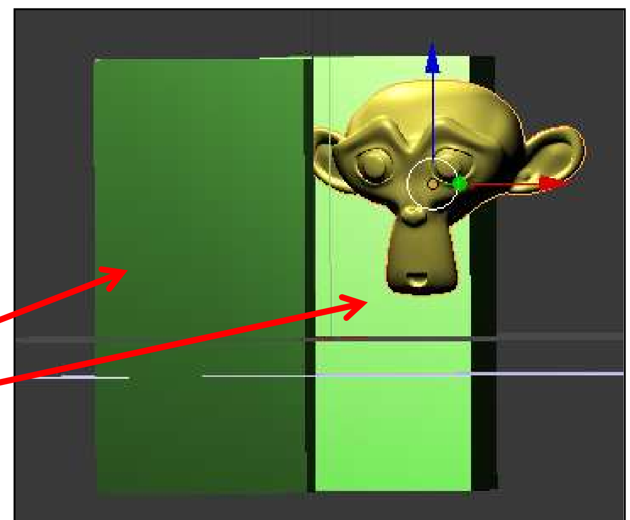


In orthographic, lines that are parallel in 3D remain parallel on the screen. Objects appear to be the same size as they get farther away.



In perspective, lines that are parallel in the 3D depth direction appear to converge on the screen. Objects appear to get smaller as they get farther away.

"Vanishing Point"

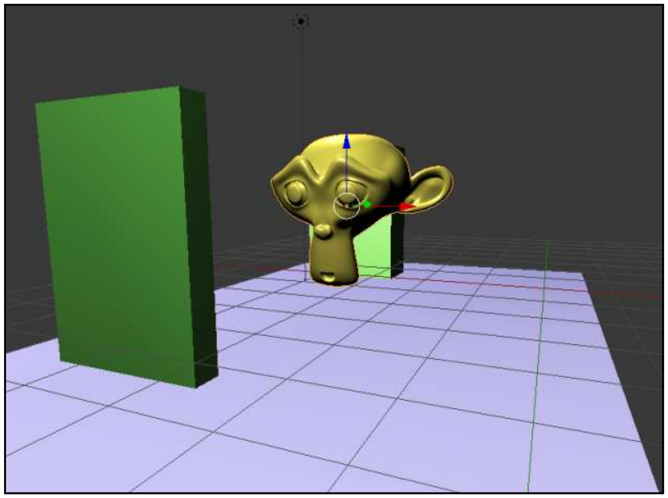


Use perspective when you want a more realistic view (which is most of the time).

Use orthographic to see if things separated in depth are the same size.

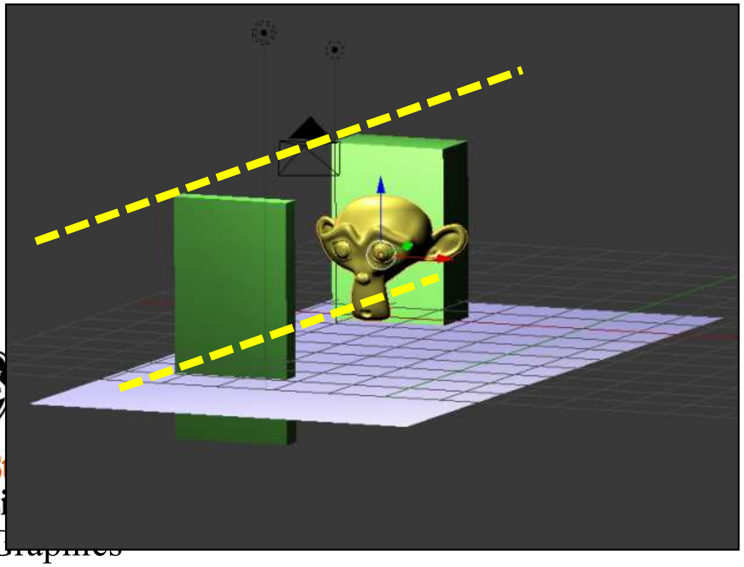
Toggling Between Perspective and Orthographic Views

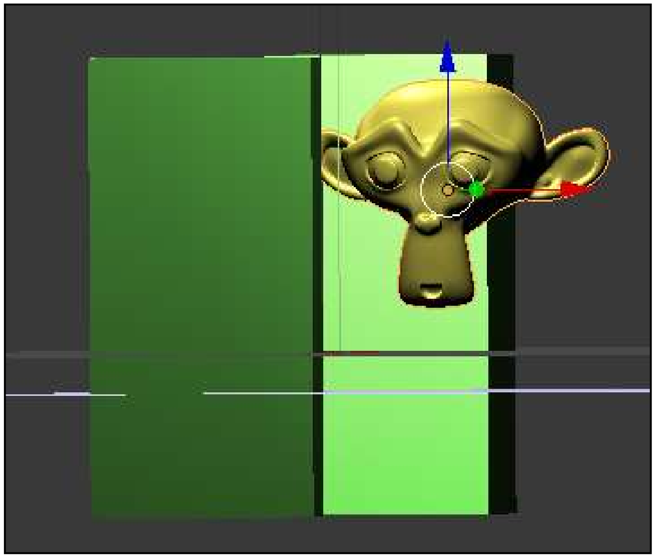
Use perspective when you want a more realistic view (which is most of the time):



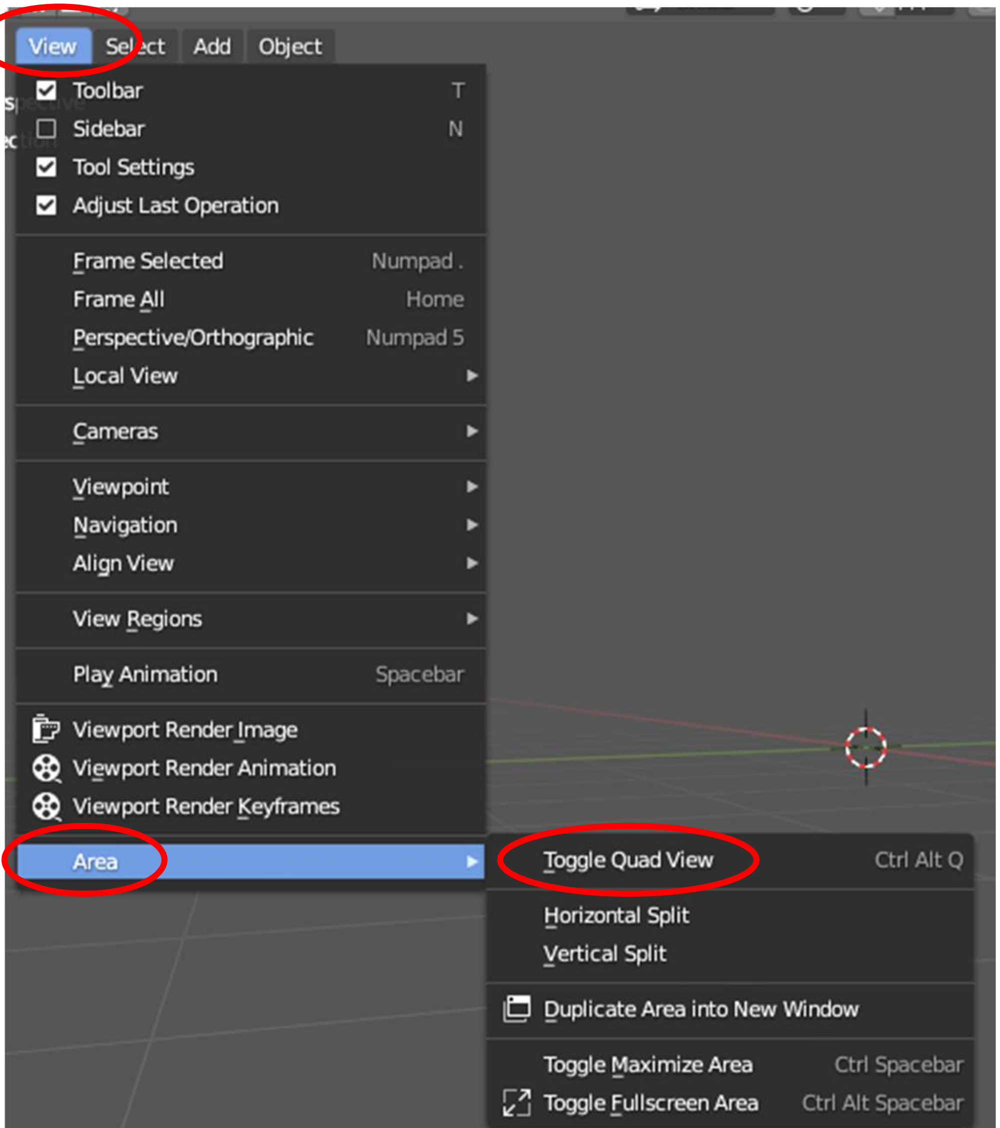
scene.blend

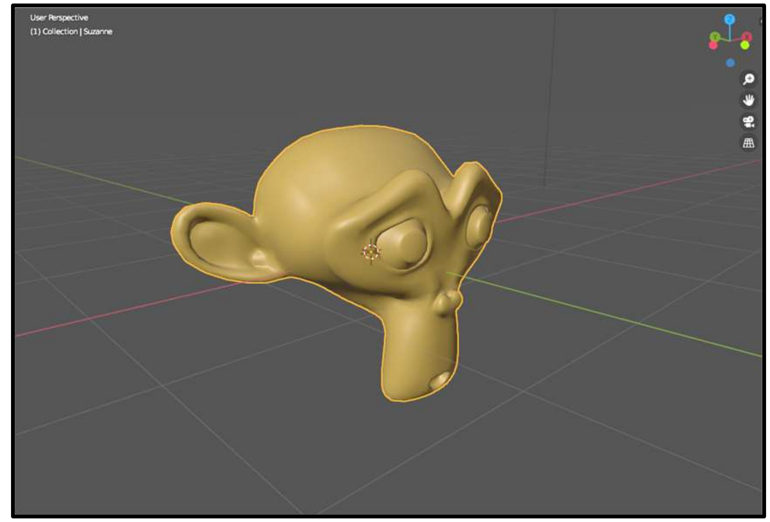
Use orthographic to see if things separated in depth are the same size:

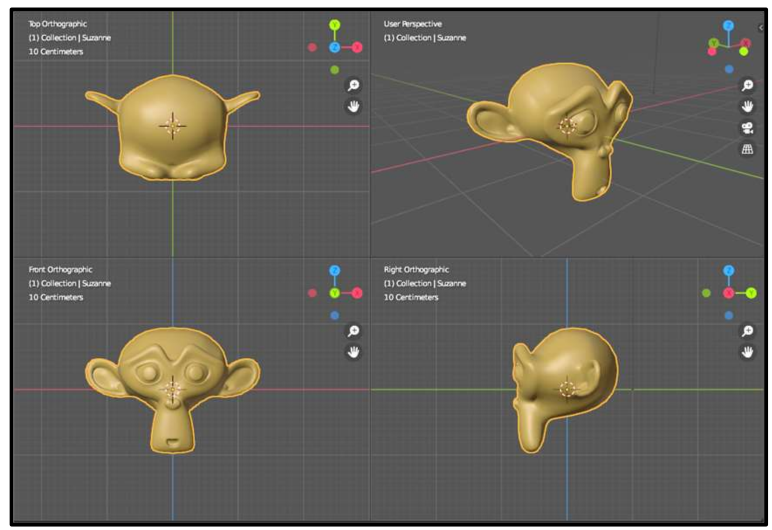




Single View vs. Quad View



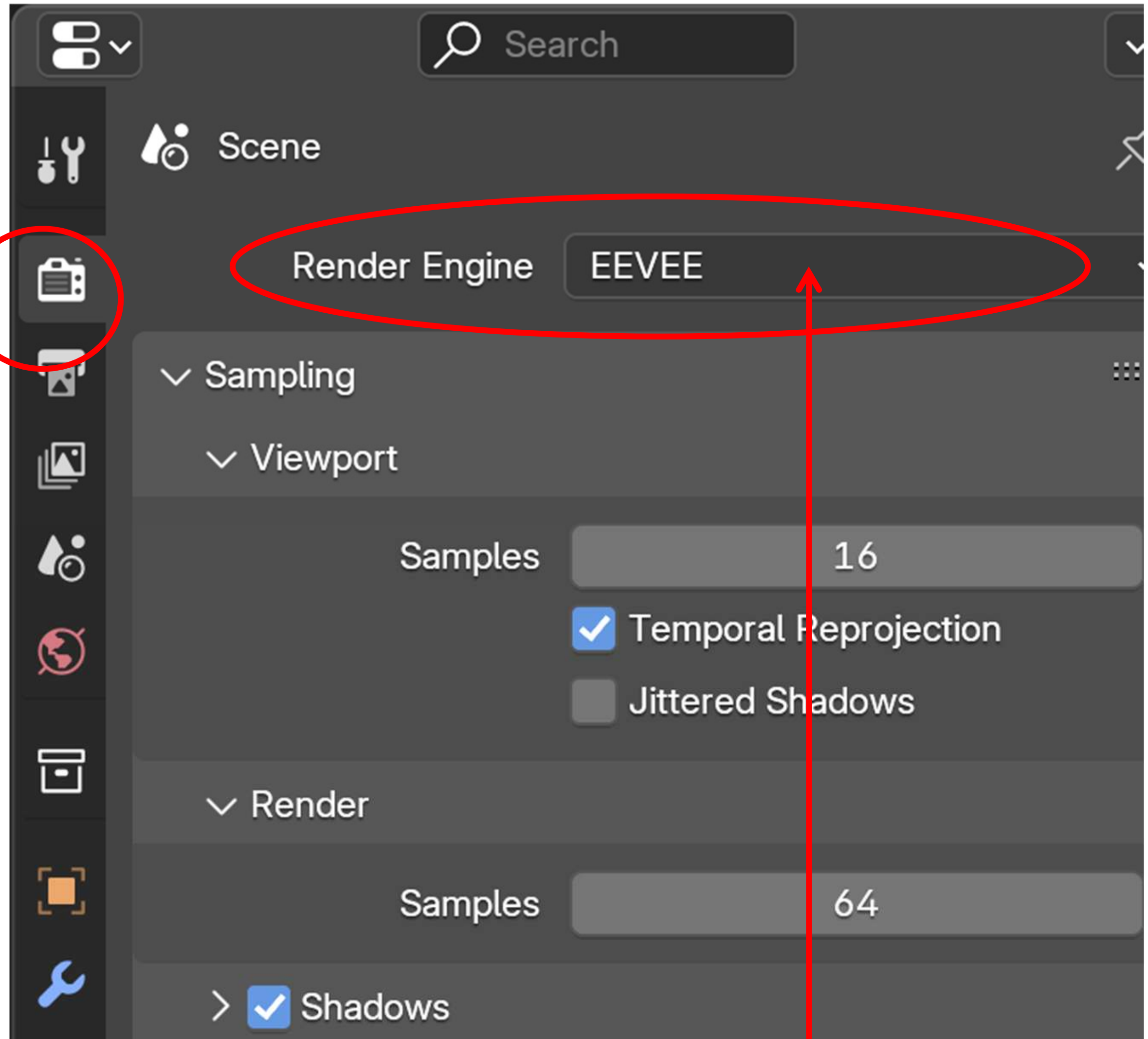




Or hit **Control-Alt-q**

Setting the initial Rendering Mode

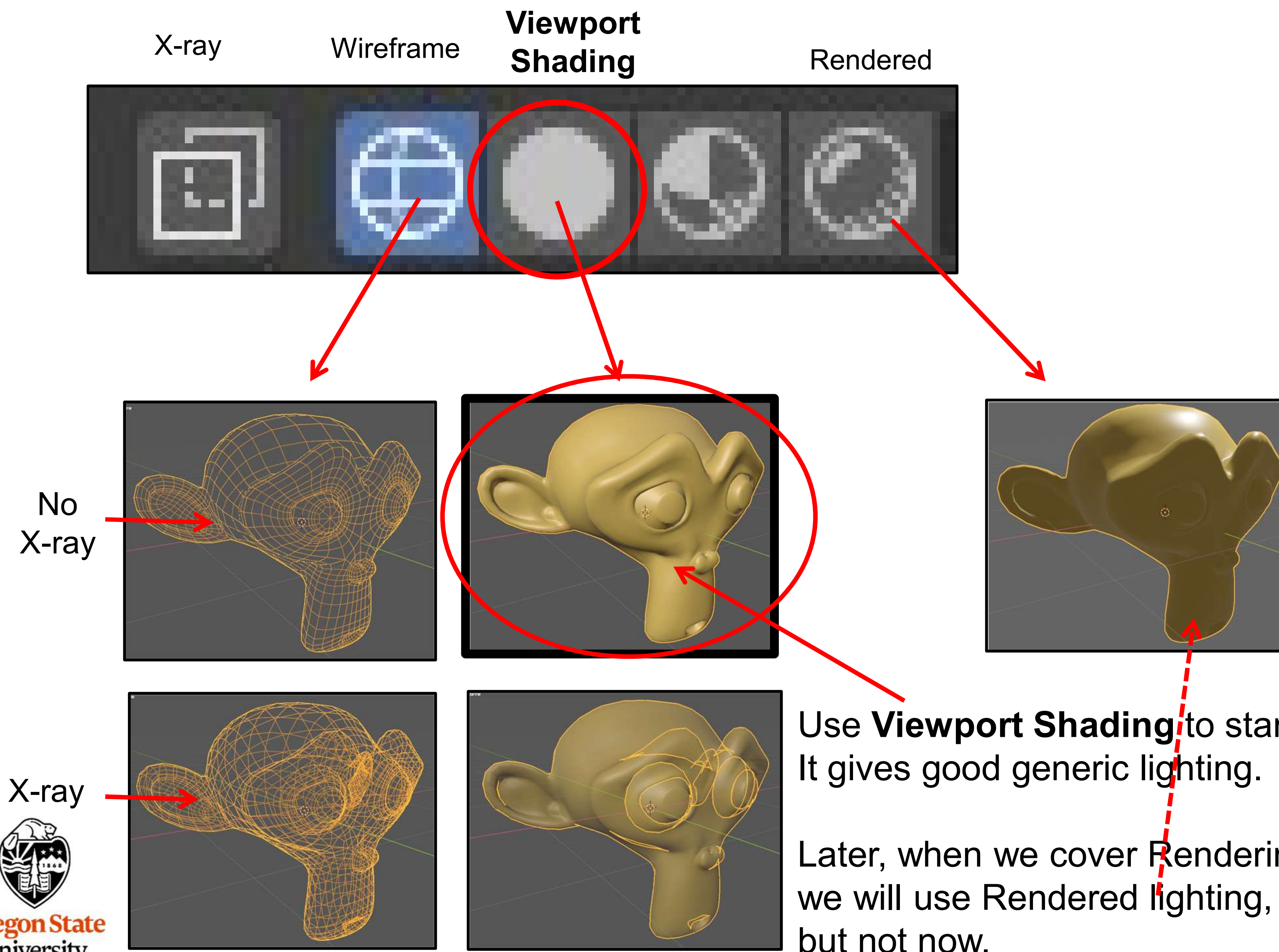
On the vertical strip of icons on the right, click this one:



And then be sure the Render Engine is set to **Eevee** for now.

BTW, ***Eevee*** stands for Extra Easy Virtual Environment Engine

Setting the initial Display Mode



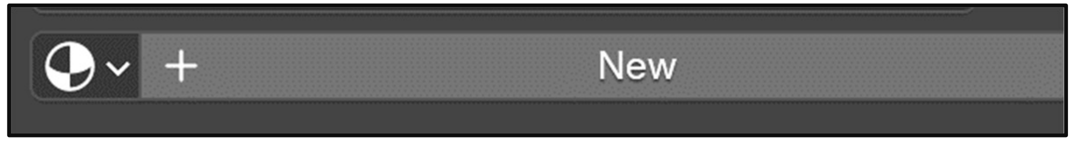
Use **Viewport Shading** to start. It gives good generic lighting.

Later, when we cover Rendering, we will use Rendered lighting, but not now.

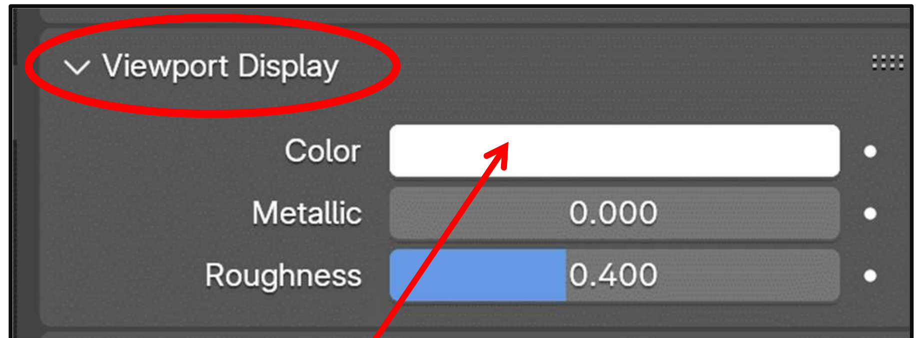
Setting the initial Display Mode

1. Click on the object whose color you want to set

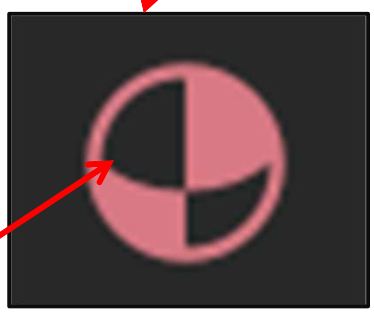
3. Click on **New**



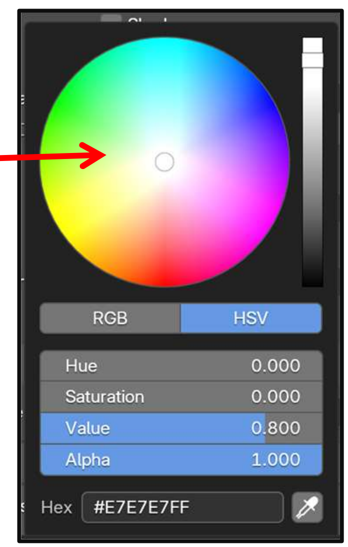
4. Scroll way down and select **Viewport Display**



2. Find this vertical column of icons, then click on this one, called **Material Properties**



5. Click here and use the color wheel to select the color you want this object to be

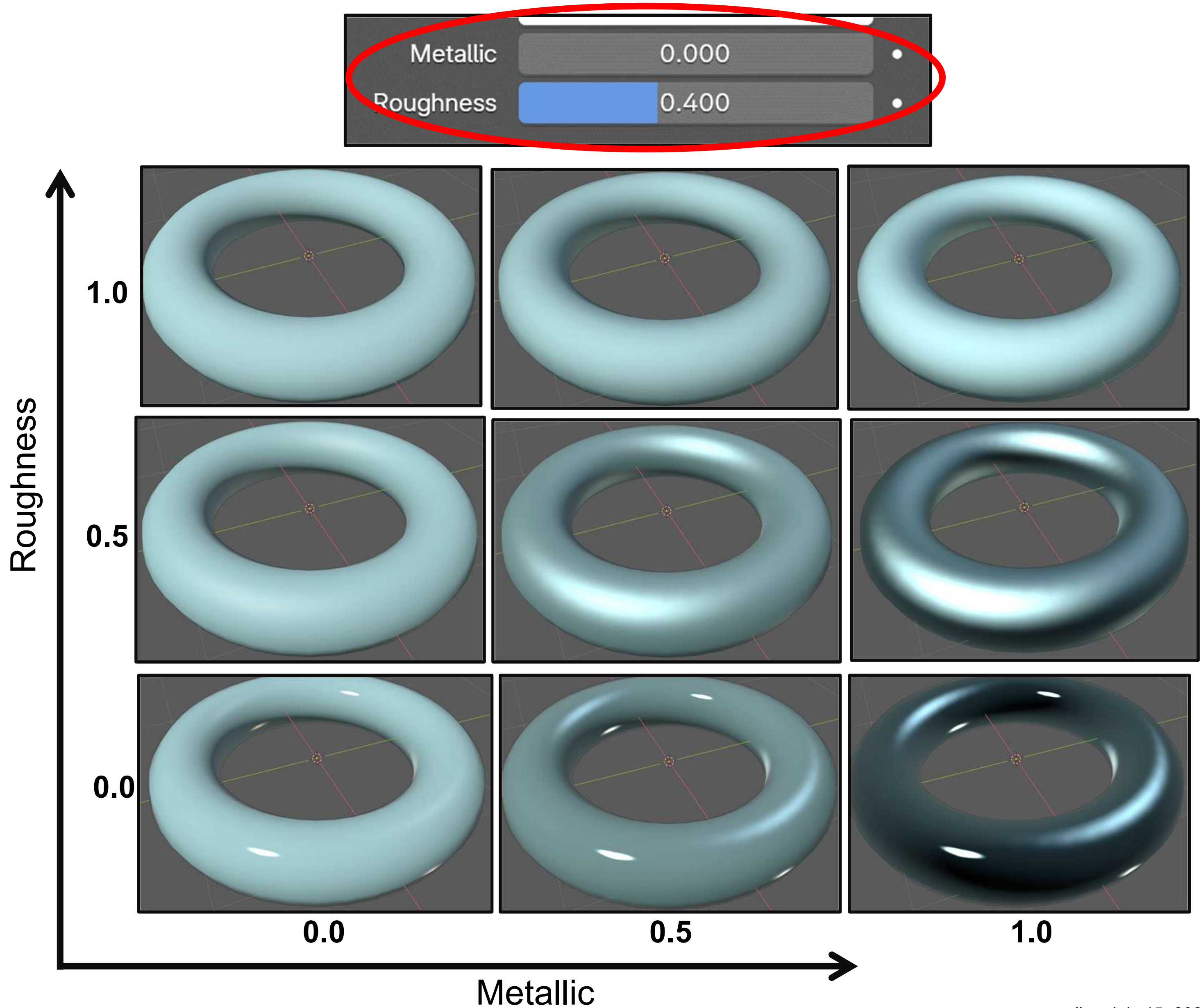


Metallic and Roughness Specify How the Color Interacts with Light

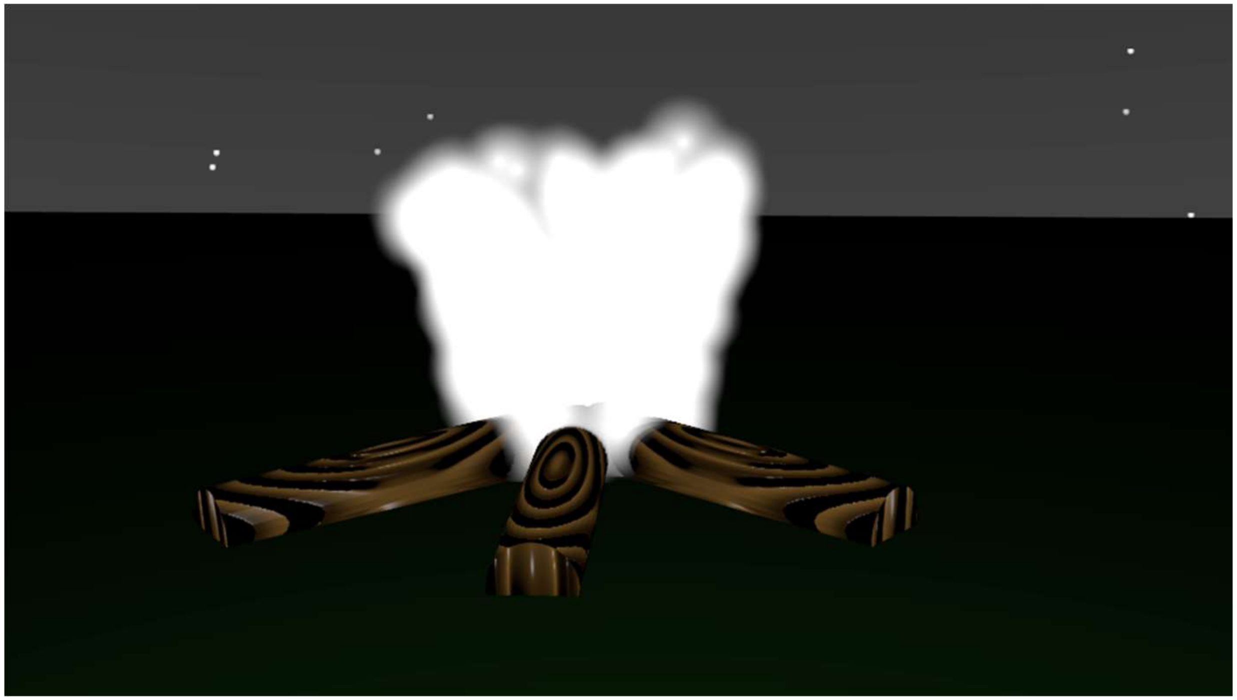
In some graphics programs, they use the word "smoothness" instead of "roughness".

If smoothness is small, roughness is large.

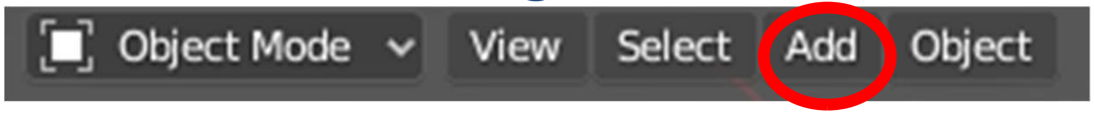
If smoothness is large, roughness is small.

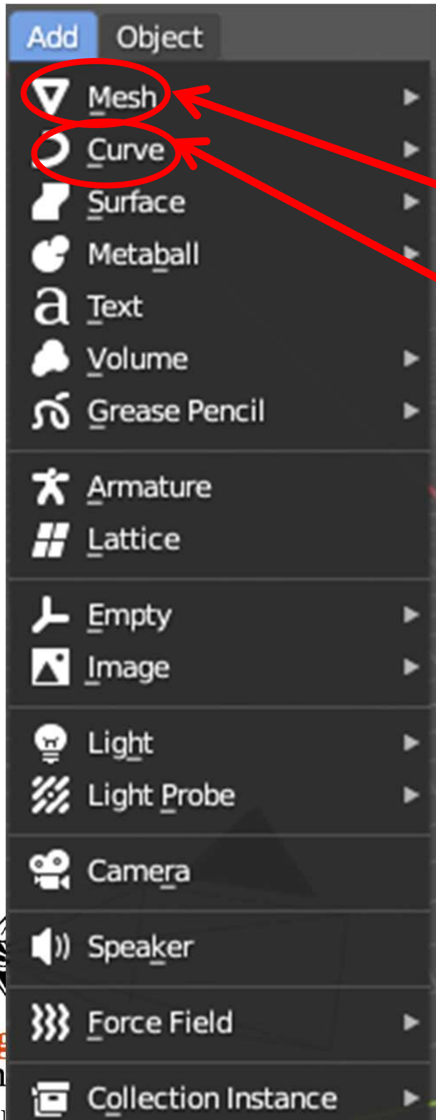


3. Moving Things Around in 3D



We will get into this in more detail later, but just so that you have something on the screen, here is the Add Menu



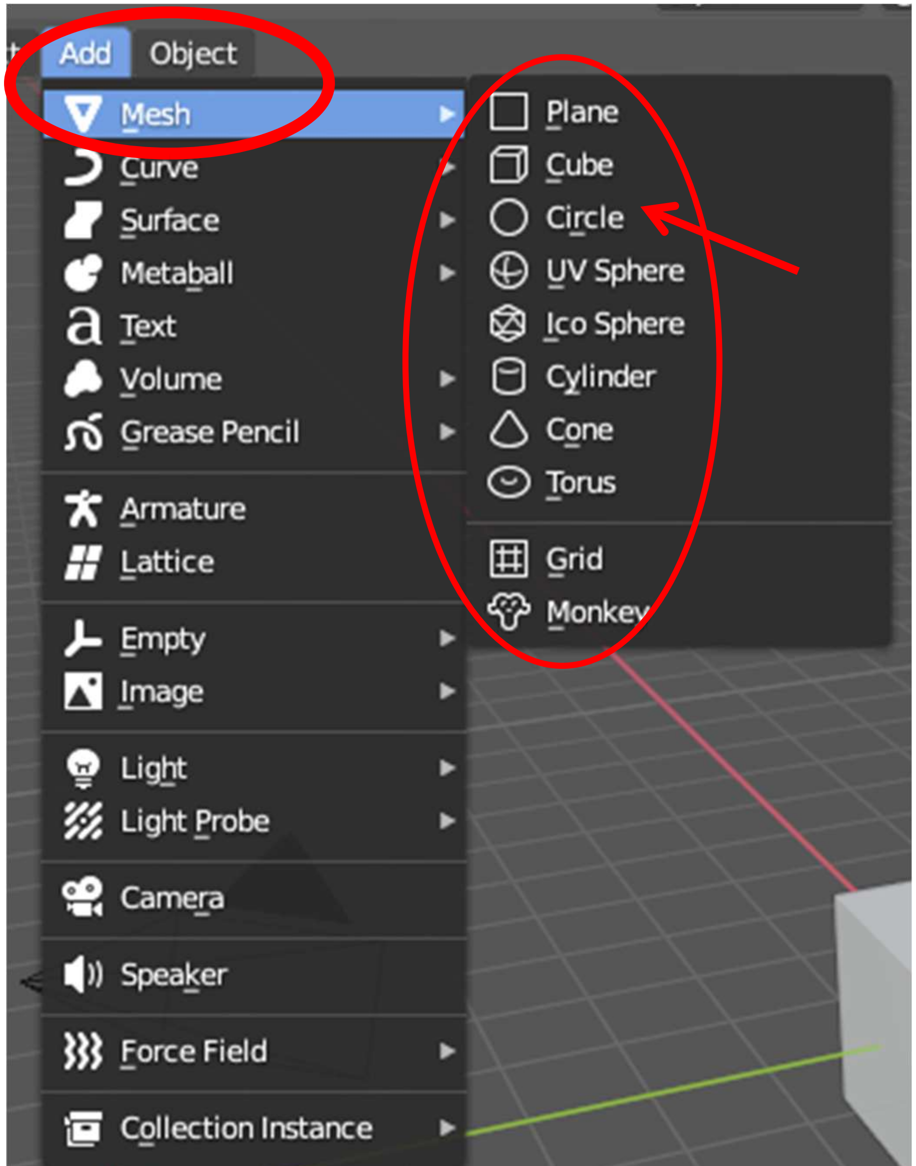


These are all the different geometry things you can add into the scene. We will cover many of them, but not all.

This group is the **meshes**.

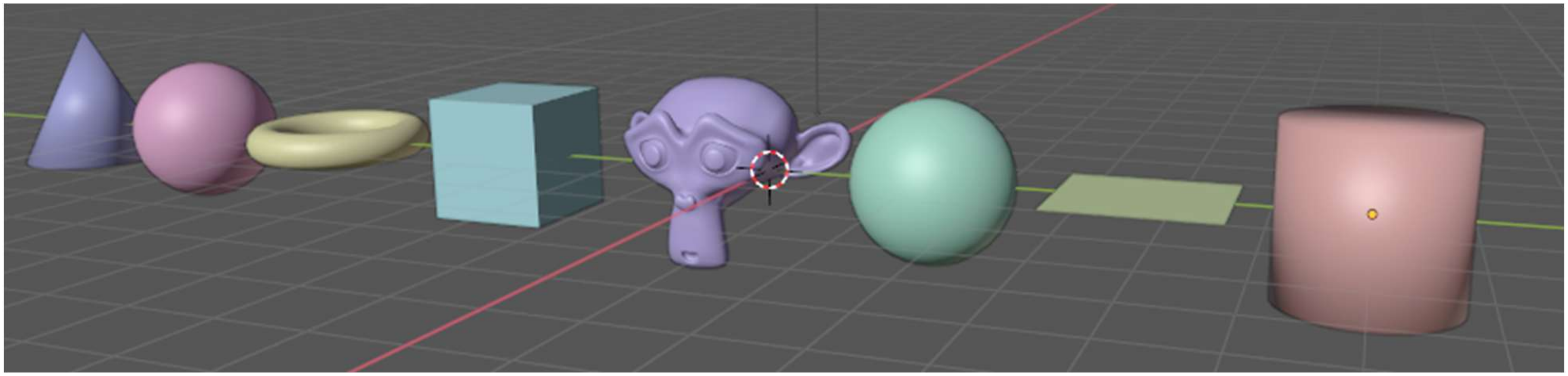
This group is the **curves**.

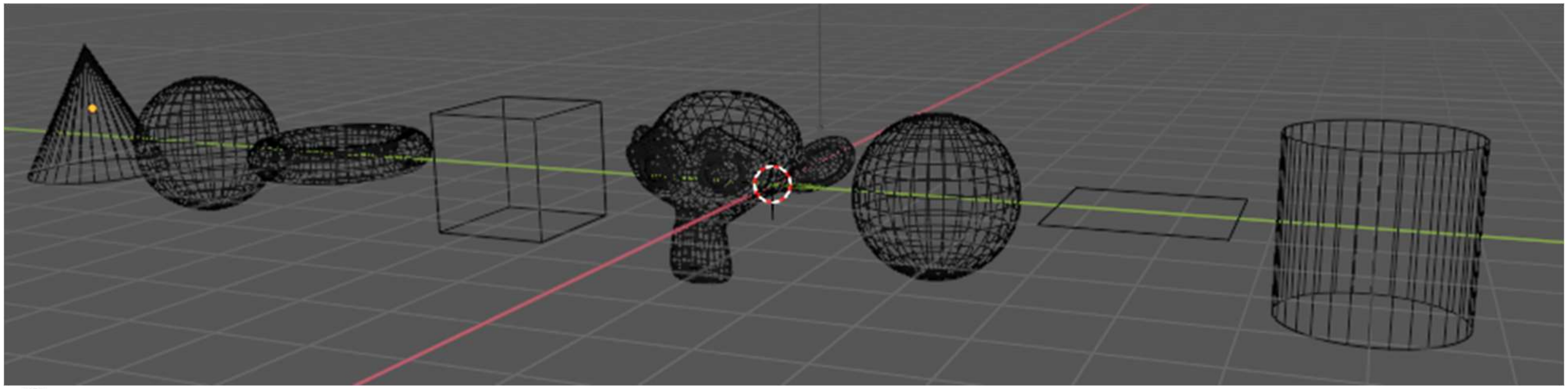
The Add→Mesh Menu



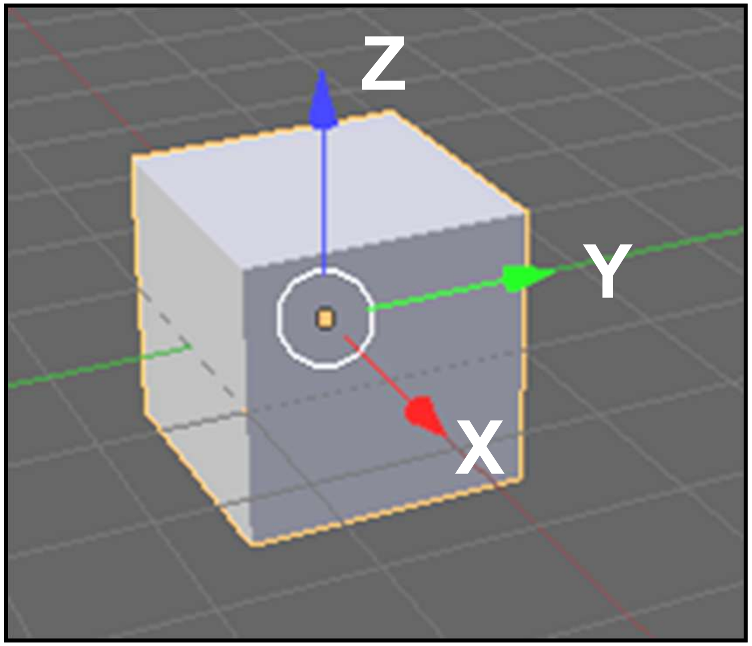
The UV Sphere, Torus, and Monkey are my favorites

Summary of the Mesh Objects



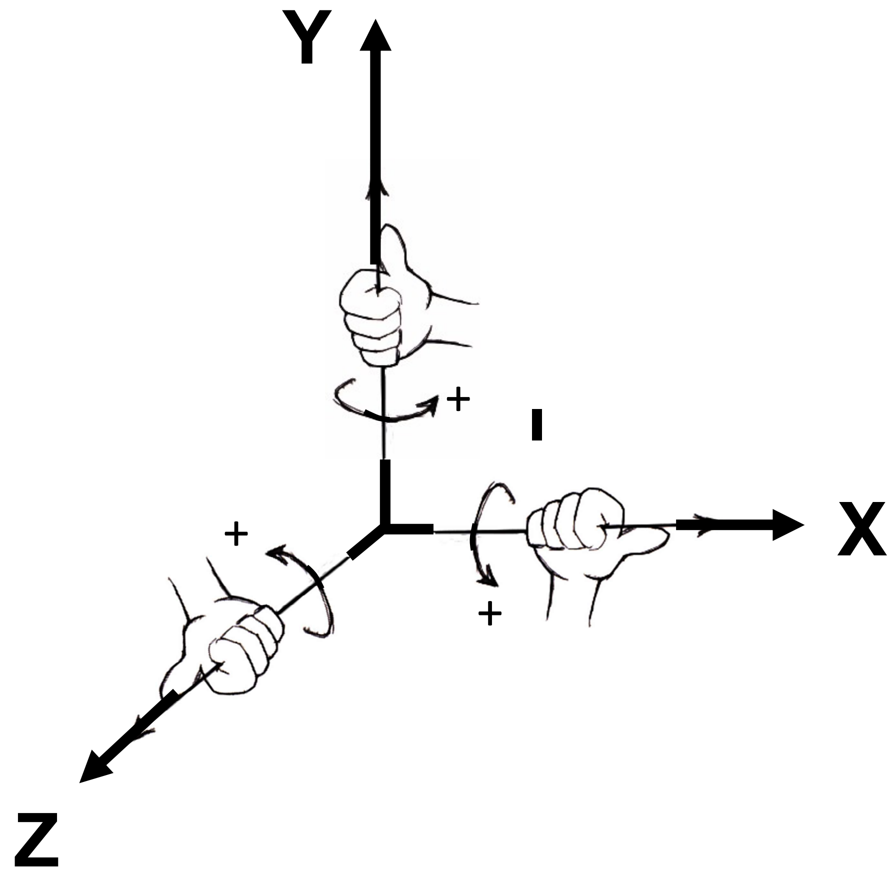


Coordinate System Conventions

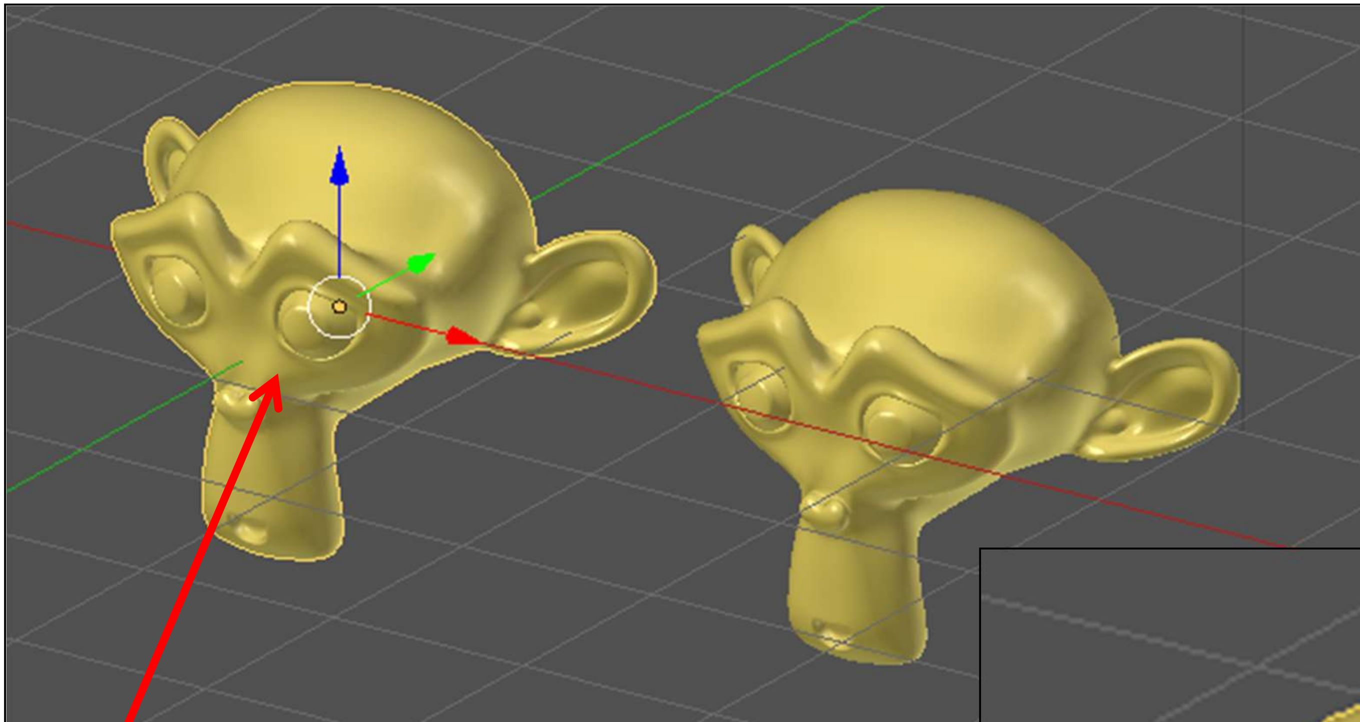


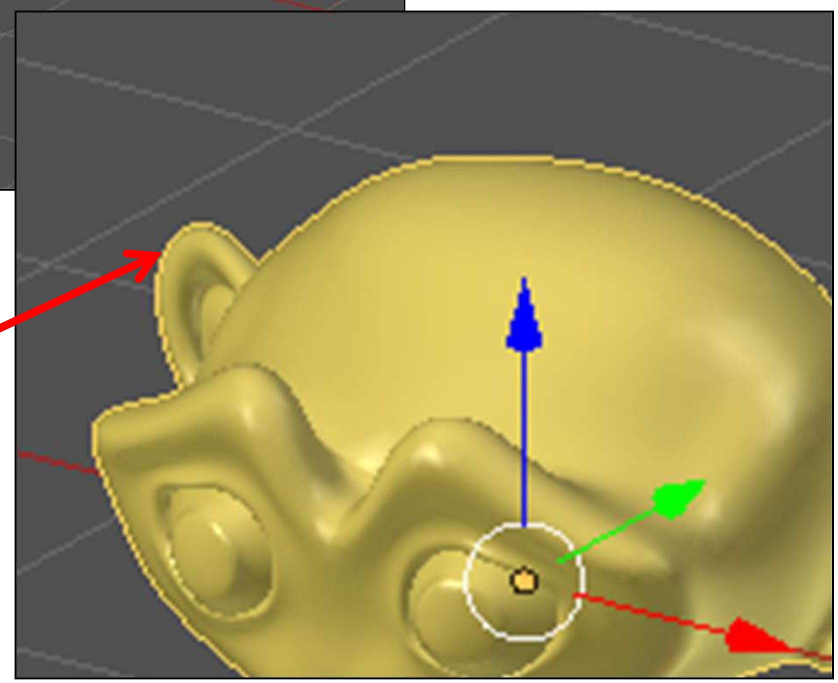
- Right-handed coordinates
- Right-handed rotation rule
- Angles are in degrees

Right-handed Rotation Rule



Selecting an Object to Work On



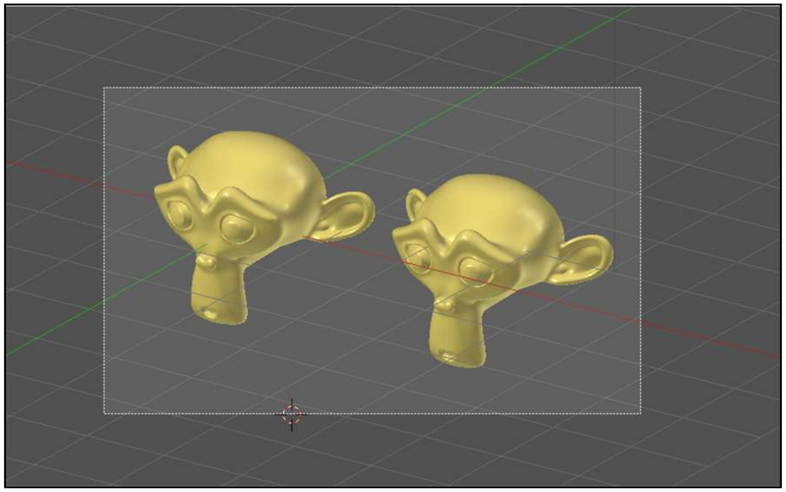


LMB-click on the object you want to select. It will then be highlighted with an orange outline.

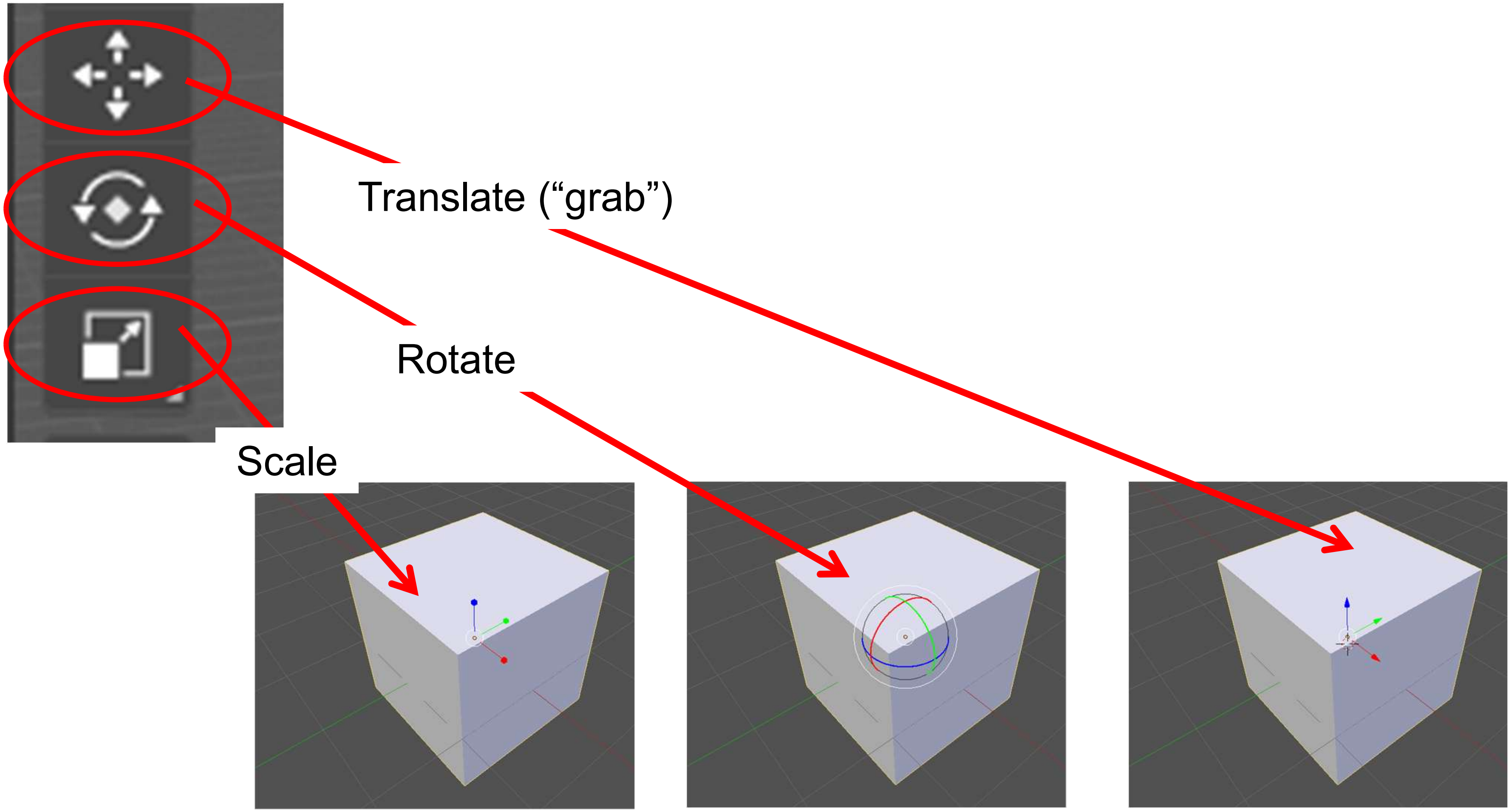
Selecting *Multiple* Objects to Work On: Two Ways to Do This

1. Hold down the Shift key while RMB-clicking

2. LMB a rectangular region around objects



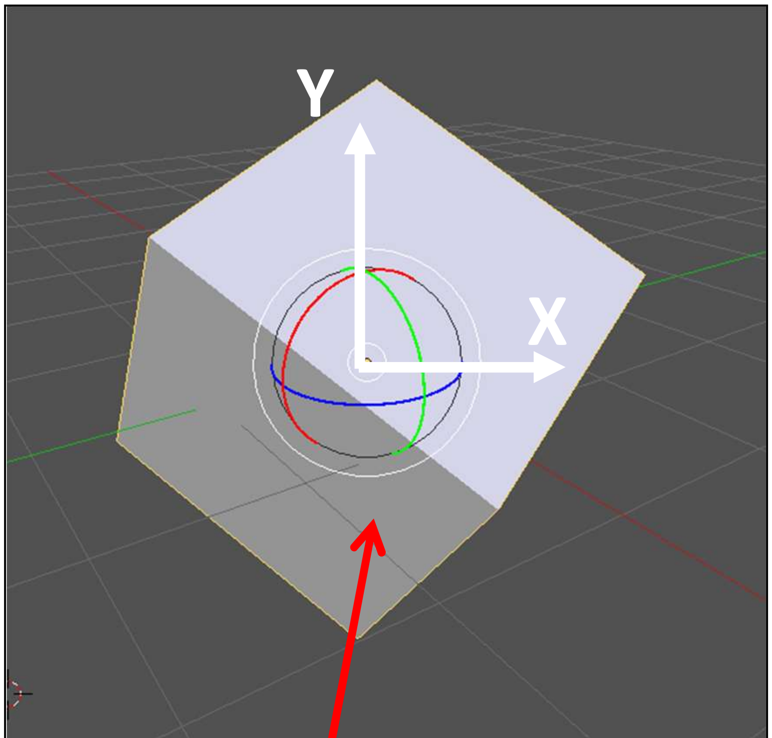
Moving Things By Clicking and Dragging



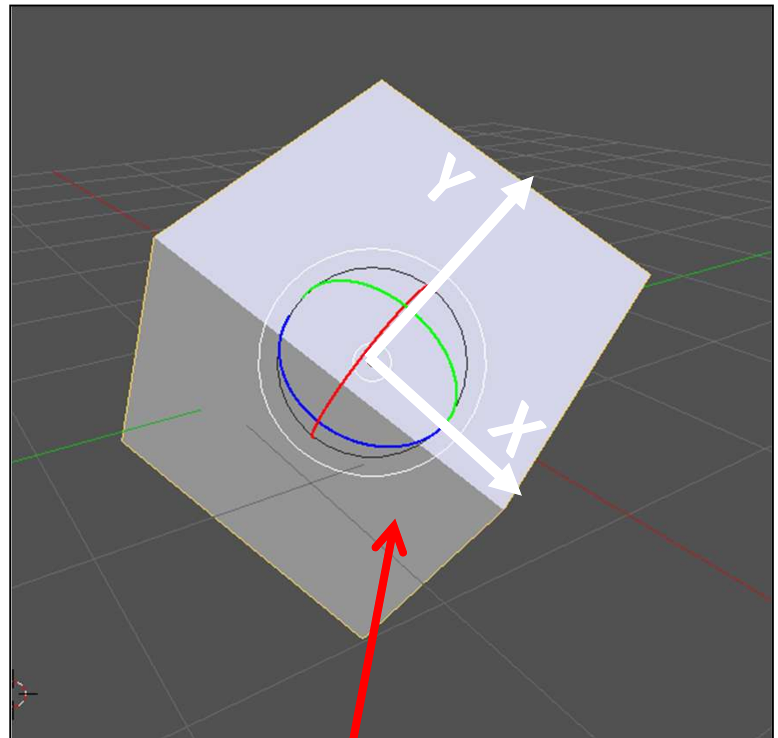
Use Global or Local Coordinate System

Global and Local Coordinates

Global



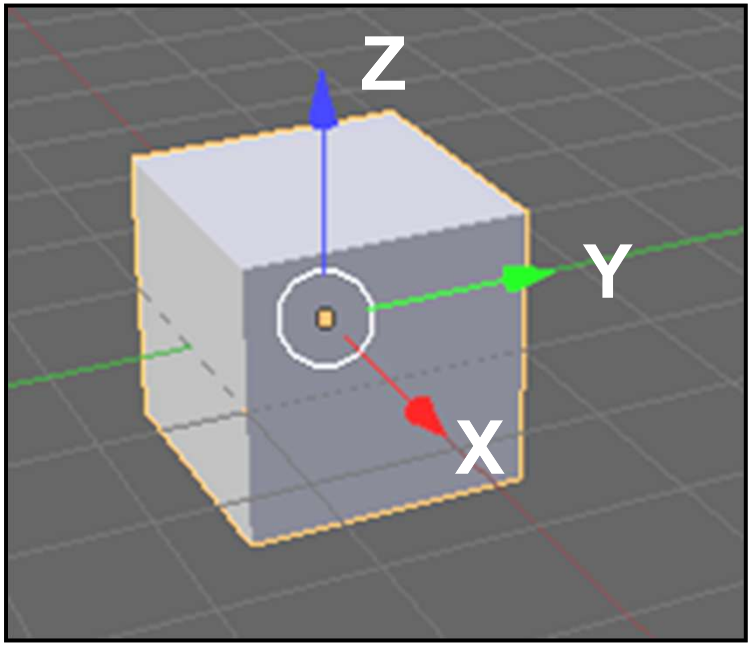
Local



Global Coordinates align with the *screen*

Local Coordinates align with the *object*

Saying How to Move Things by Using the Keyboard

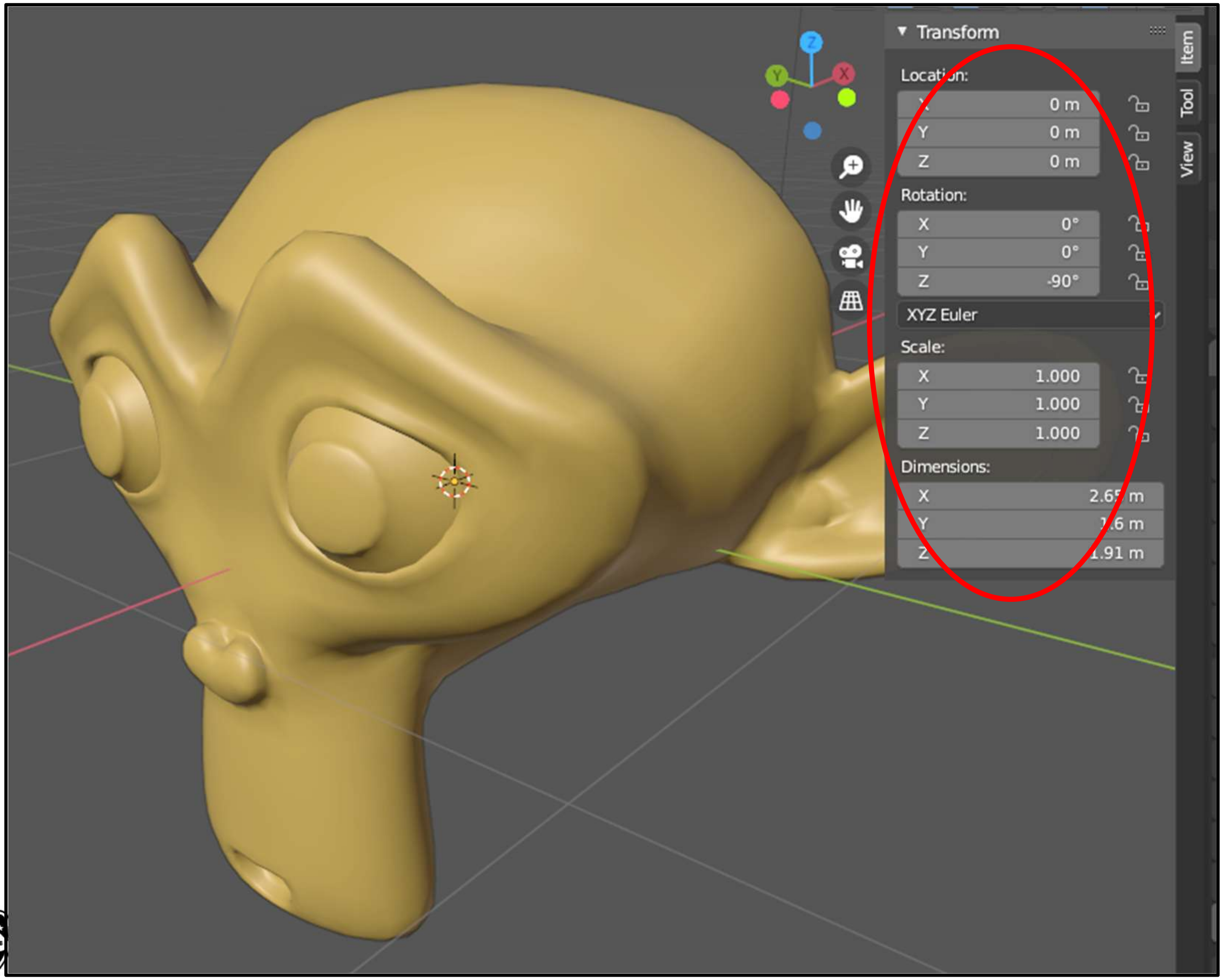


- LMB click to select an object
- Grab: g
- Rotate: r
- Scale: s
- Grab using global axis: g → x, etc.
- Grab using local axis: g → x → x
- Pick all *but* a particular axis: g → X, g → X → X, etc.
- Grab a specific distance: g → x → 12.25 <return>
- Rotate a specific angle: r → x → 45 <return>
- Scale a specific factor: s → 2.0 <return>
- Scale a specific factor: s → x → 2.0 <return>

This is *important* – you will use this a lot!

The arrows (→) mean “and then hit”

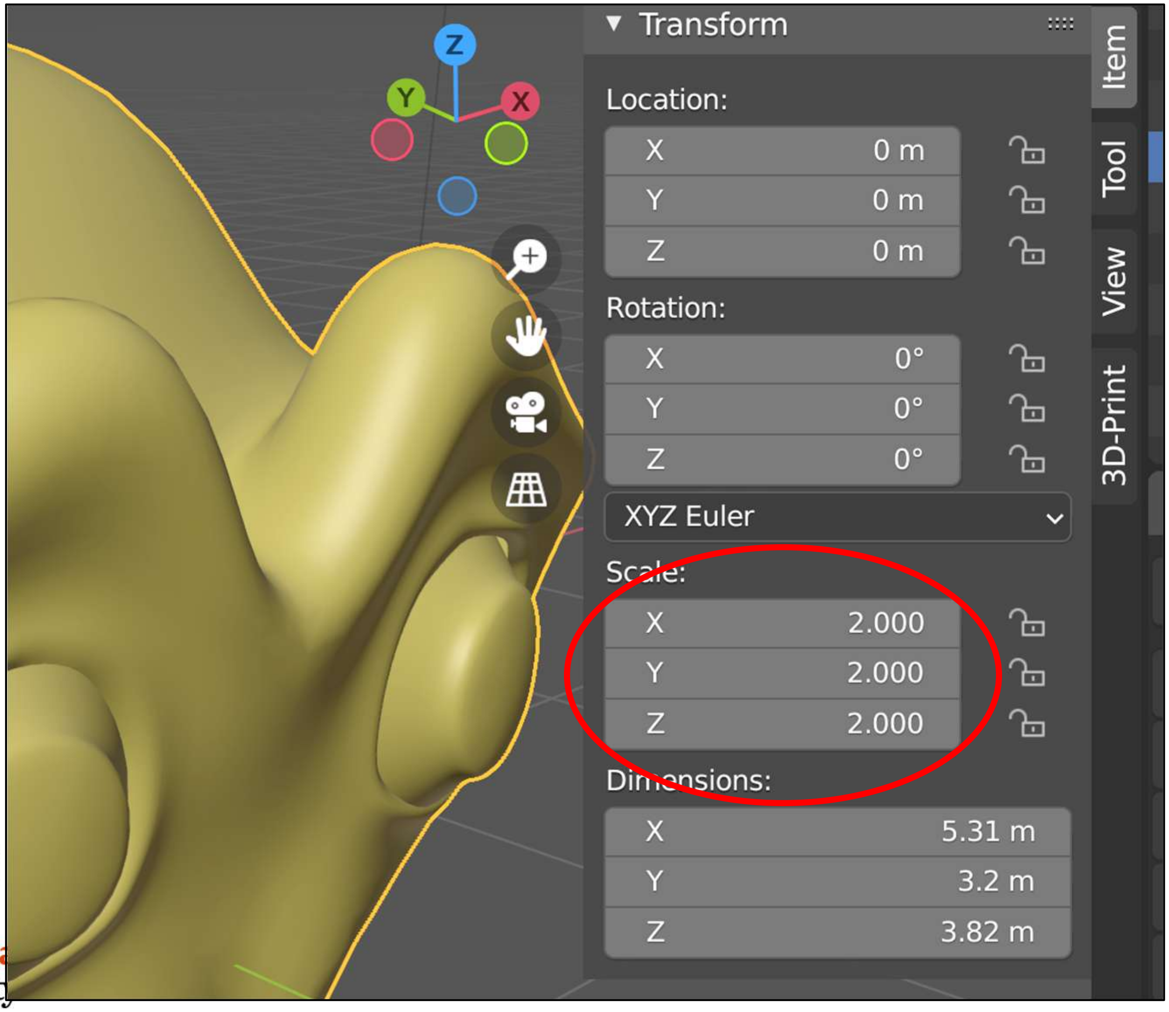
You Can Also Use the Sidebar Panel



Hit the **'n'** key to toggle this panel on and off

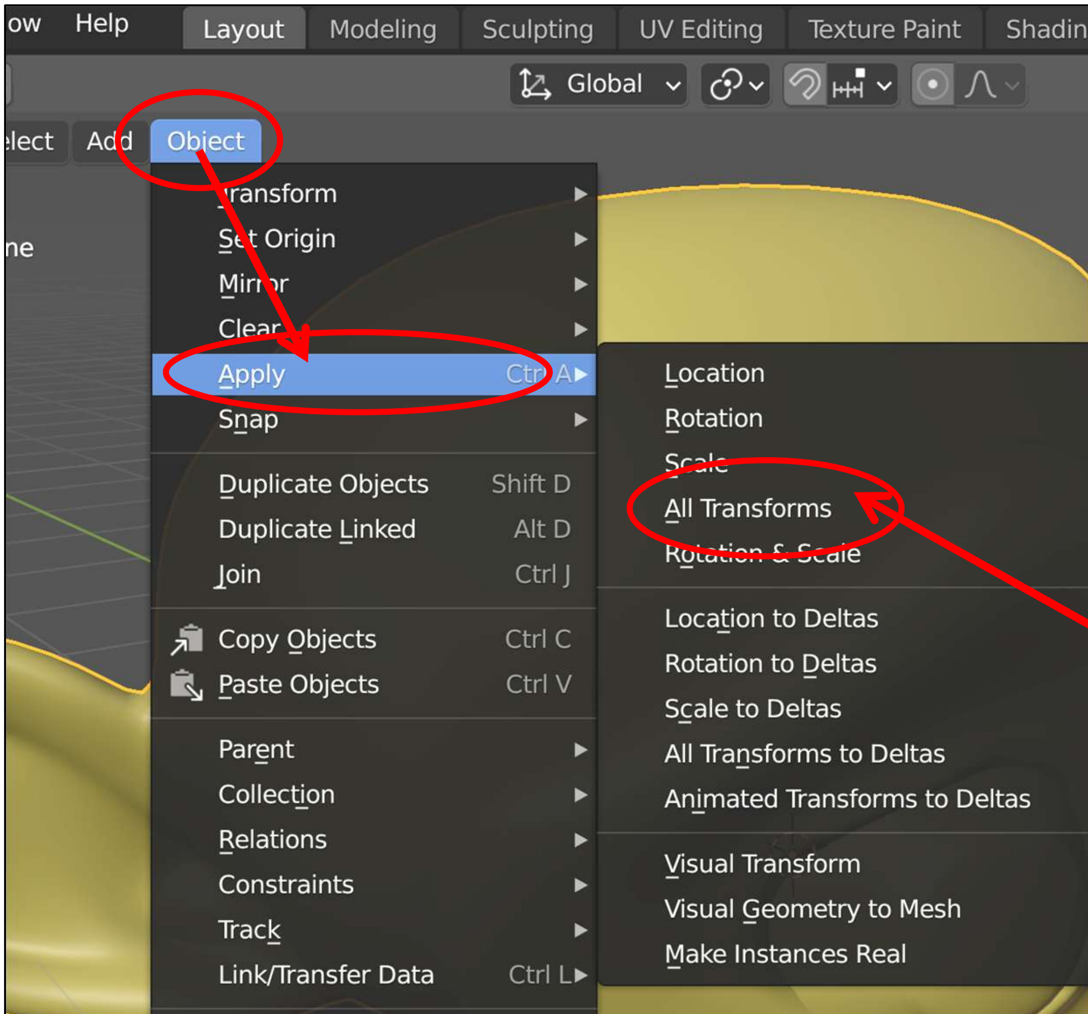
Applying the Transformation

When you transform an object, Blender *doesn't change the object's coordinates*.
It keeps the object's original coordinates plus a record of the transformation.
So, for example, if you scale an object by 2.0, Blender remembers it like this:



Applying the Transformation

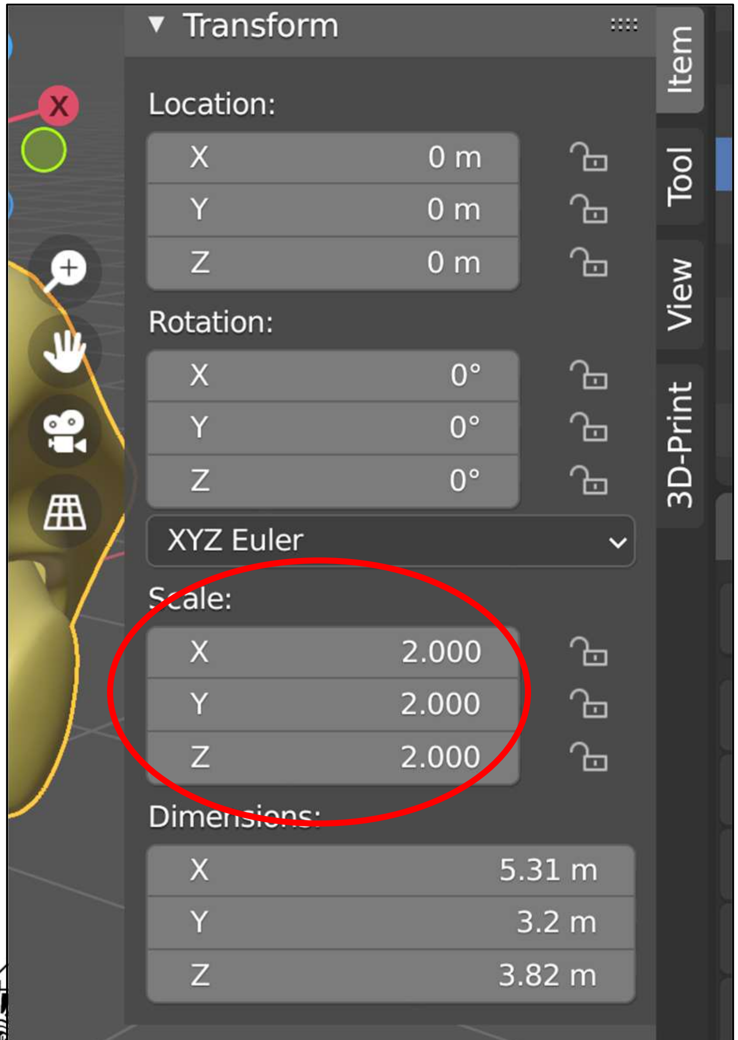
If you want to actually *alter* the object's coordinates, choose **Object → Apply**



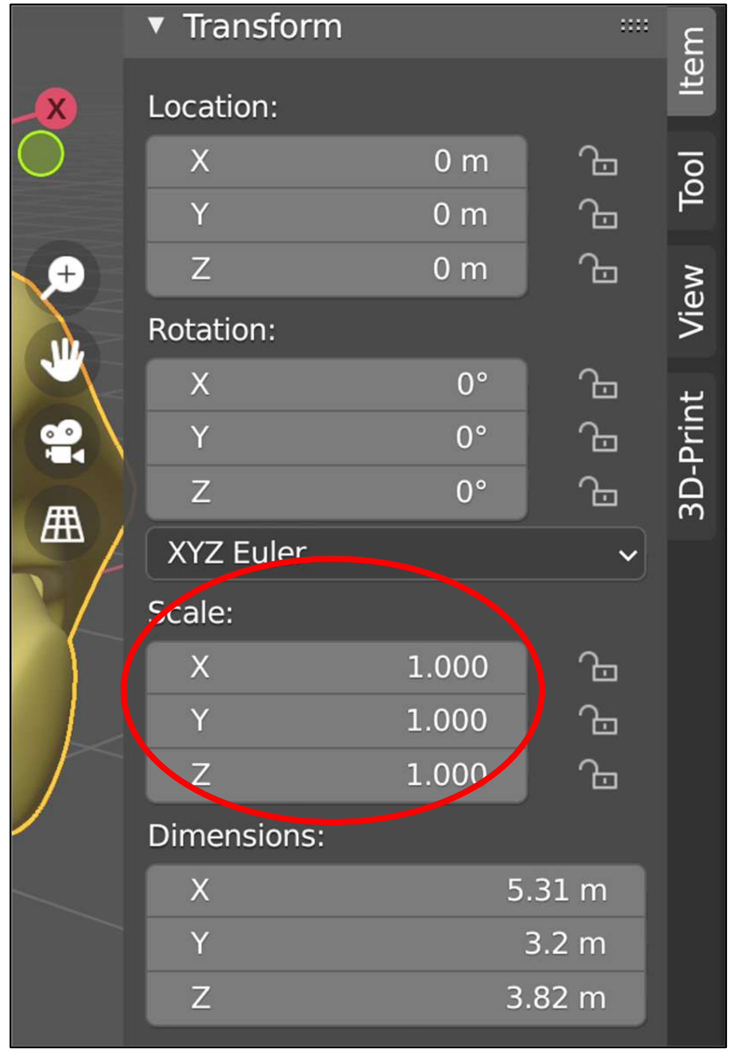
You can pick a specific transformation to apply, but most of the time it is easiest to select **All Transforms**

Applying the Transformation

Once you apply the transformation, the Object Properties Box looks like this:

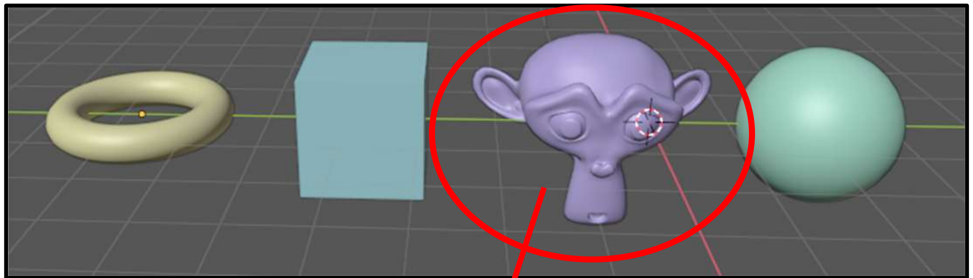


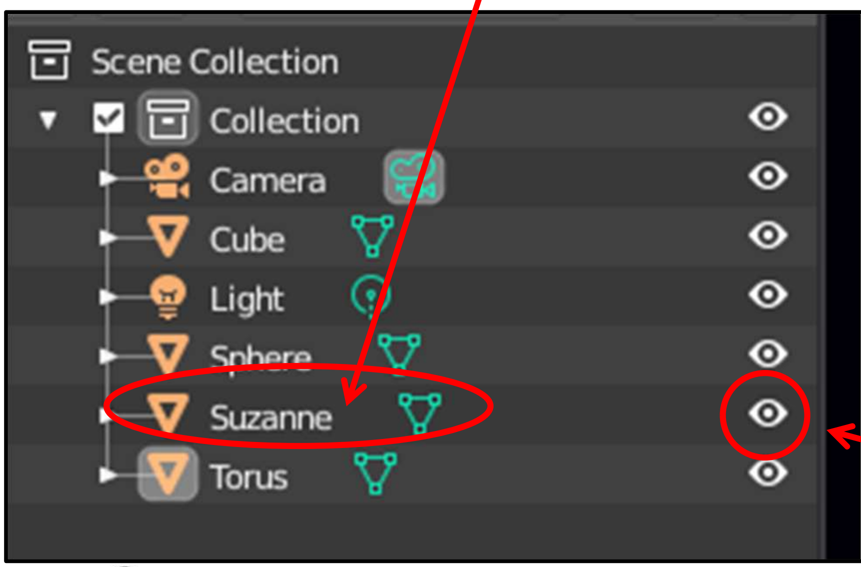
Before



After

The Outliner





In the upper-right portion of the screen is the Outliner. Like the name implies, it shows an outline of your scene.

It is sometimes nice to have a summary of the scene so you can remind yourself of what all is in it.

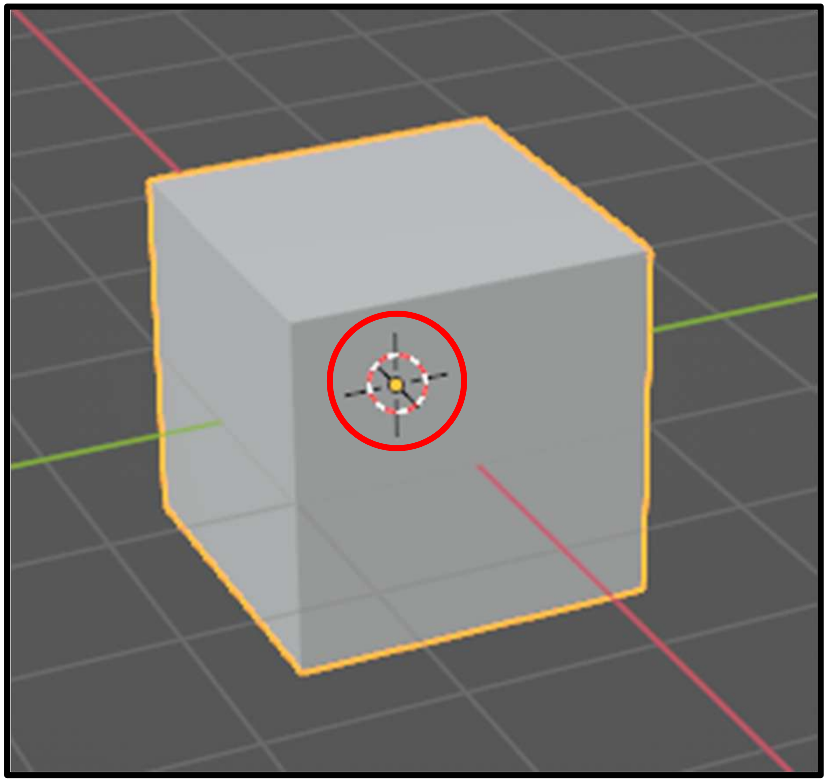
Also, if your scene is cluttered, you can select on object by **left-clicking on its name** in the outliner as opposed to selecting it in the scene.

Double-clicking on a name will allow you to rename that object to something more sensible than, say, “sphere”

Also, you can use the outliner to hide certain objects. Just click on the eye icon to hide/unhide.

Hint: If you hide something, don’t forget that you have hidden it. It is pretty freaky to be certain that you once created something, but now can’t find it anywhere in the scene. ☺

The 3D Cursor

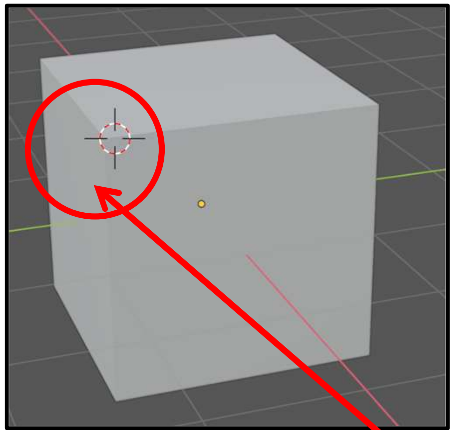


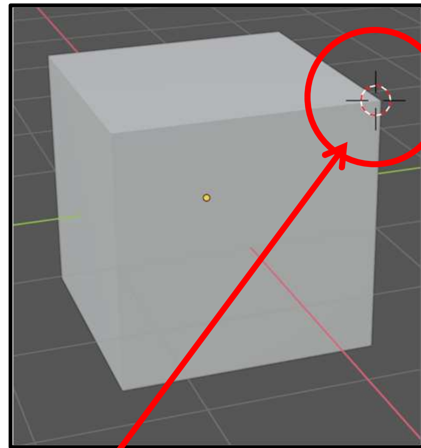
You have probably noticed that when you start up Blender, there is a mysterious cursor positioned at the origin.

This is Blender's **3D View Editor Cursor**.

With this, you can point *anywhere* in space.

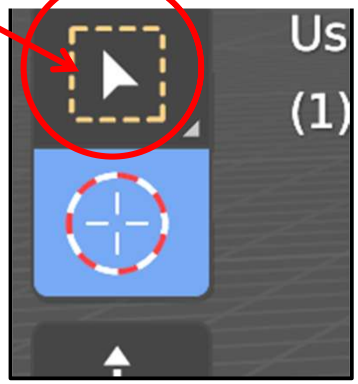
Positioning the 3D Cursor



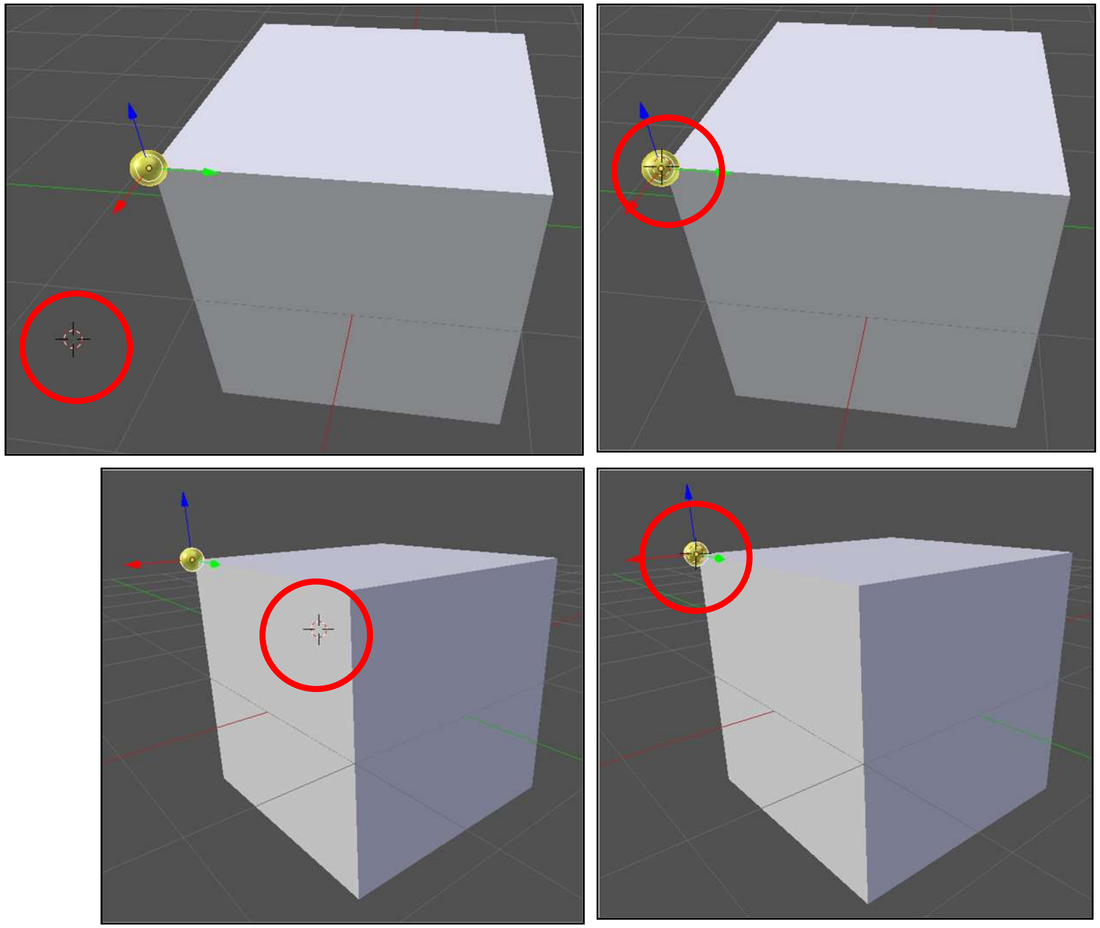


One way to position the 3D View Editor Cursor is to click on the **Cursor icon** and start left-clicking around the scene.

When you are done, be sure to let go of the 3D Cursor by clicking here



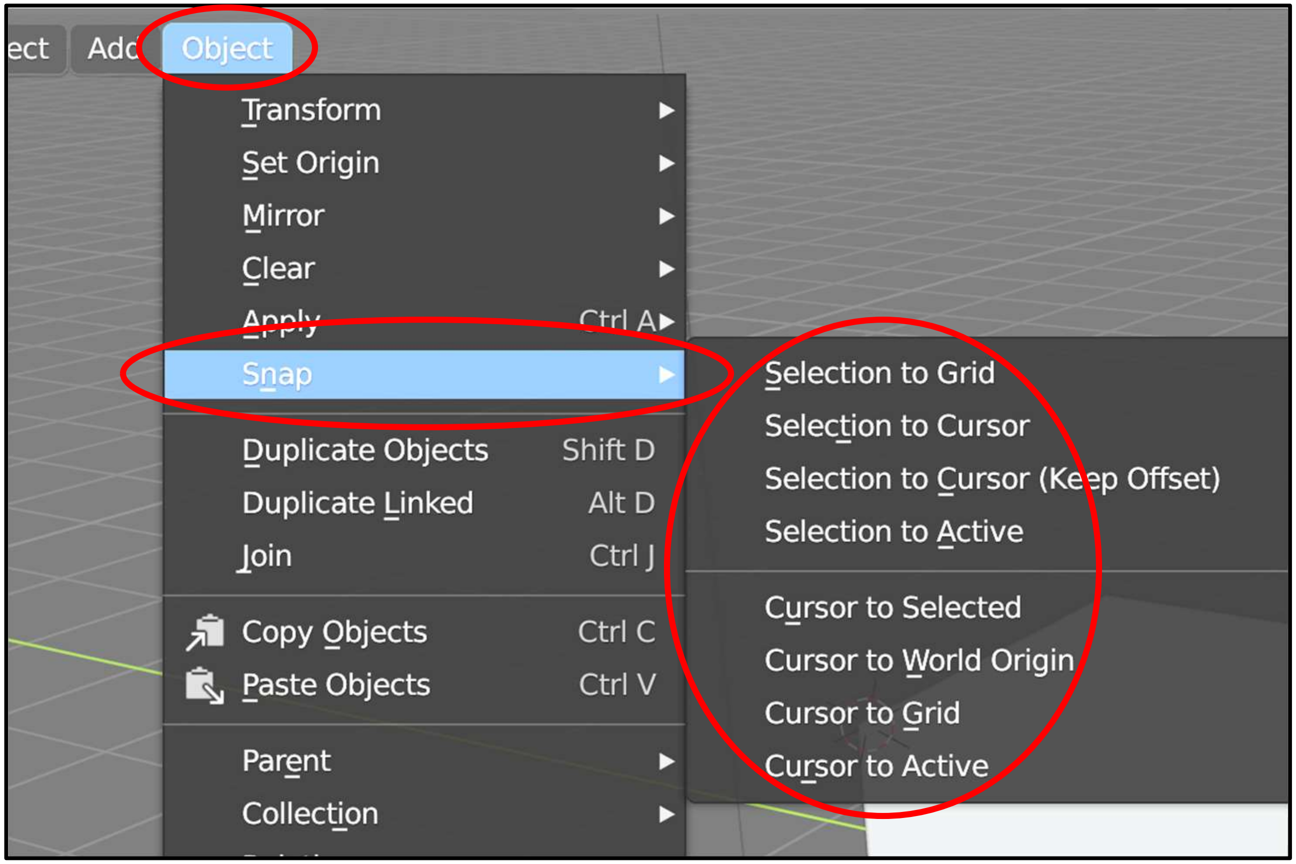
Positioning the 3D Cursor



But, it is hard to get the 3D Cursor exactly where you want it to be. For example, if you want to position the 3D Cursor at the corner of the cube indicated by the yellow dot, LMB click on it. But, upon rotating, you realize that it is at the wrong depth. So, get a view roughly 90˚ from the last view, and click again. You might have to do this a couple more times.

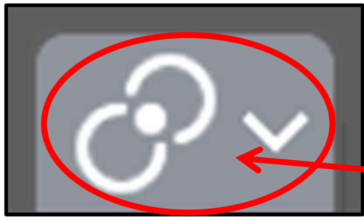
The 3D Cursor

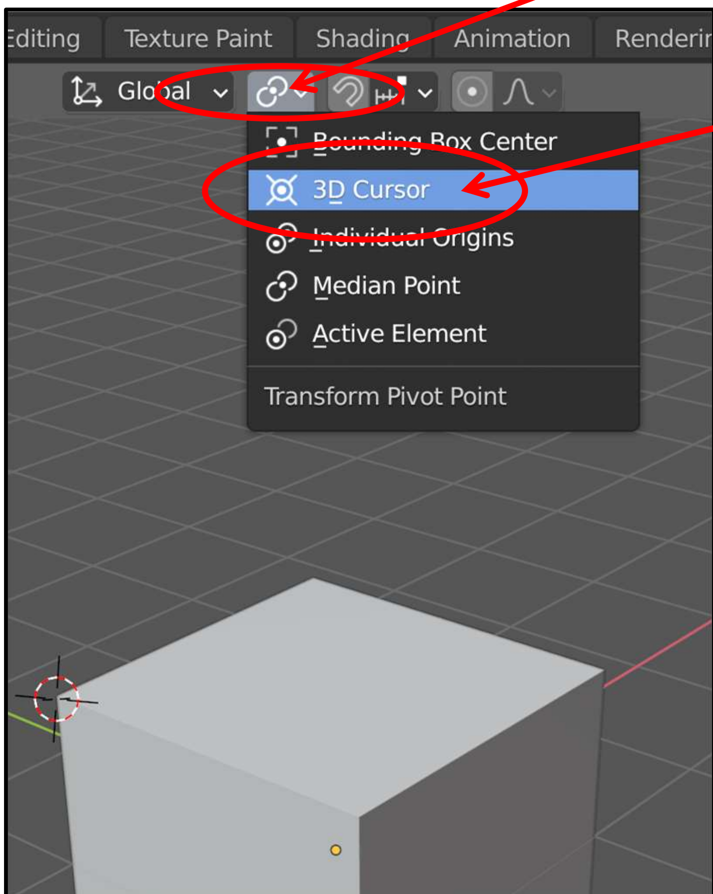
You can also automatically position the 3D Cursor using the **Object → Snap** menu



For example, choosing **Cursor to Selected** will move the 3D Cursor to the median point of the object you have most recently selected. Choosing **Selected to Cursor** will move the selected object's median point to where the 3D Cursor is.

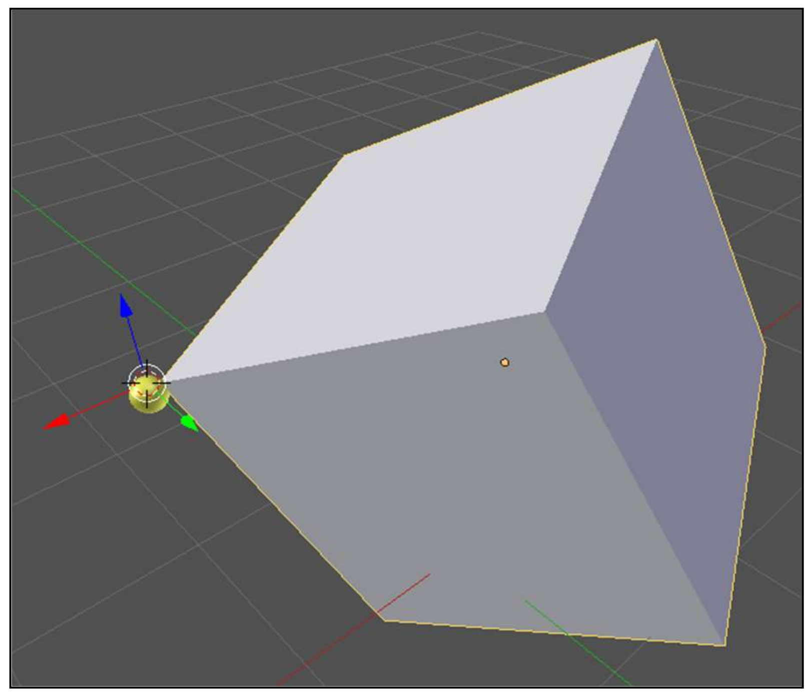
A Use for the 3D Cursor – Arbitrary Pivot Point





Suppose you then wanted to rotate the cube about the yellow corner point. After positioning the 3D Cursor there, you would then go to the **Pivot Center menu** and select **3D Cursor**. Rotations and Scaling will now take place around the yellow corner

Later, you probably want to change the pivot point back to **Median Point.**



Another Way to Set the Arbitrary Pivot Point

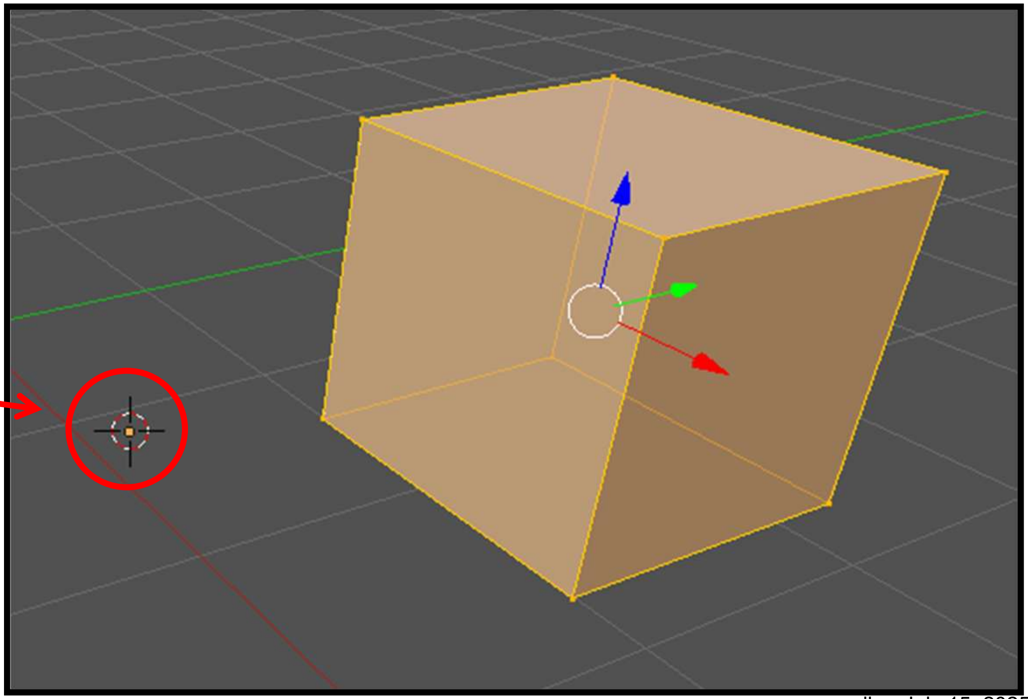
Select the object, tab **to Edit Mode**, select all vertices (‘a’) and translate them (‘g’).

In Edit mode, the pivot point stays put while the vertices move.

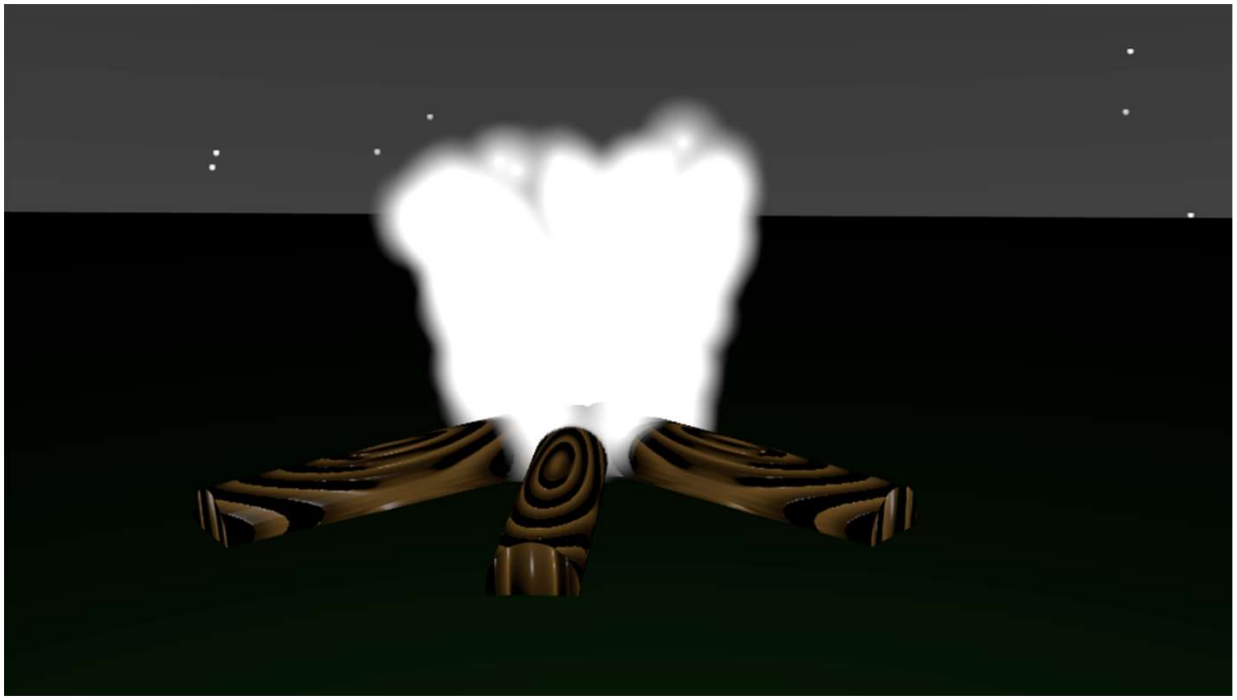
Tab back to Object mode, and rotate the object to confirm that the pivot point has changed.

In contrast, in Object Mode, the pivot point moves with the vertices.

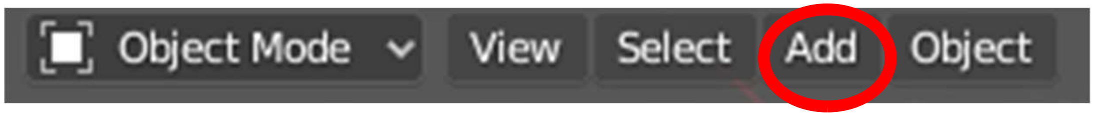
The little orange dot is the pivot point.

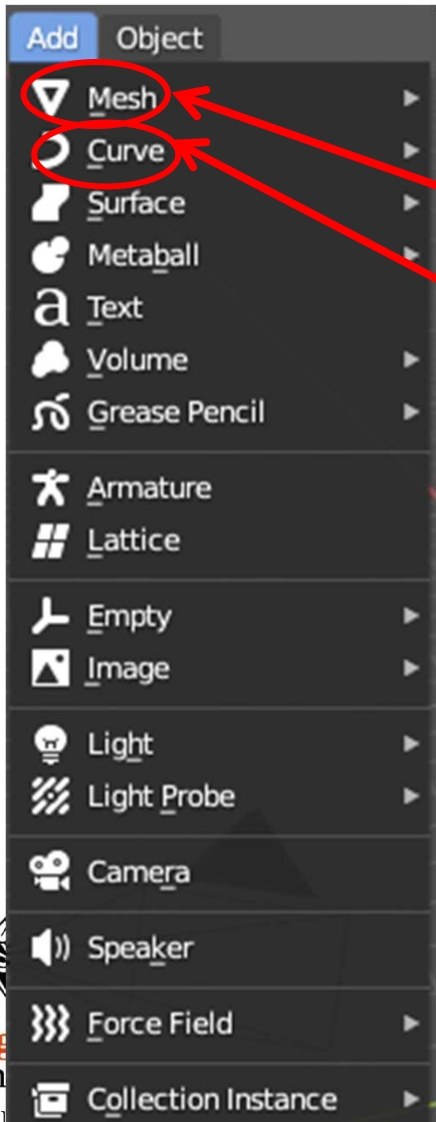


4. Modeling, I



The Add Menu



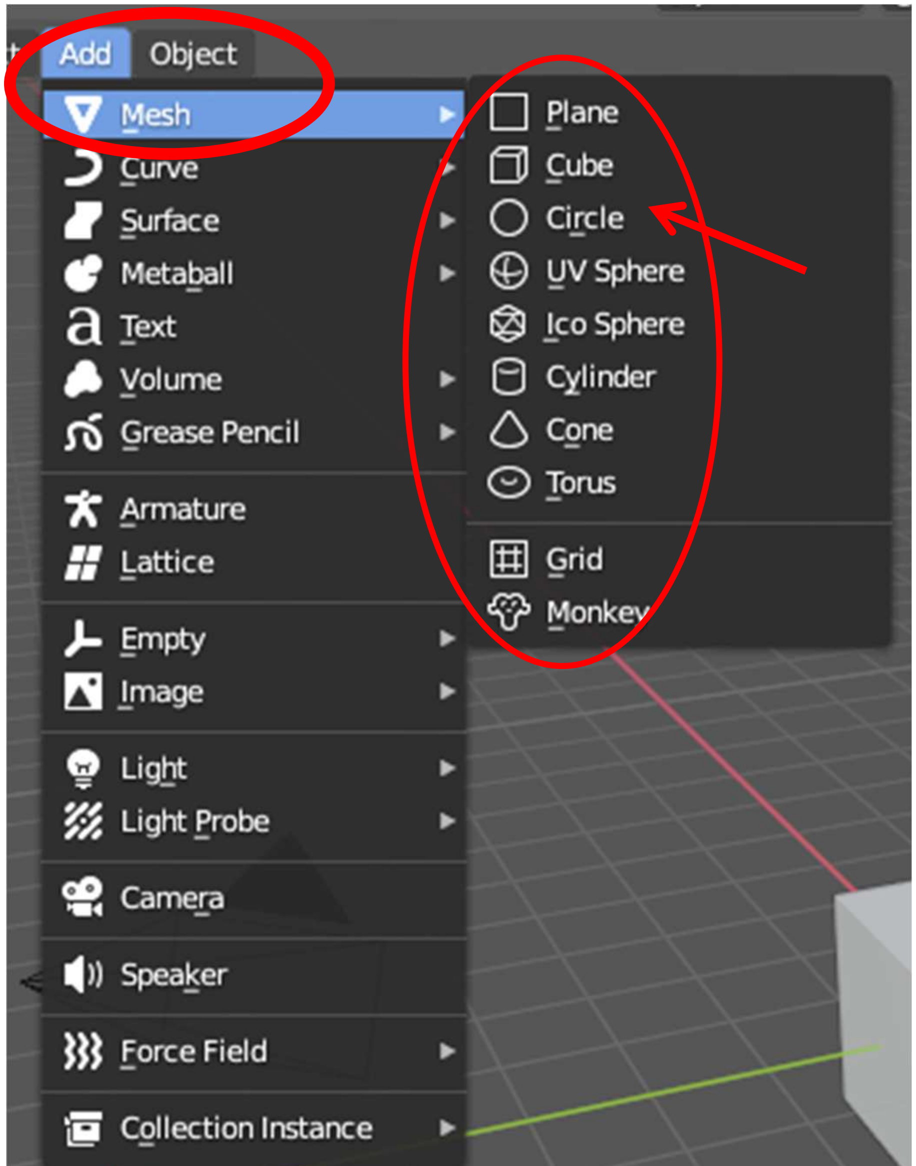


These are all the different geometry things you can add into the scene. We will cover many of them, but not all.

This group is the **meshes**.

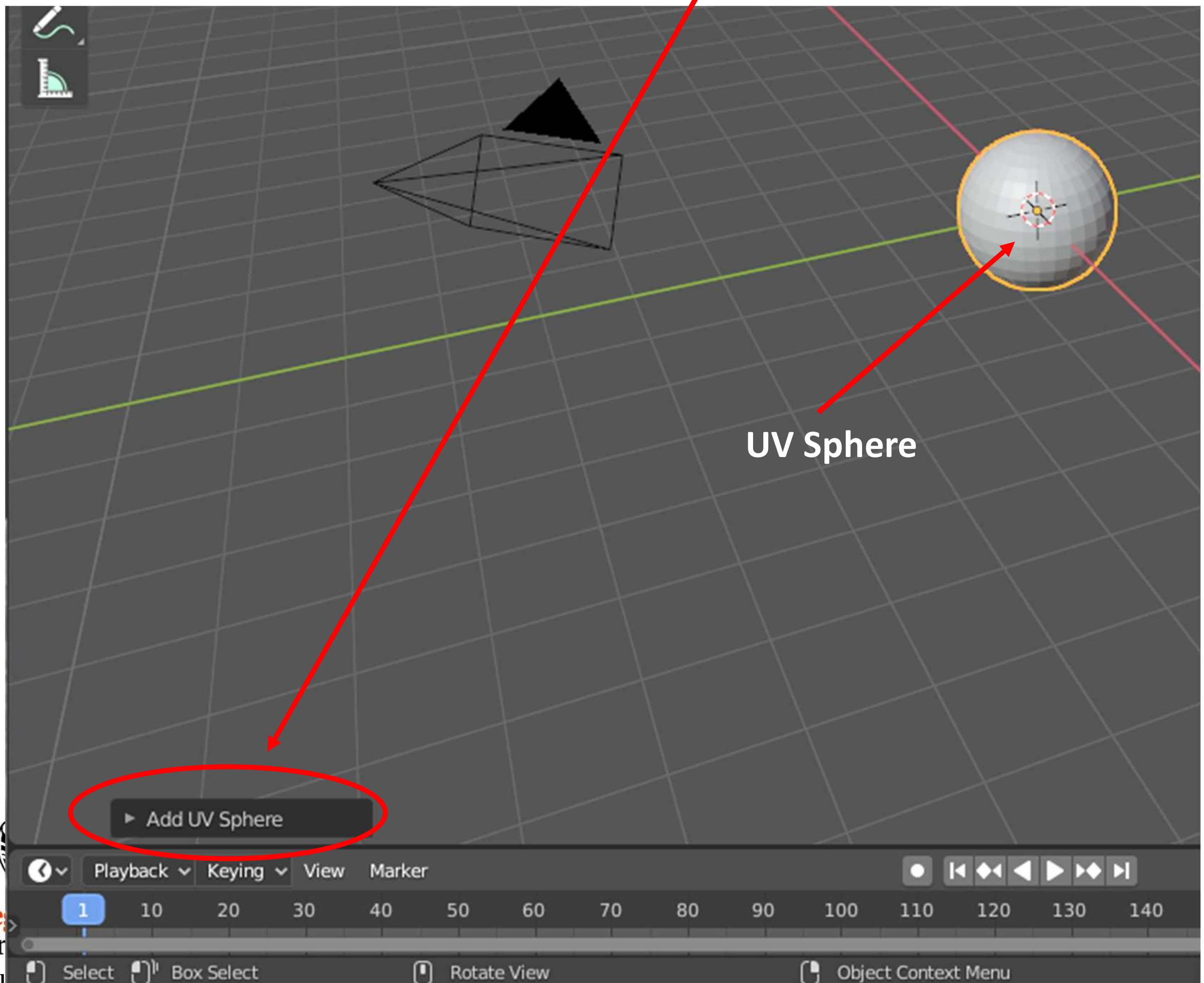
This group is the **curves**.

The Add → Mesh Menu



The UV Sphere, Torus, and Monkey are my favorites

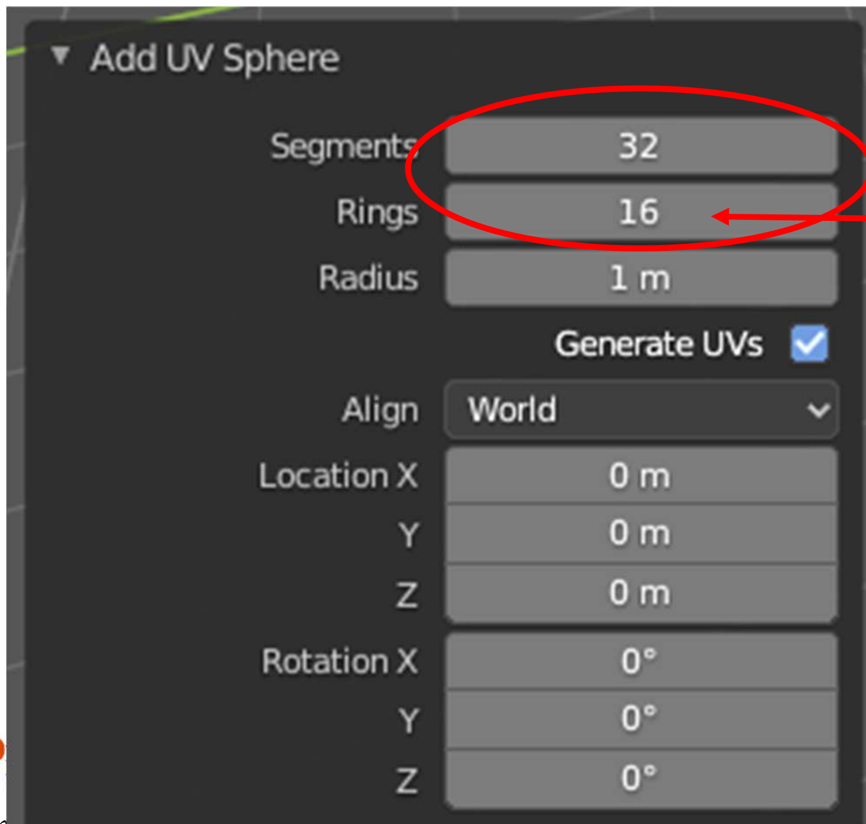
When you Add a Mesh, a Small Menu Appears in the LL Corner



When you Add a Mesh, a Small Menu Appears in the LL Corner

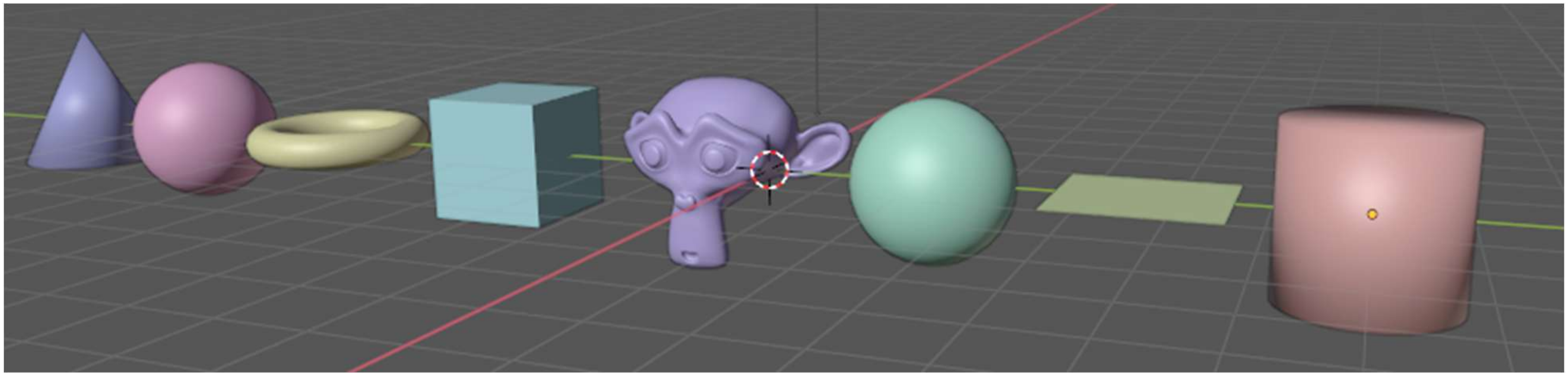
Try clicking on it.

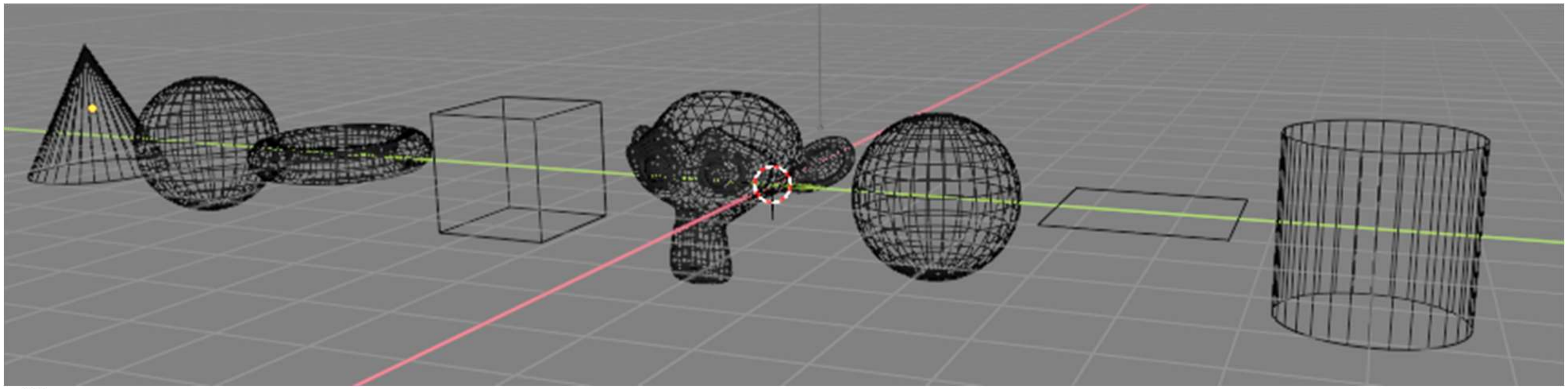
The small menu lets you modify how the last thing you did works. In this case, the most important thing it is doing is letting you change the polygon resolution of the sphere. ***But, this menu only exists until you do something else. After that, the ability to change these values is gone.***



Personally, I like changing these two values to **64** and **32**, respectively.

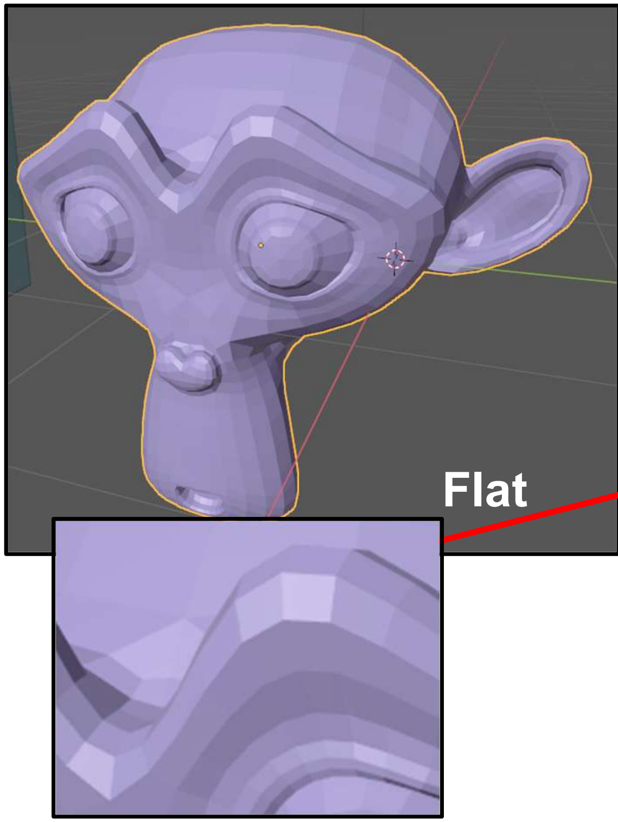
Summary of the Mesh Objects

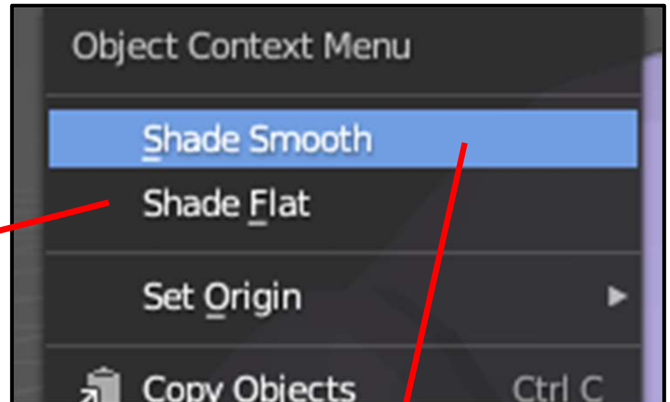


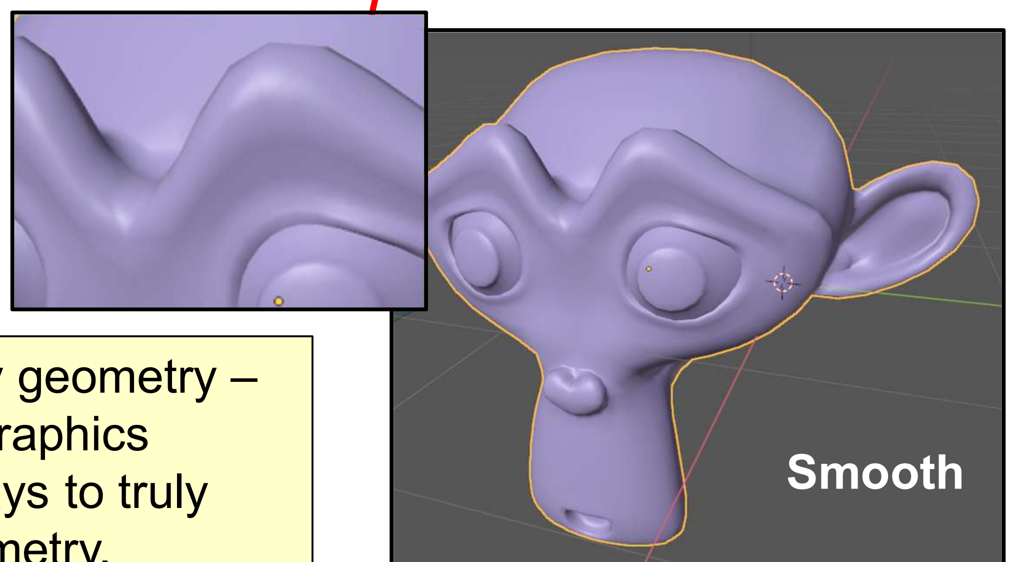


Making the Mesh Objects Look Nicer

Blender is able to play a graphics trick to make your curved geometry look better. Select the object (LMB) then click the RMB and select **Shade Smooth**. To go back, select **Shade Flat.**

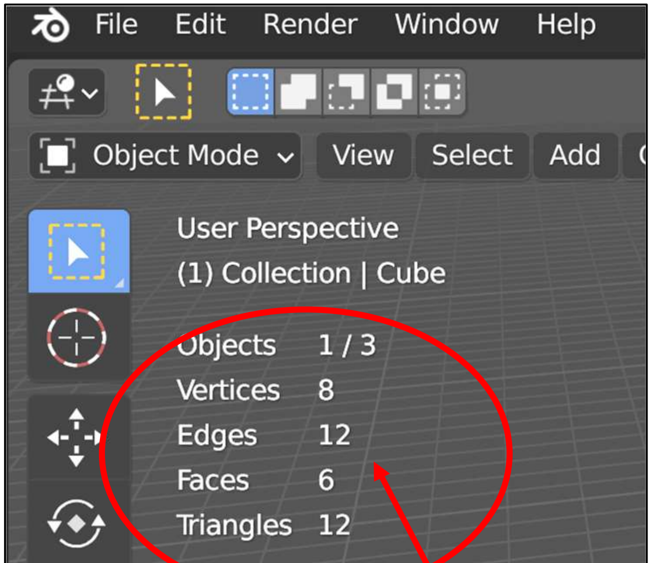




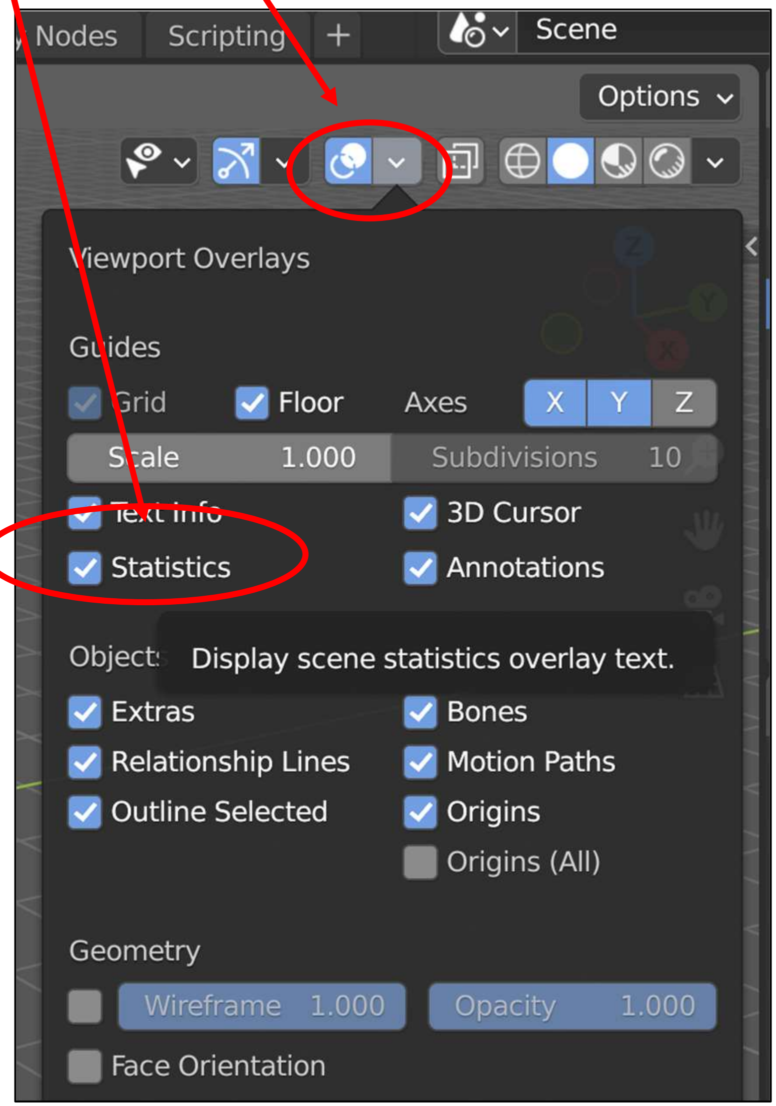


This doesn't actually change any geometry – it's just a really good computer graphics display trick. There are other ways to truly create smoother underlying geometry.

How to Find Out How Detailed a Mesh Object Is



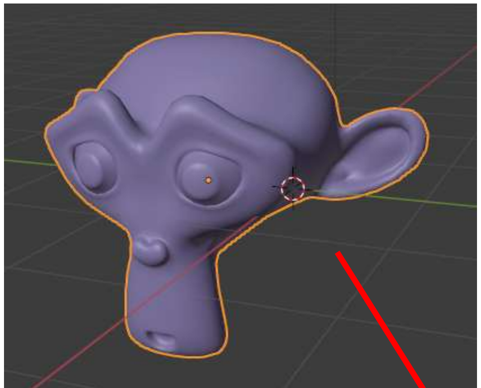
In the overlay menu, turn on **Statistics**



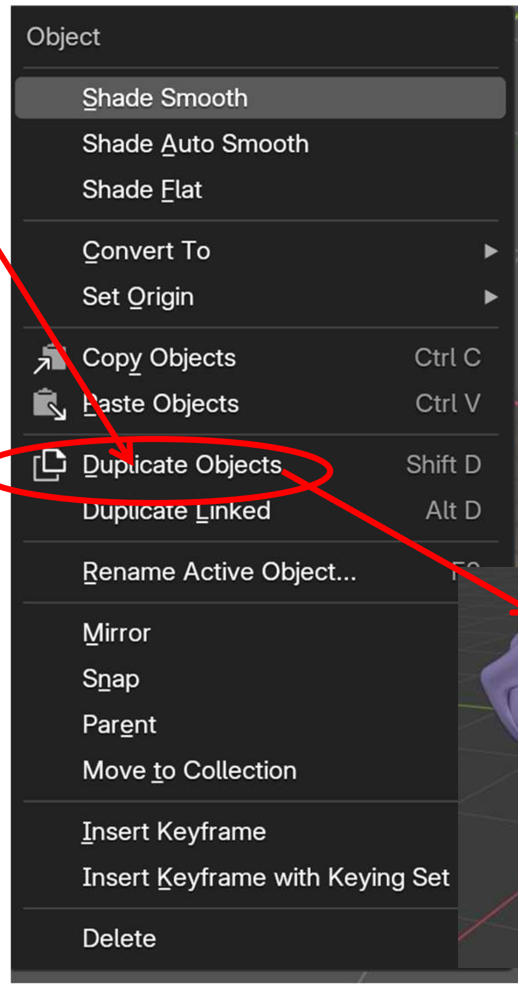
The number of Vertices, Edges, Faces, and Triangles show on the left side of the screen

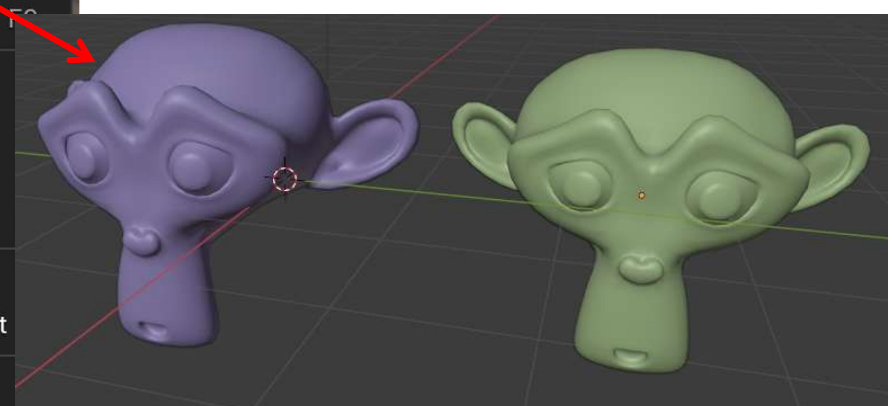
Oregon State University
Computer Graphics

Duplicating an Object from the RMB Menu



Select the object (LMB) then click the RMB and select **Duplicate Objects**. This leaves the new object right on top of the old object and leaves you in **Grab mode**. Just move the mouse to separate the two objects.



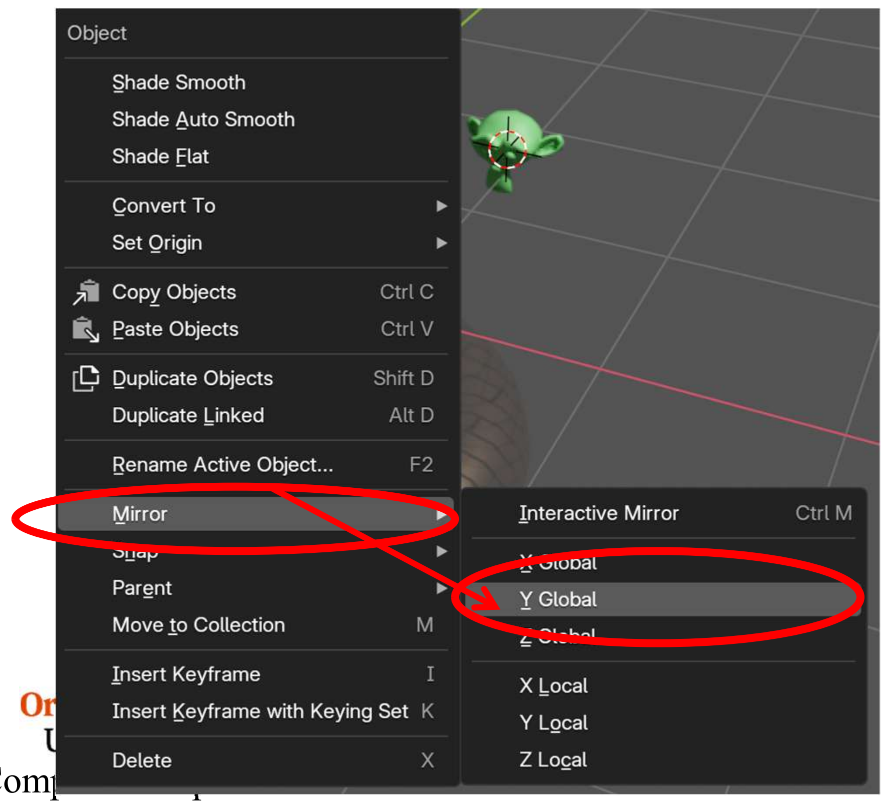


Mirroring an Object

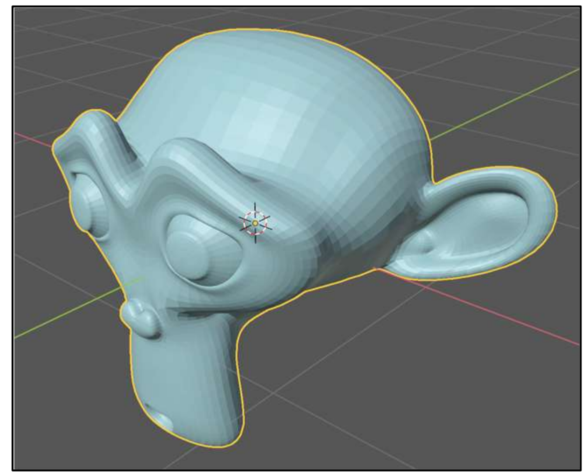
Oftentimes you want to create an object that is identical to itself but is symmetric about an axis. This type of operation is called **mirroring**.

Create an object, in this case, Suzanne the Monkey.

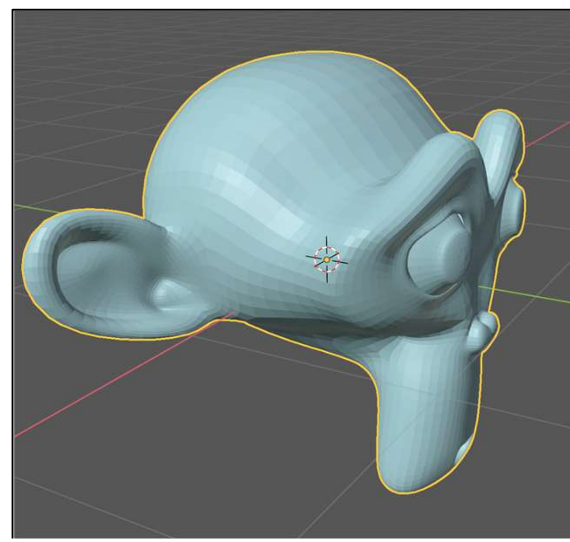
Let's say that we want to mirror this object left-right (y). Select the monkey, right click, then select **Mirror**, and then select **Y Global**.



Before



After



Editing a Vertex, Edge, or Face on a Mesh

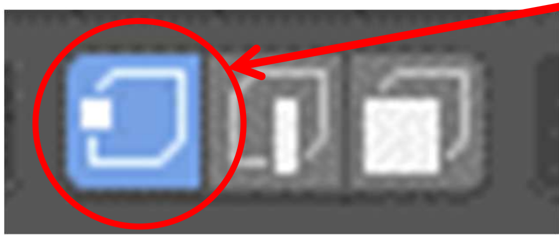
Click here, or hit the **Tab** key, to get into Edit Mode

Select and edit:

A vertex **An edge** **A face**

Using the ***Tab key*** is so common, that "tab" has become a *verb* in the Blender community. As we like to say, "Just tab over into edit mode."

Editing a Vertex

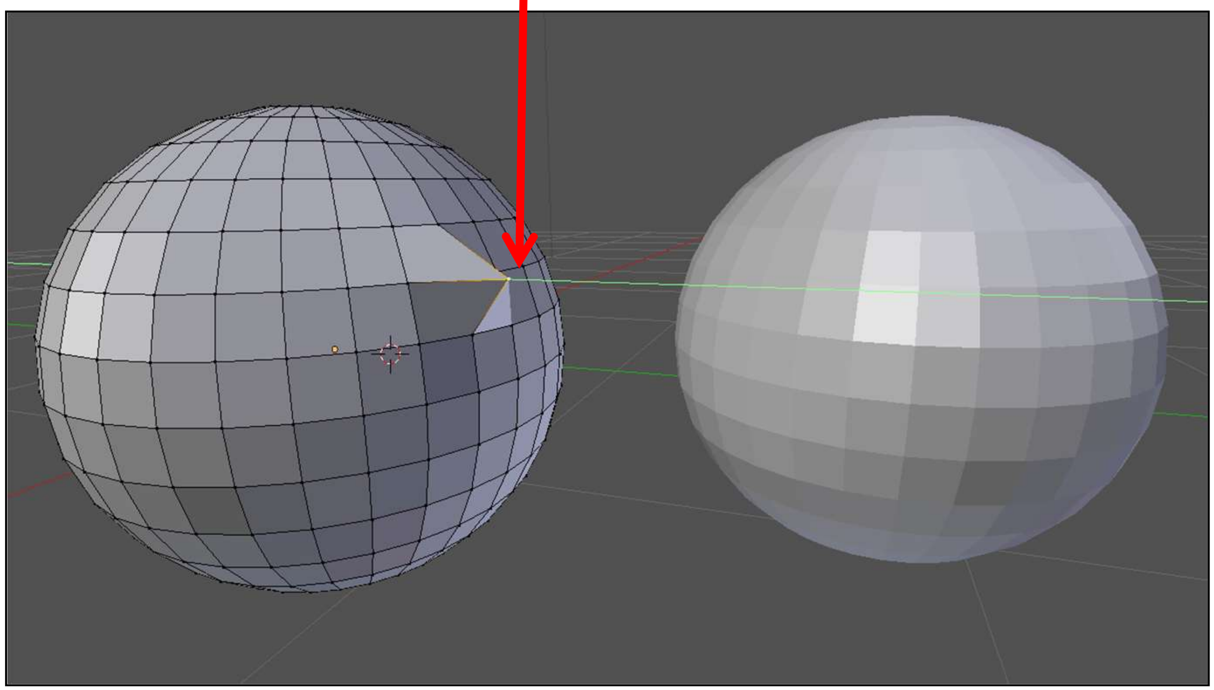


Be sure you are in vertex-editing mode

Left click on a vertex

Hit ‘g’ (grab) and move the mouse

You can also hit ‘x’, ‘y’, or ‘z’ to restrict motion



Editing a Vertex with Proportional Editing

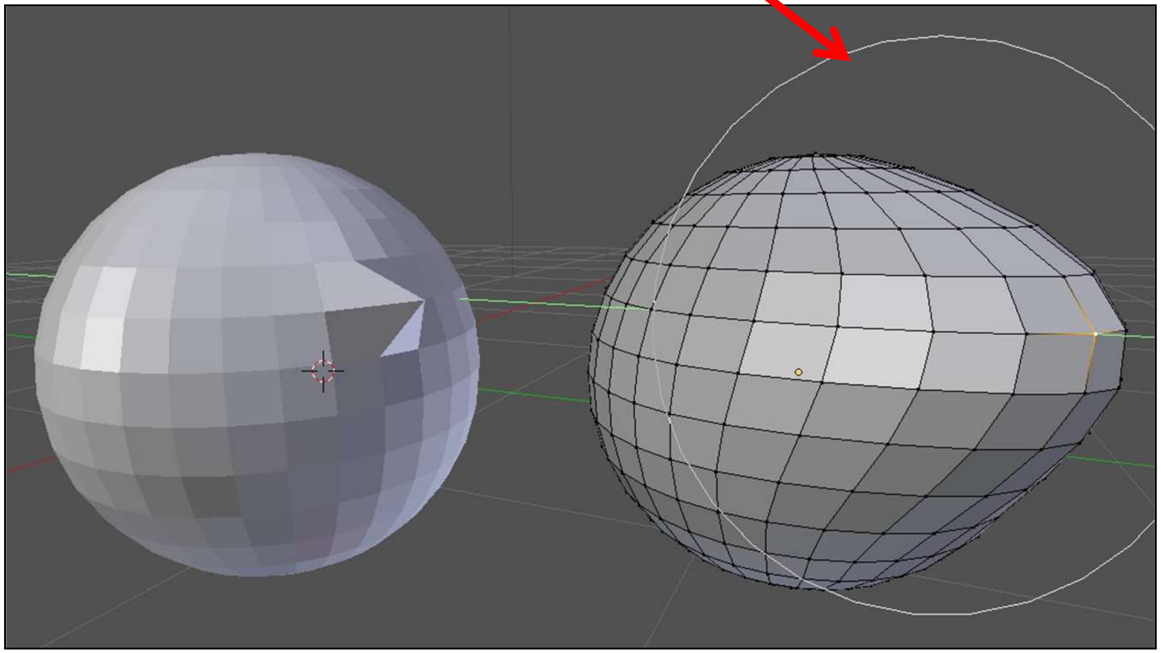
Be sure you have Proportional Editing enabled

LMB click on a vertex

Hit ‘g’ (grab) and move the mouse

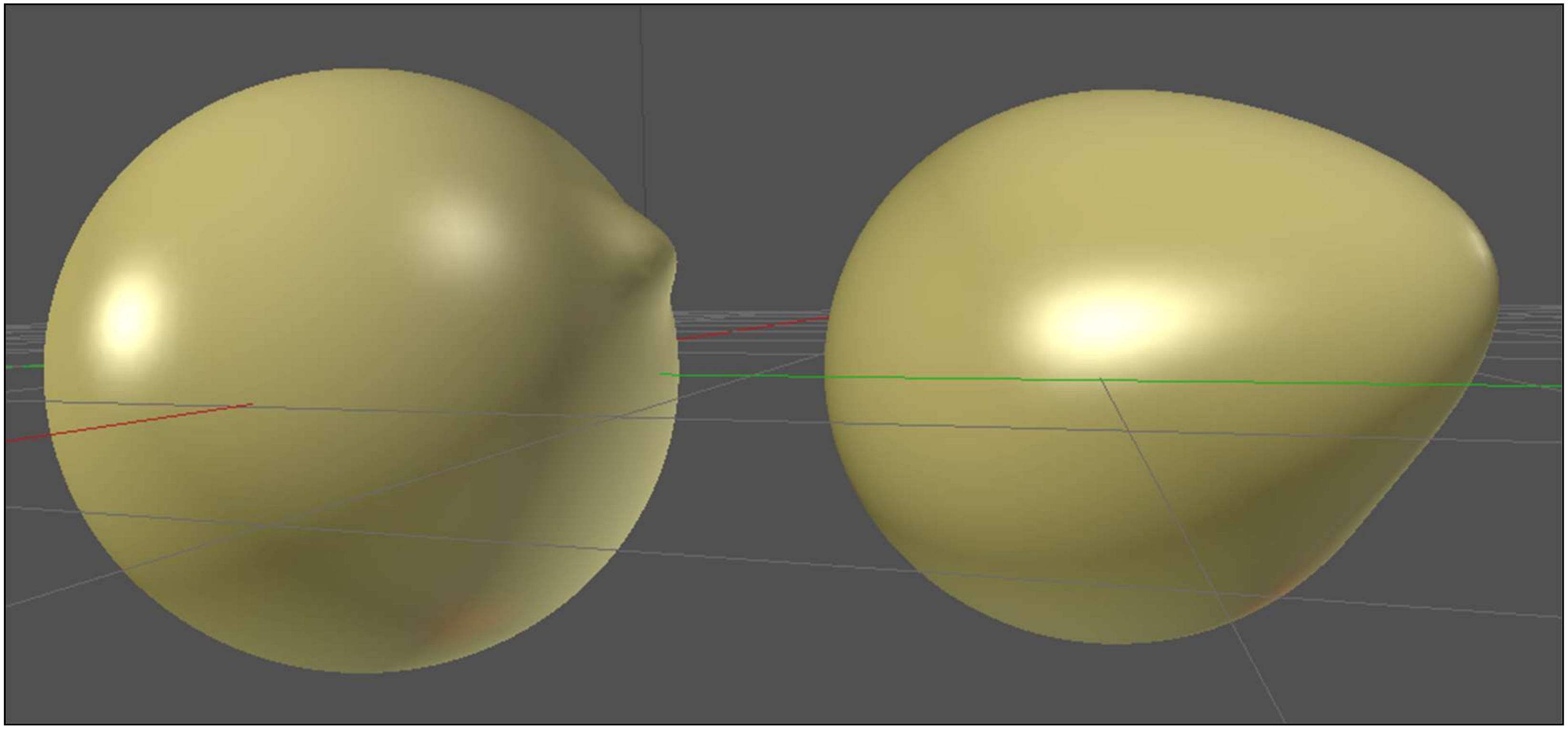
You can also hit ‘x’, ‘y’, or ‘z’ to restrict motion

The mouse Scroll Wheel changes the size of the Circle of Influence



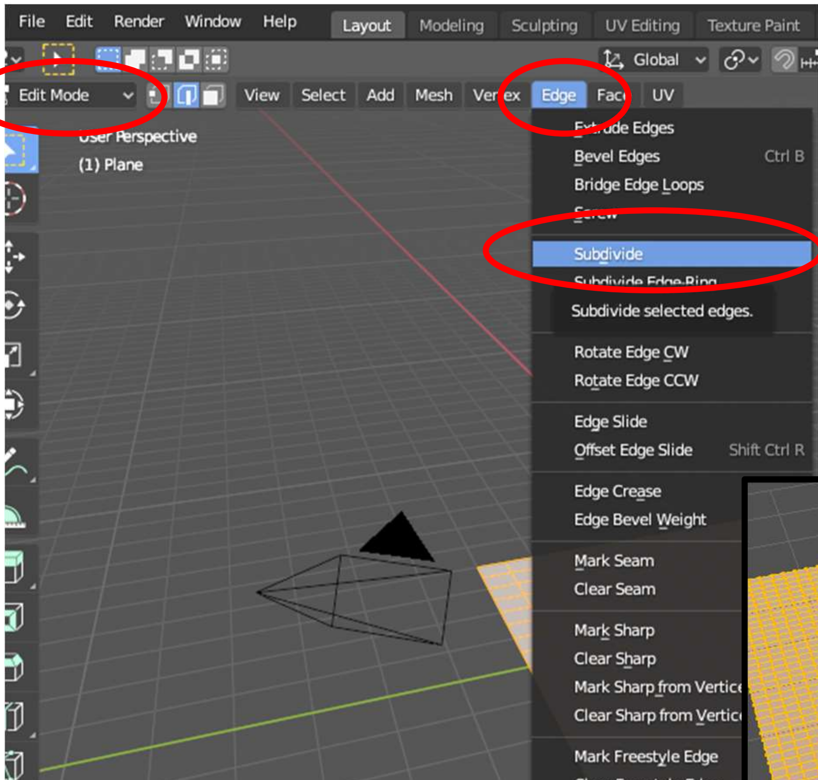
You can also LMB select an edge or a face for editing or proportional editing.

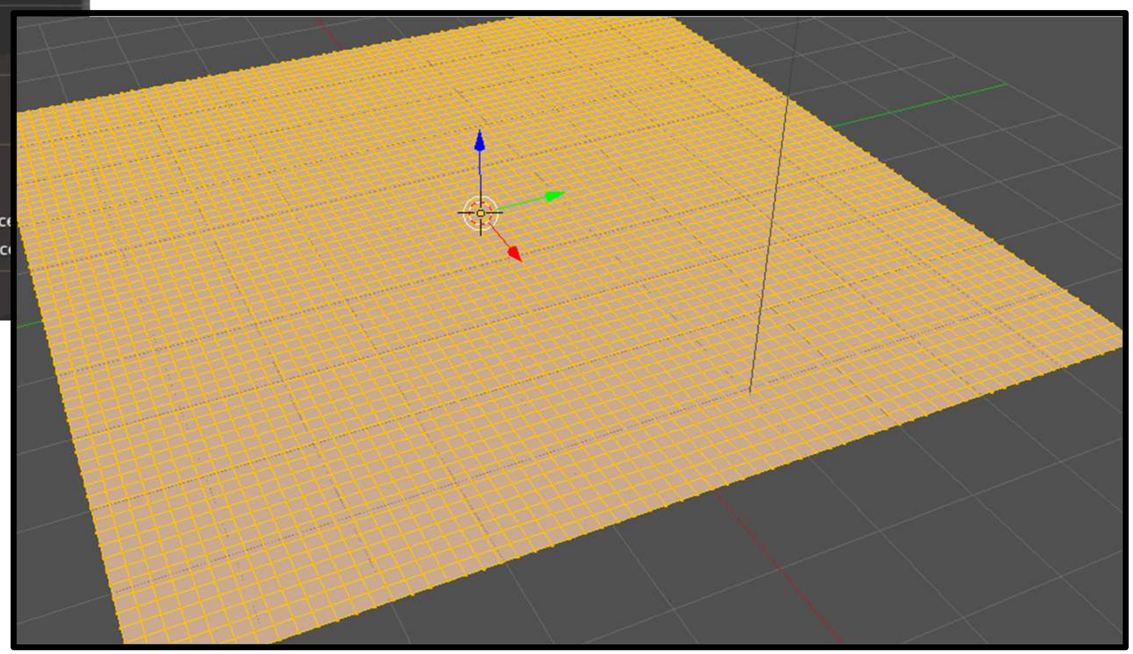
Subdividing and Smoothing Really Show the Difference Between Localized and Proportional Editing



An Unexpected Use for Proportional Editing

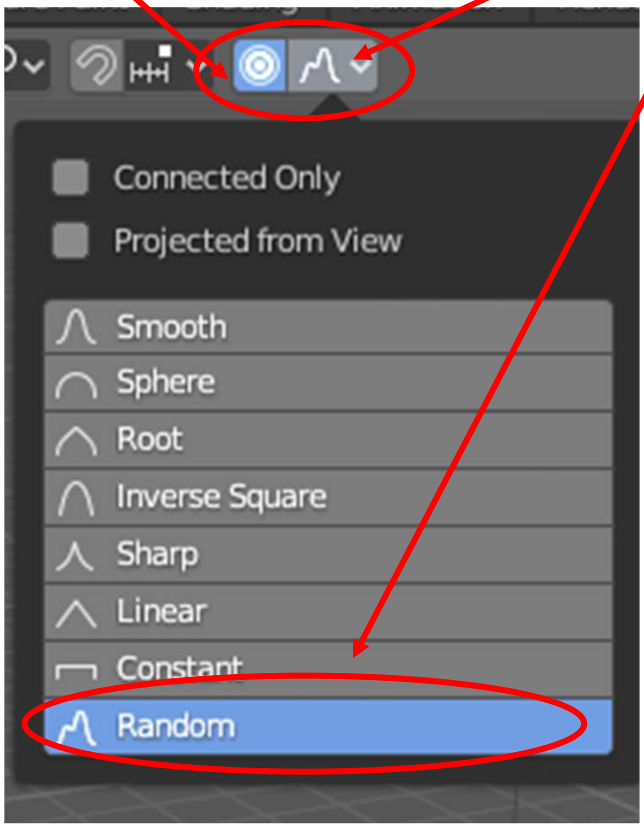
Create a **Plane**, then go to **Edit Mode,** then box select all the edges, then click on **Edge → Subdivide** and subdivide it several times





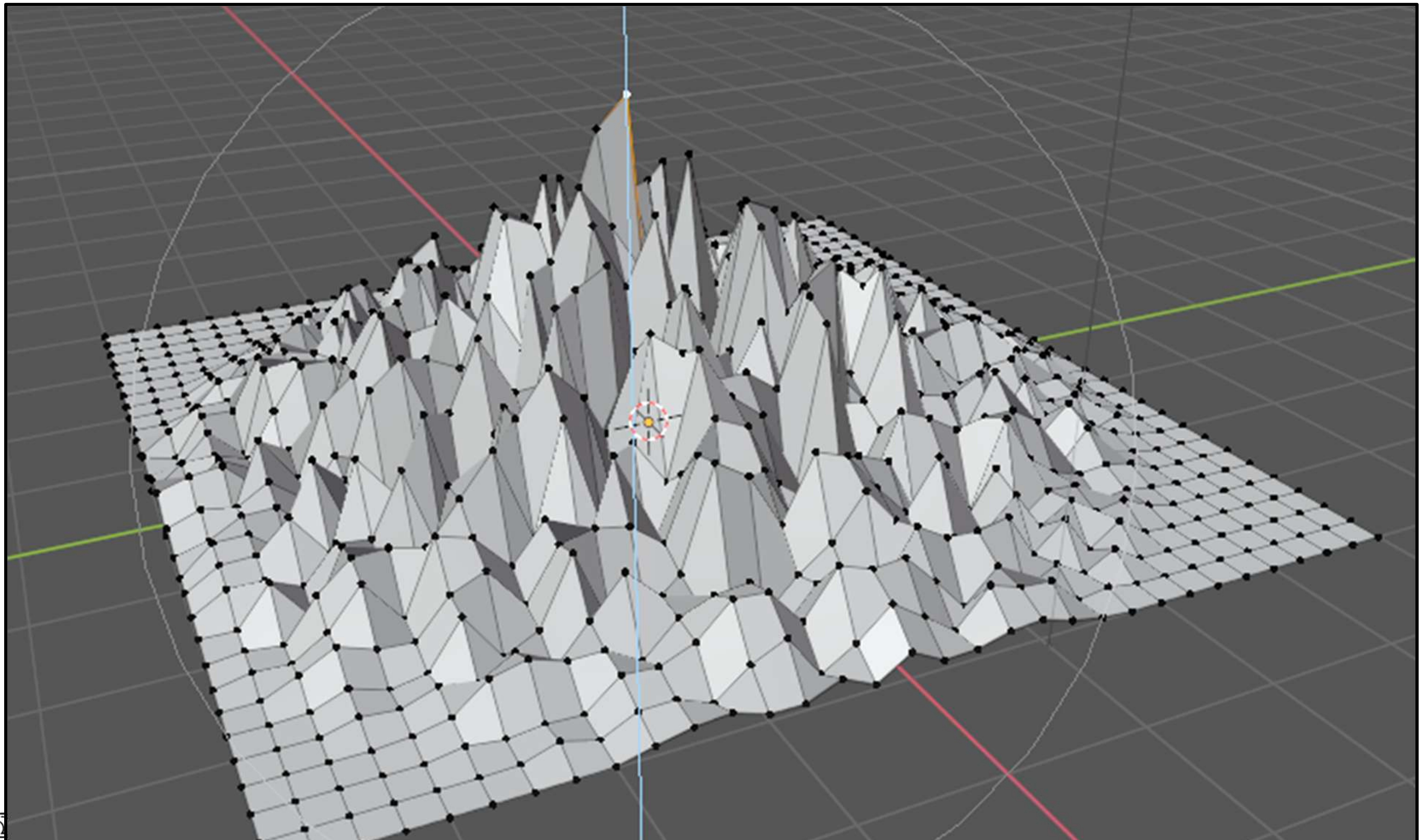
An Unexpected Use for Proportional Editing

Enable **Proportional Editing**, then go one widget to the right and change the kind of Proportional Editing from **Smooth** to **Random**



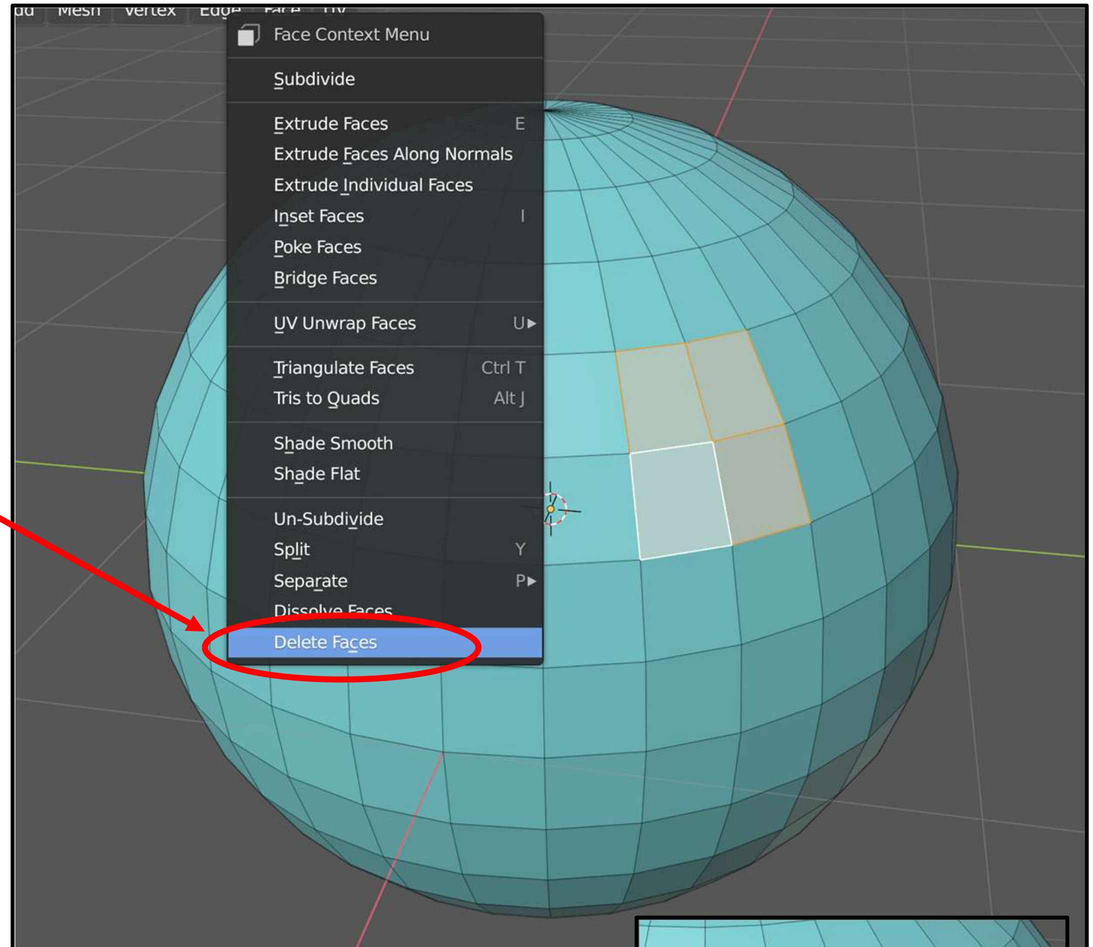
An Unexpected Use for Proportional Editing

Go to **Edit Mode**, select a vertex, and lift it along with those around it

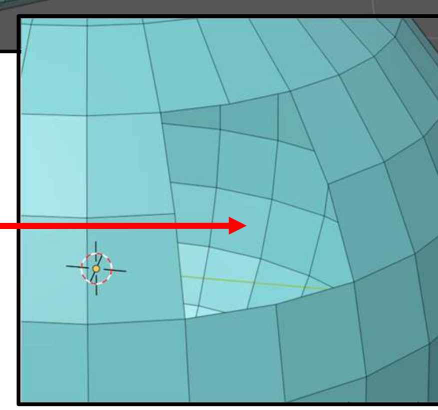


Deleting

In **Edit Mode**, you can delete things. For example, here four faces have been selected. **Right-click** and select **Delete Faces** from the pop-up menu

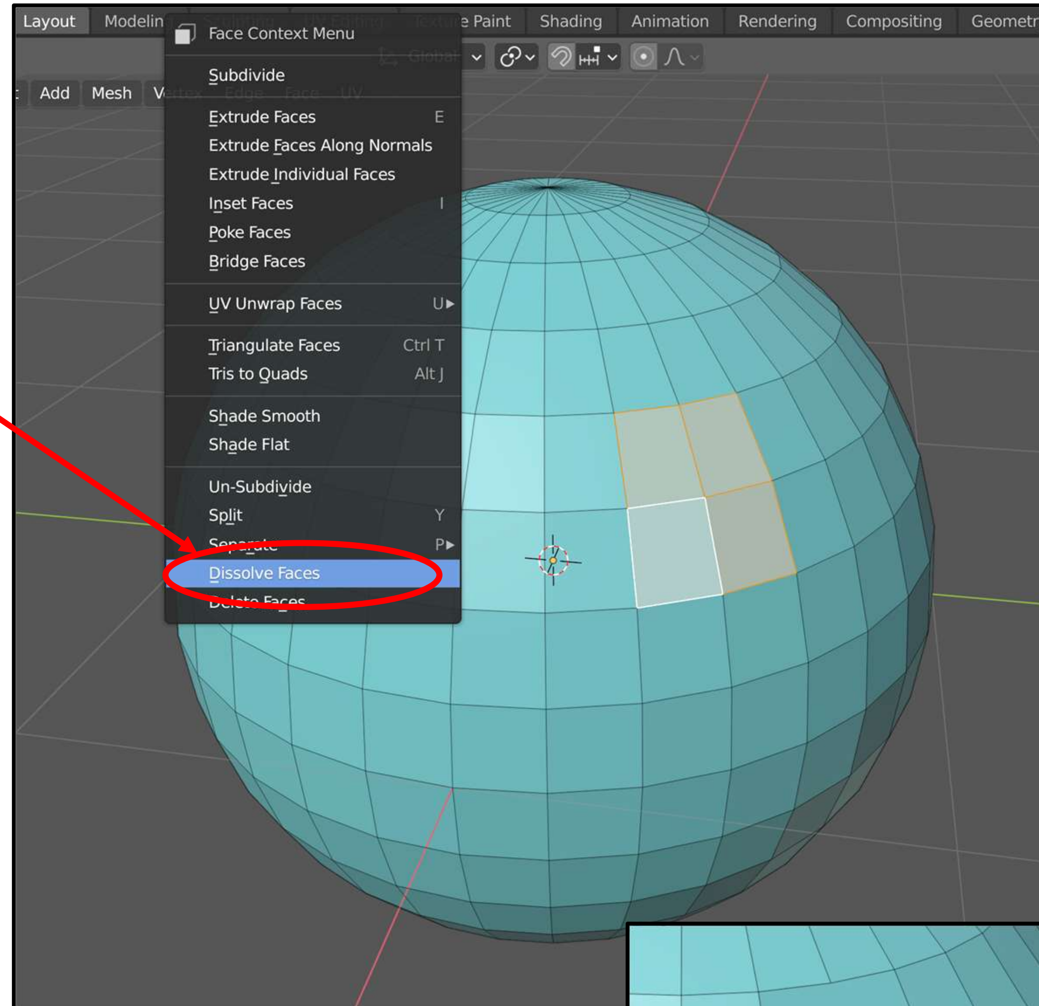


Here's what you get:

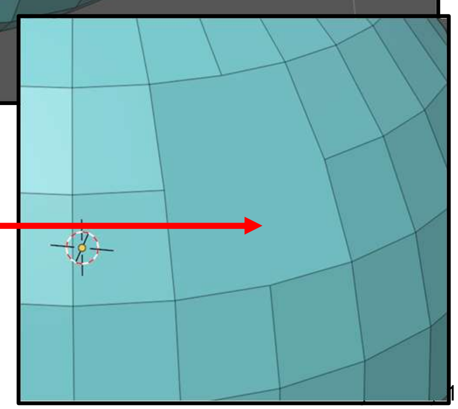


Dissolving

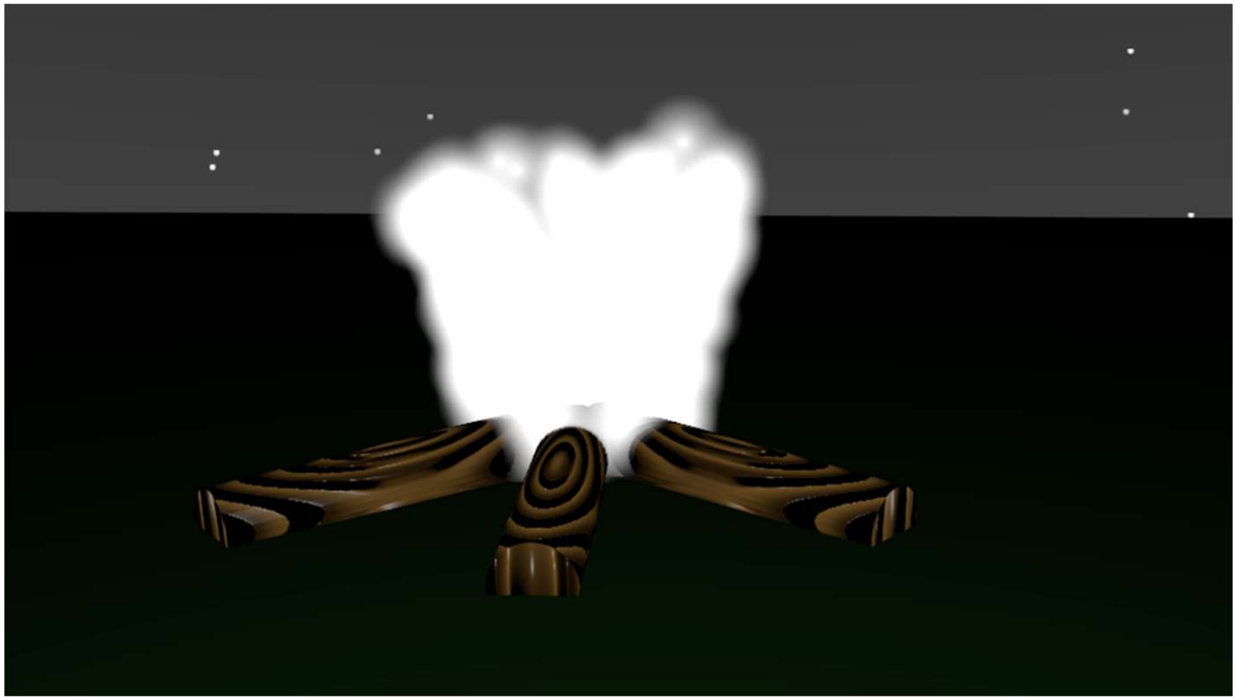
You can also **right-click** and select **Dissolve Faces** from the pop-up menu



In which case, you get this:



5. Appearance, I



The Button Properties Menus

Tells you that we are in the Button Properties Menu

Render Properties

Output Properties

View Layer Properties

Scene Properties

World Properties

Collection Properties

Object Properties

Modifier Properties

Particle Properties

Physics Properties

Object Constraint Properties

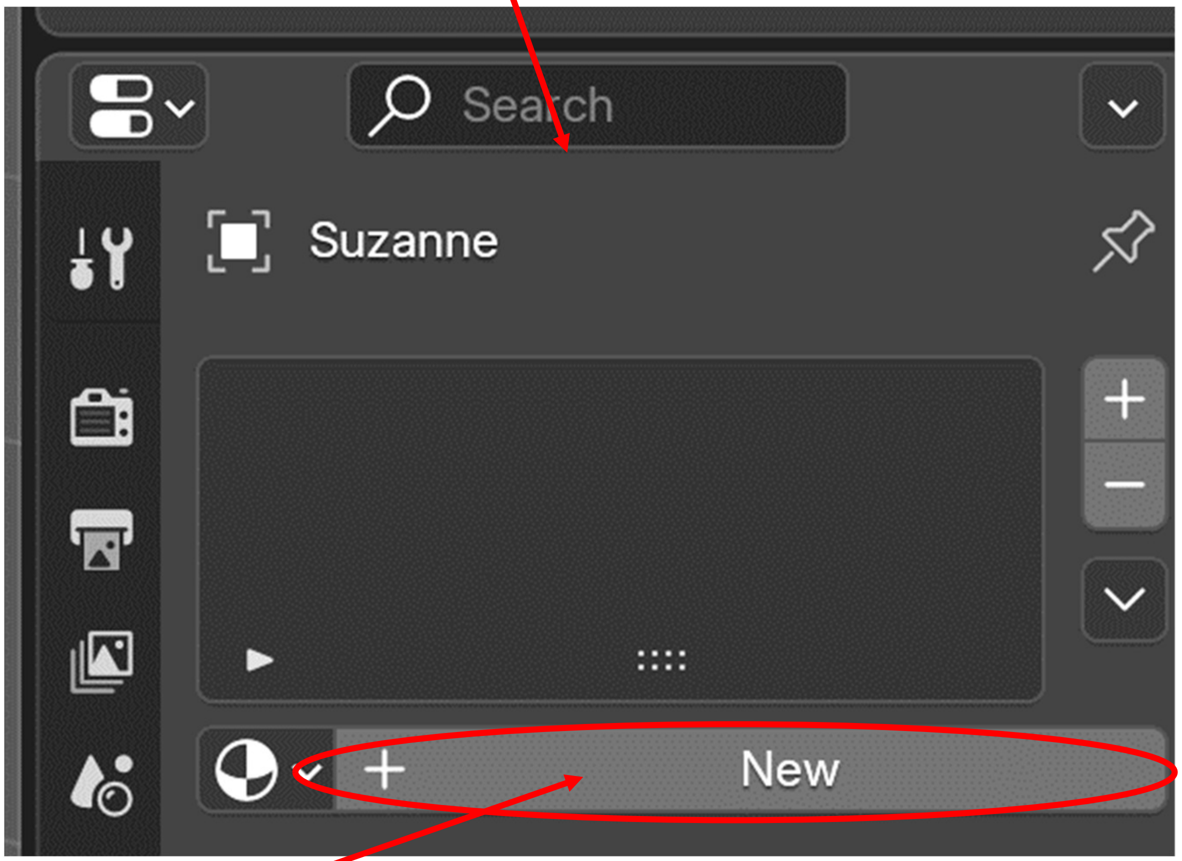
Object Data Properties

Material Properties (colors)

Clicking one of these brings up a much more detailed menu of options

Using the Material Properties Menu

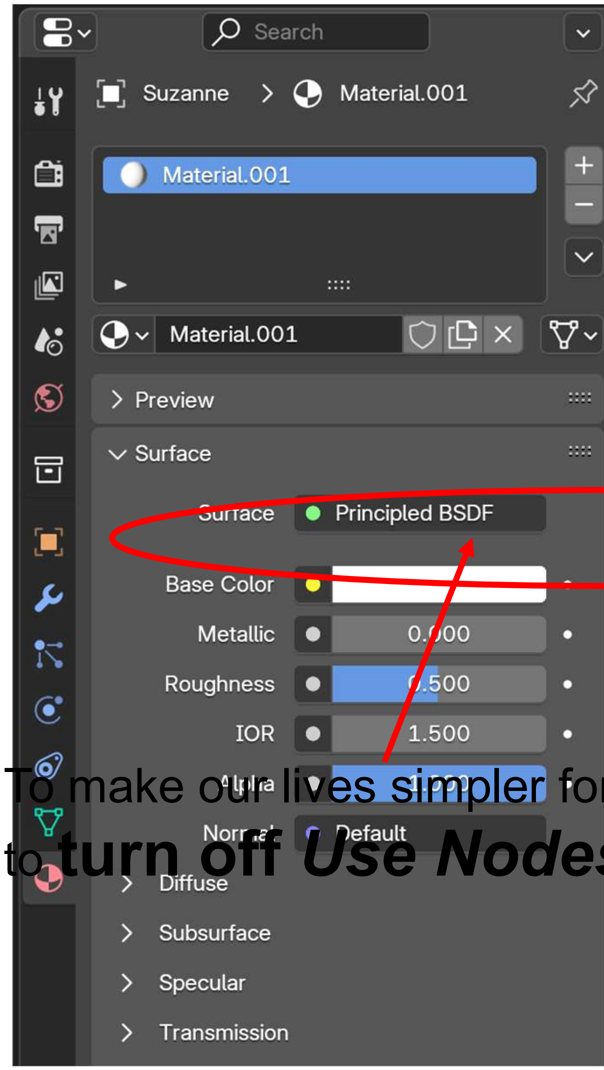
Click on this … to get this



Then, click on **New**

Using the Material Properties Menu

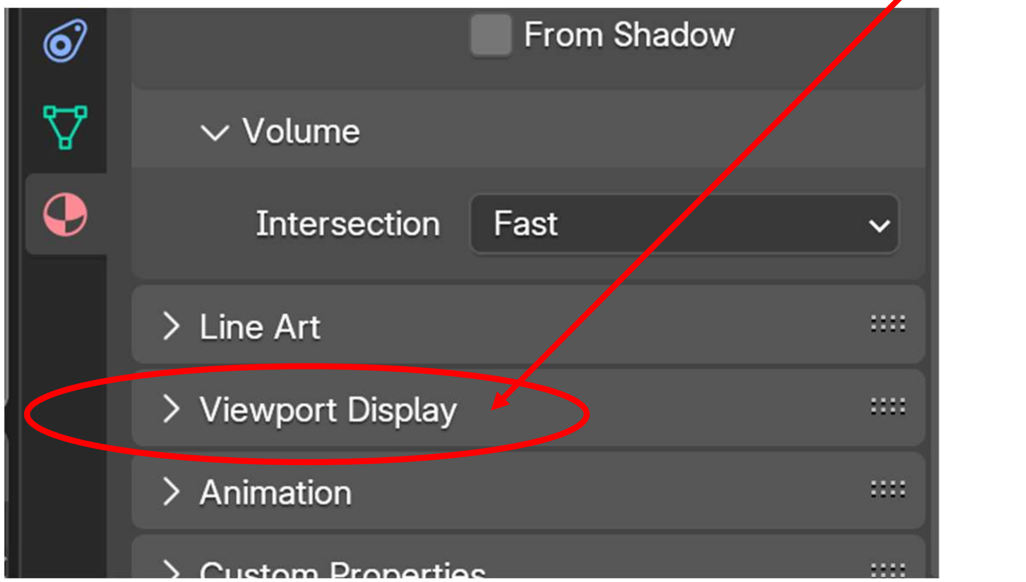
This is what you will see next.
Don’t click anywhere here!



To make our lives simpler for now, click here to **turn off *Use Nodes* mode**

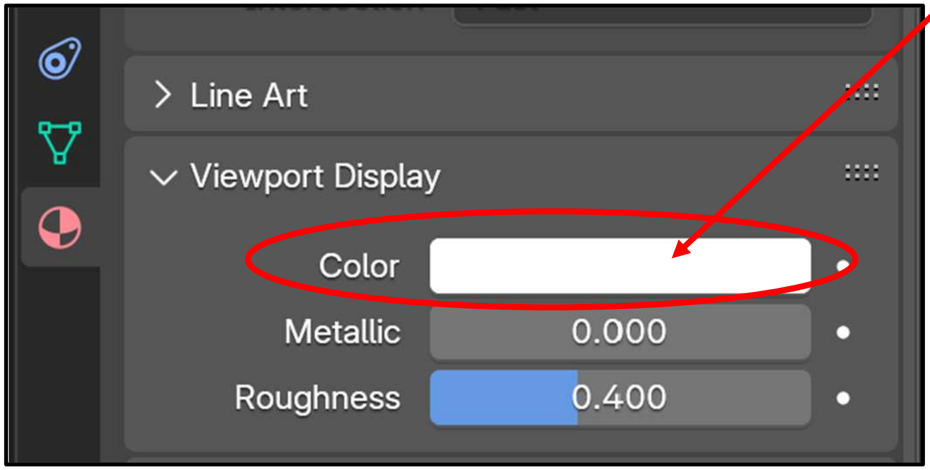
Using the Material Properties Menu

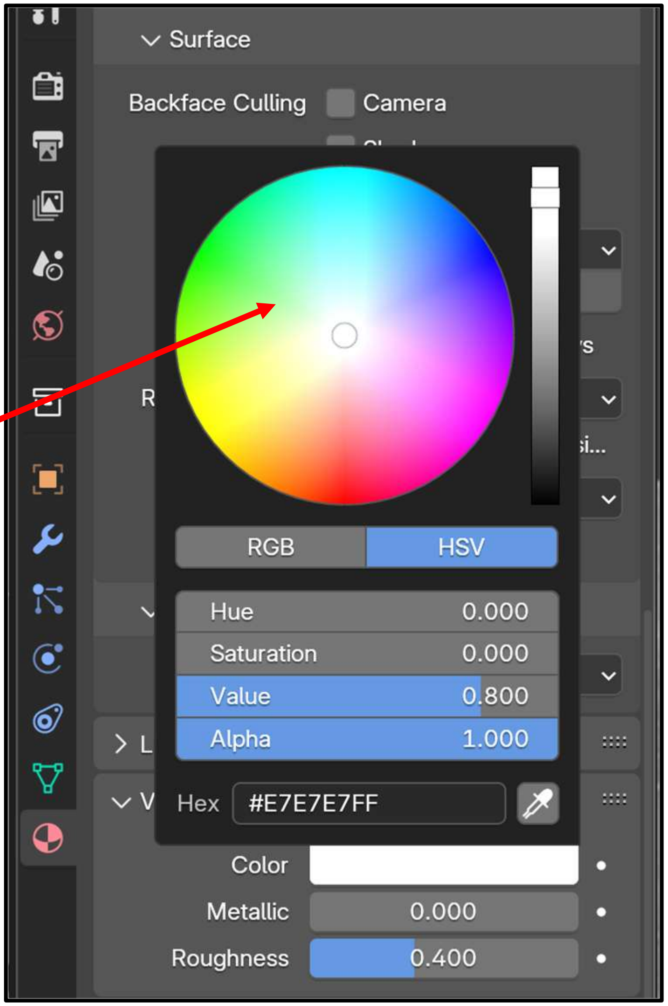
Scroll *way down* and click on **Viewport Display**



Using the Material Properties Menu

Open up the **Viewport Display** and click in here …





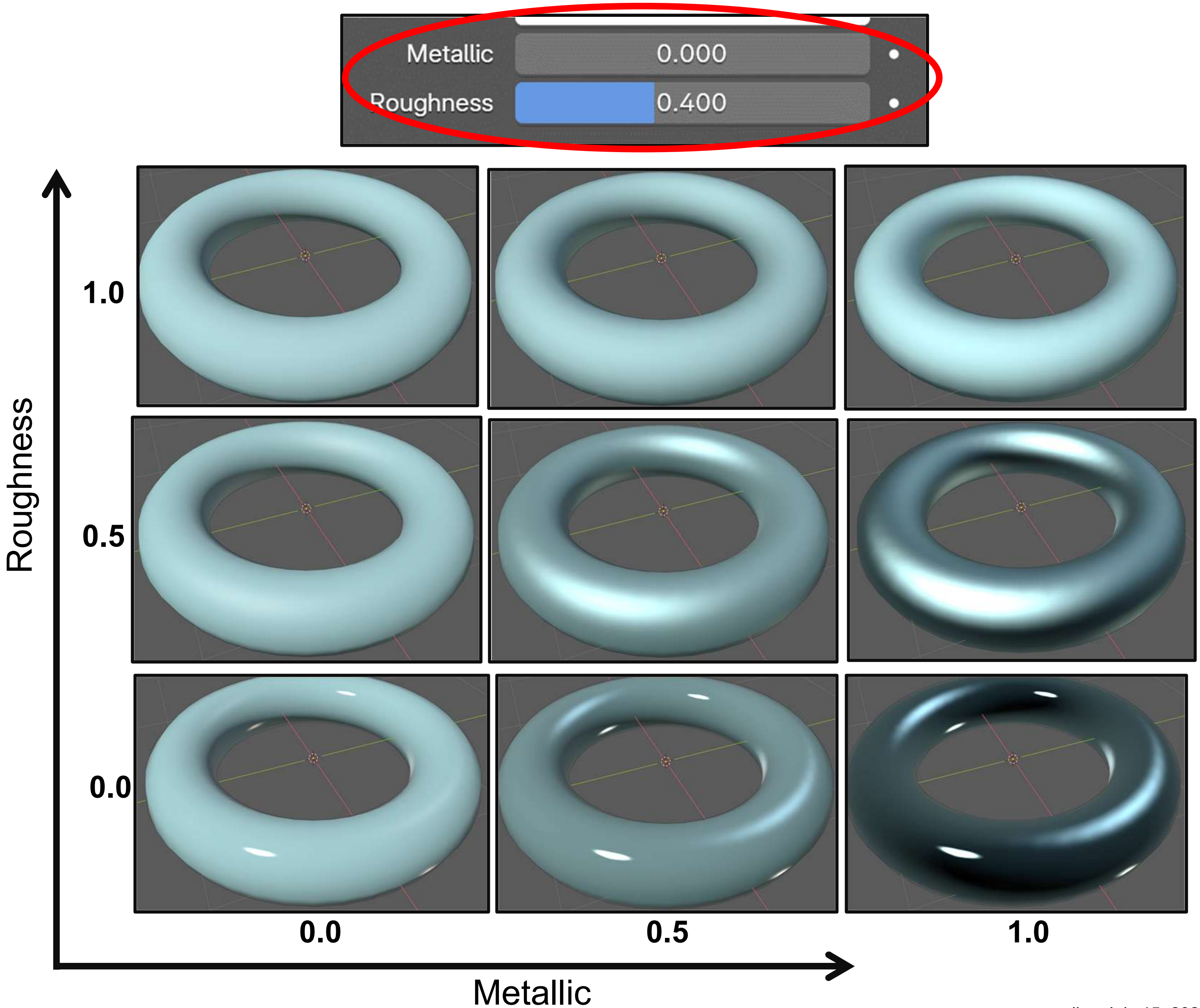
… to bring up this color wheel. Click in here to get the color you want to give that object.

Metallic and Roughness Specify How the Color Interacts with Light

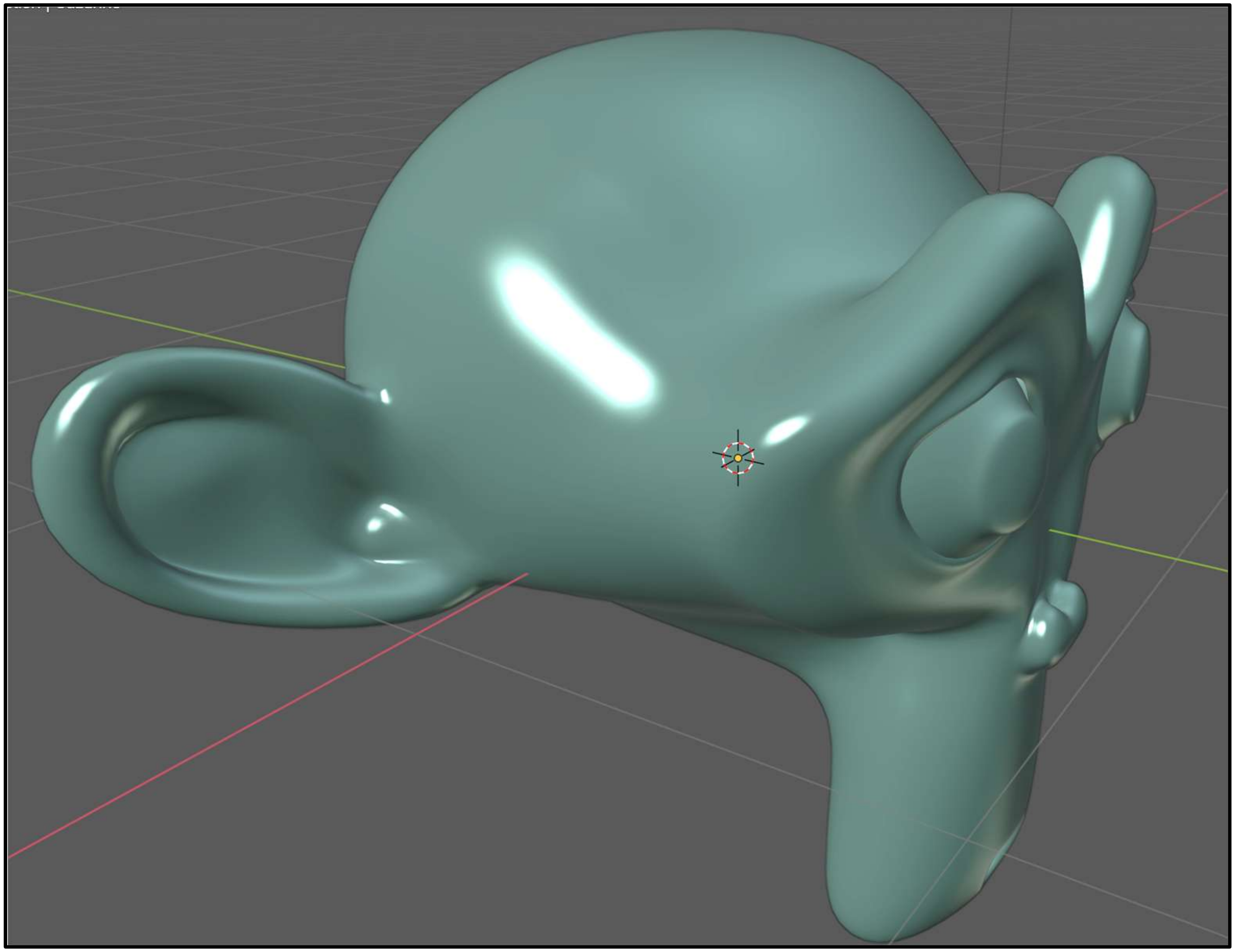
In some graphics programs, they use the word "smoothness" instead of "roughness".

If smoothness is small, roughness is large.

If smoothness is large, roughness is small.



Using the Material Properties Menu



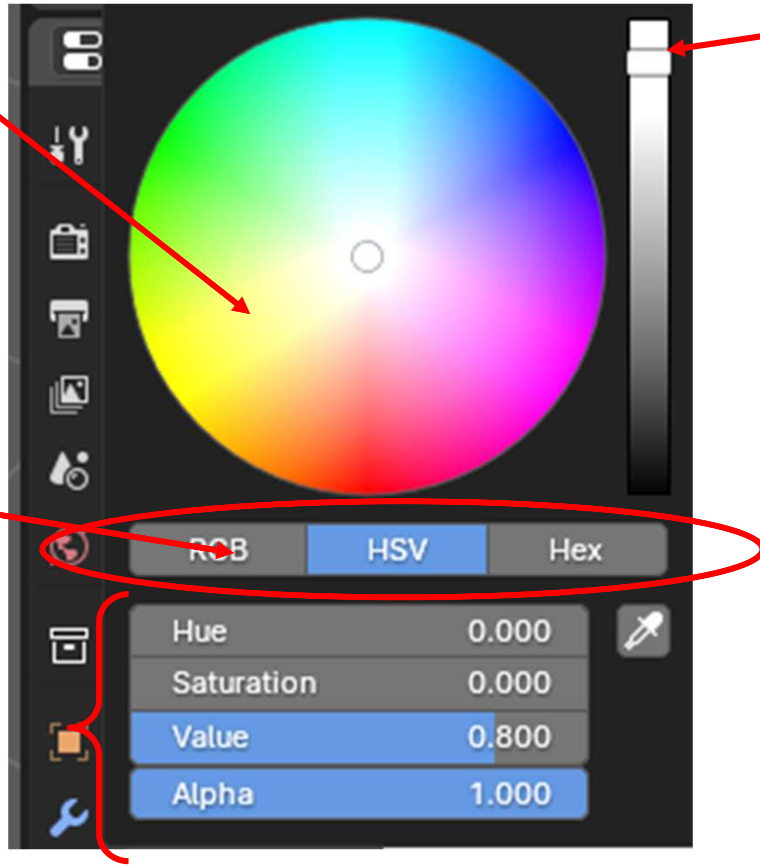
The Color Wheel

Click in here to change the **Hue** and **Saturation**

Hue is angle around the wheel
Saturation is the radius

These are the possible ways the color will be defined

If you know the color definition numbers you want, you can type or slider them here



Click in here to change the **Value** (brightness)

Color Scales

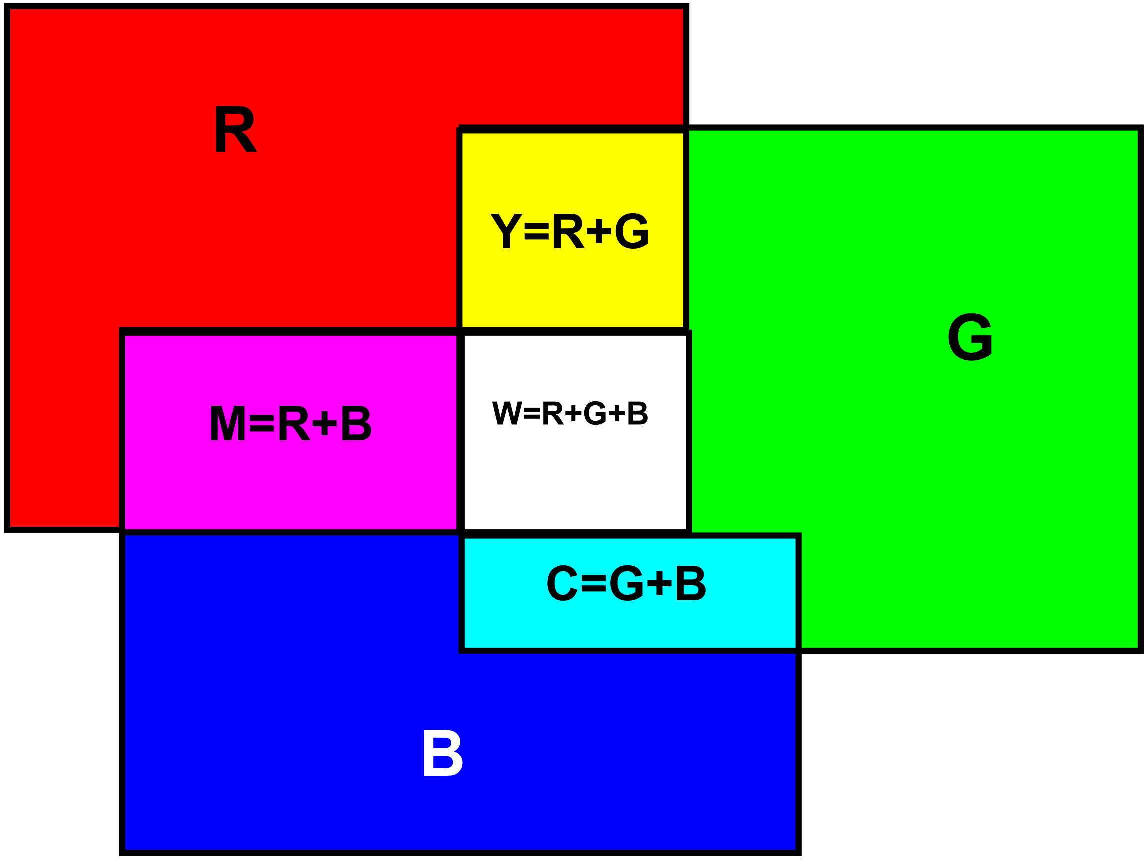
Red-Green-Blue

Hue-Saturation-Value

Hexadecimal

Eyedropper
(lets you select a color you see somewhere else on the screen)

RGB Additive Color Scale



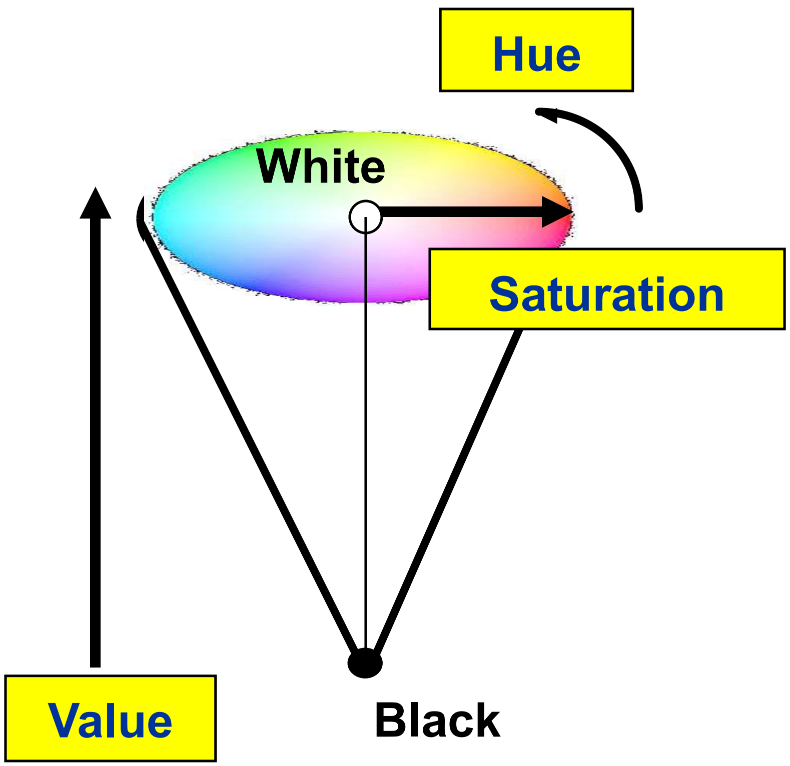
R = Red
G = Green
B = Blue
W = White

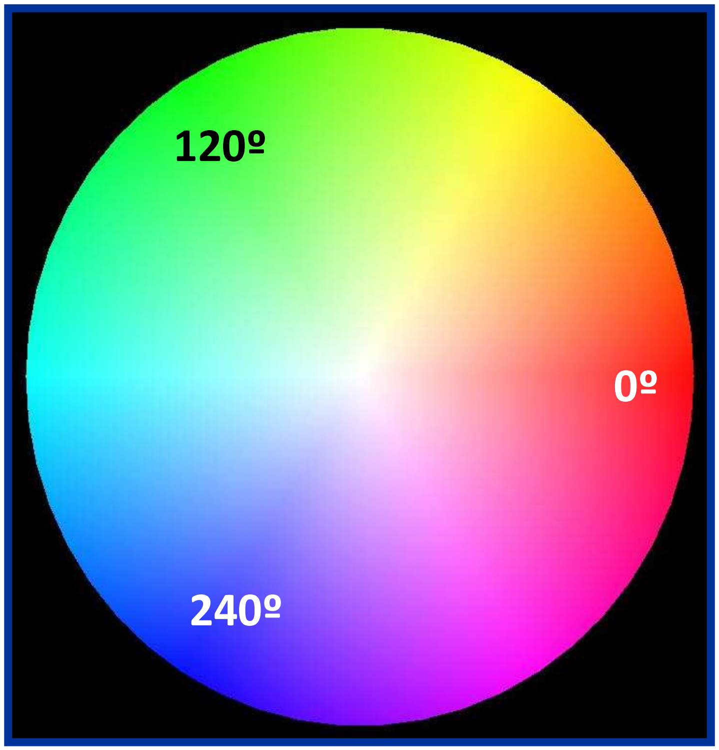
C = Cyan
M = Magenta
Y = Yellow
K = Black

Blender’s RGB scale lets you give the red, green, and blue components in the range **0. – 1.**

Blender’s hexadecimal scale lets you give the red, green, and blue components in the range 00 00 00 – FF FF FF

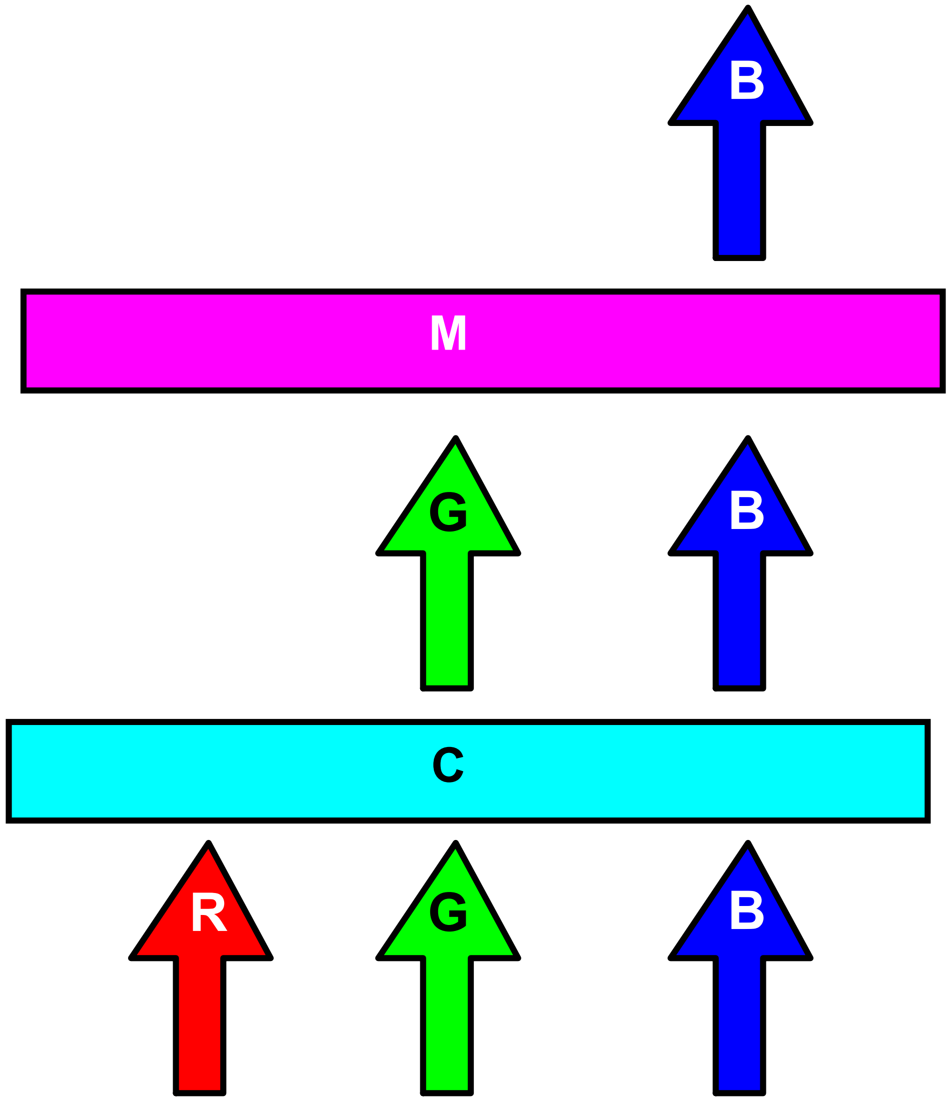
Hue-Saturation-Value (HSV) Color Scale





Blender's HSV scale lets you give the hue, saturation, and value components in the range **0. – 1.**

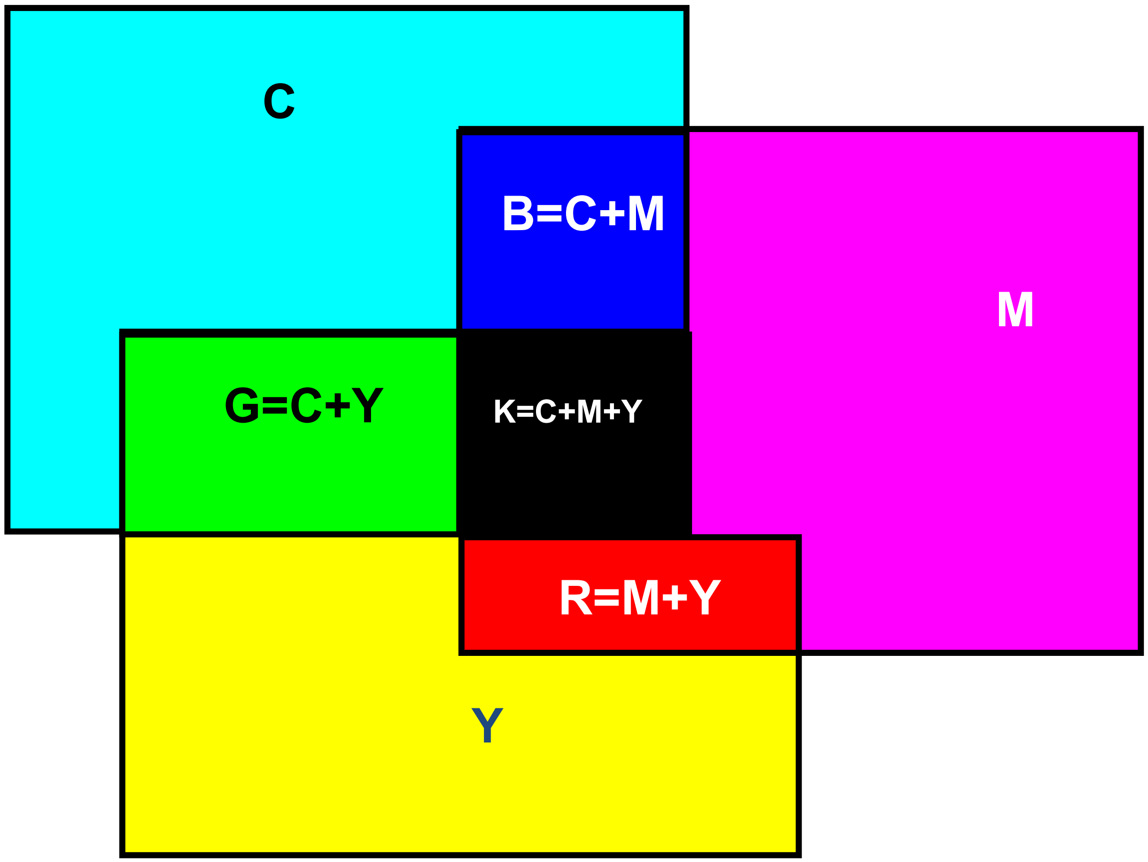
Subtractive Colors (CMYK) are Something Different



R = Red
G = Green
B = Blue
W = White

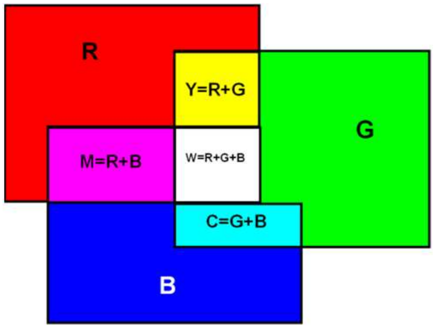
C = Cyan
M = Magenta
Y = Yellow
K = Black

Subtractive Color (CMYK)



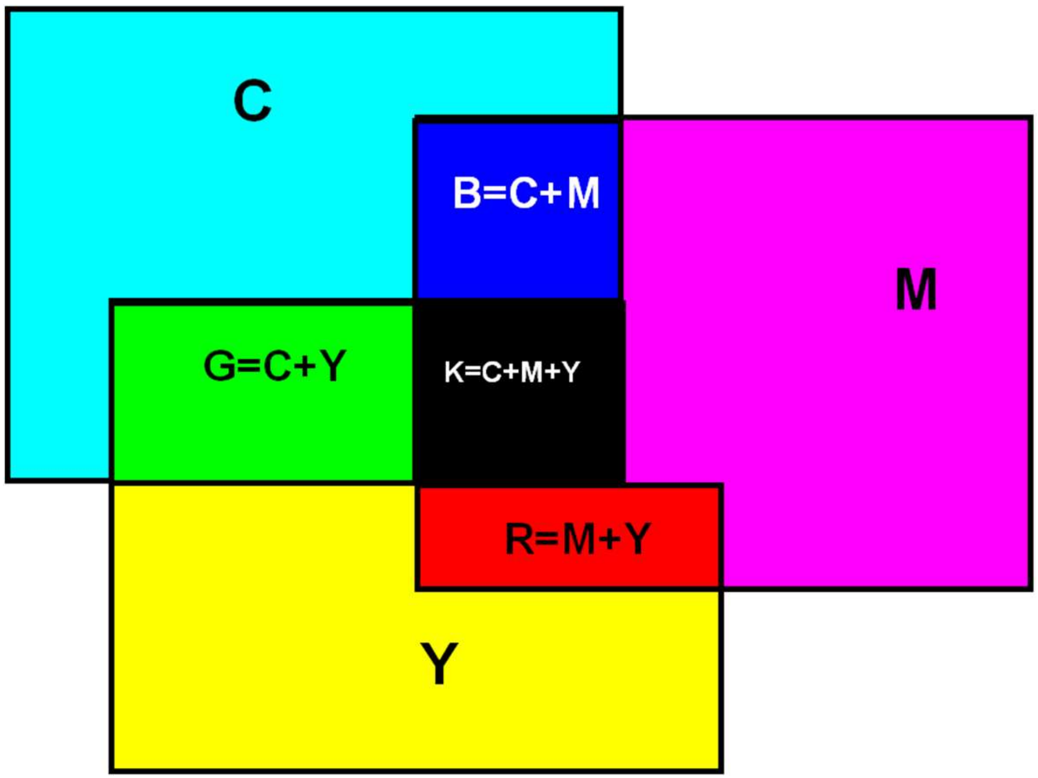
R = Red
G = Green
B = Blue
W = White

C = Cyan
M = Magenta
Y = Yellow
K = Black



Color Printing

- Uses subtractive colors
- Uses 4 separate passes (CMYK)

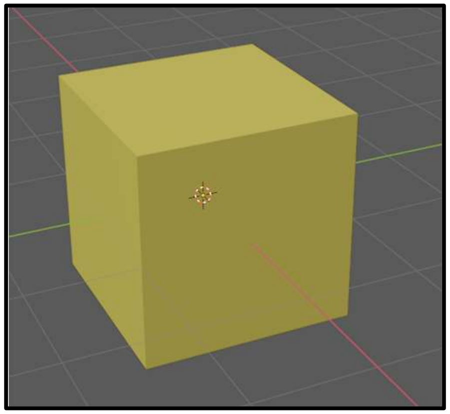


R = Red
G = Green
B = Blue
W = White

C = Cyan
M = Magenta
Y = Yellow
K = Black

Changing the Color of Individual Faces

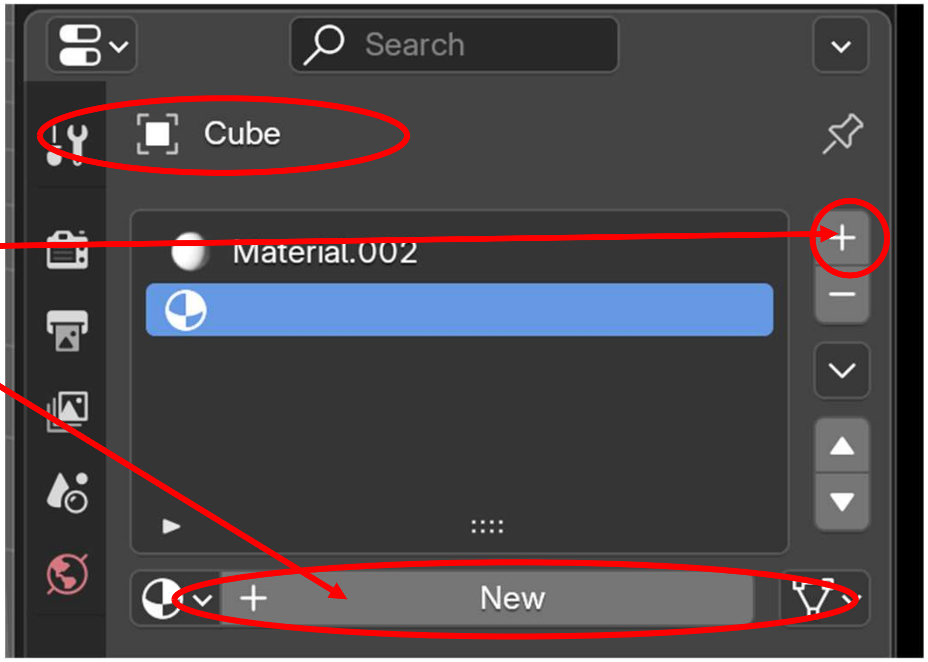
Let's say that we have created and colored this yellow cube and you want to color the front face cyan instead.



With the yellow cube selected, add another color slot (**+**).

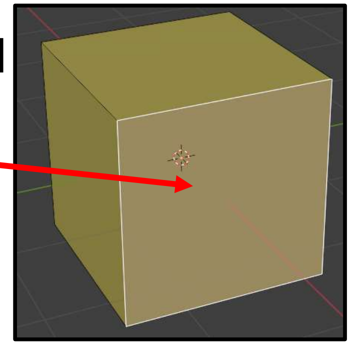
Then define that color by clicking on **New**

This will assign a Material name to the slot you just created.

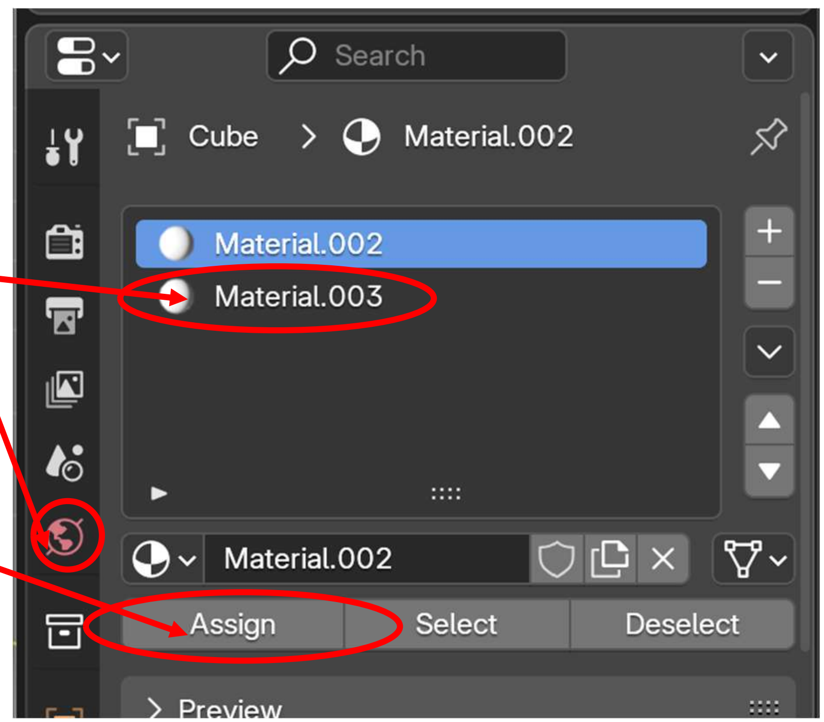


Changing the Color of Individual Faces

Now select the yellow cube and Tab into **Edit Mode**. Tell Blender that we will be selecting faces.



Let go of all faces by clicking in an empty area and then click on the front face.



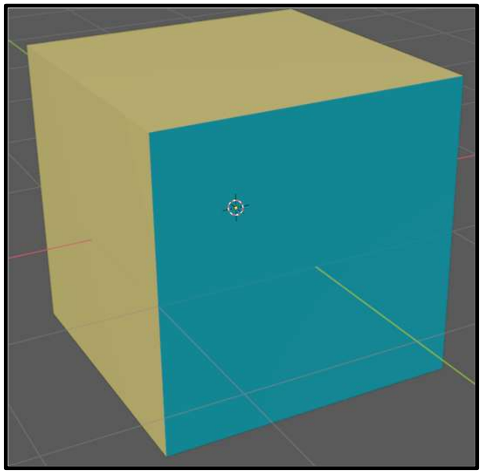
Click on the **Material Properties** menu icon

From this list, select the new color you want this face to be.

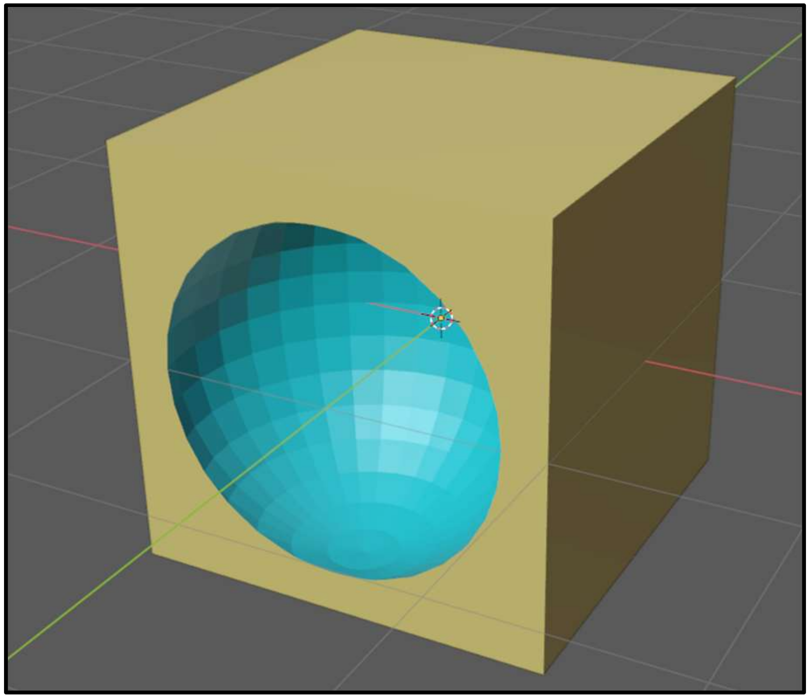
Click **Assign**

Changing the Color of Individual Faces

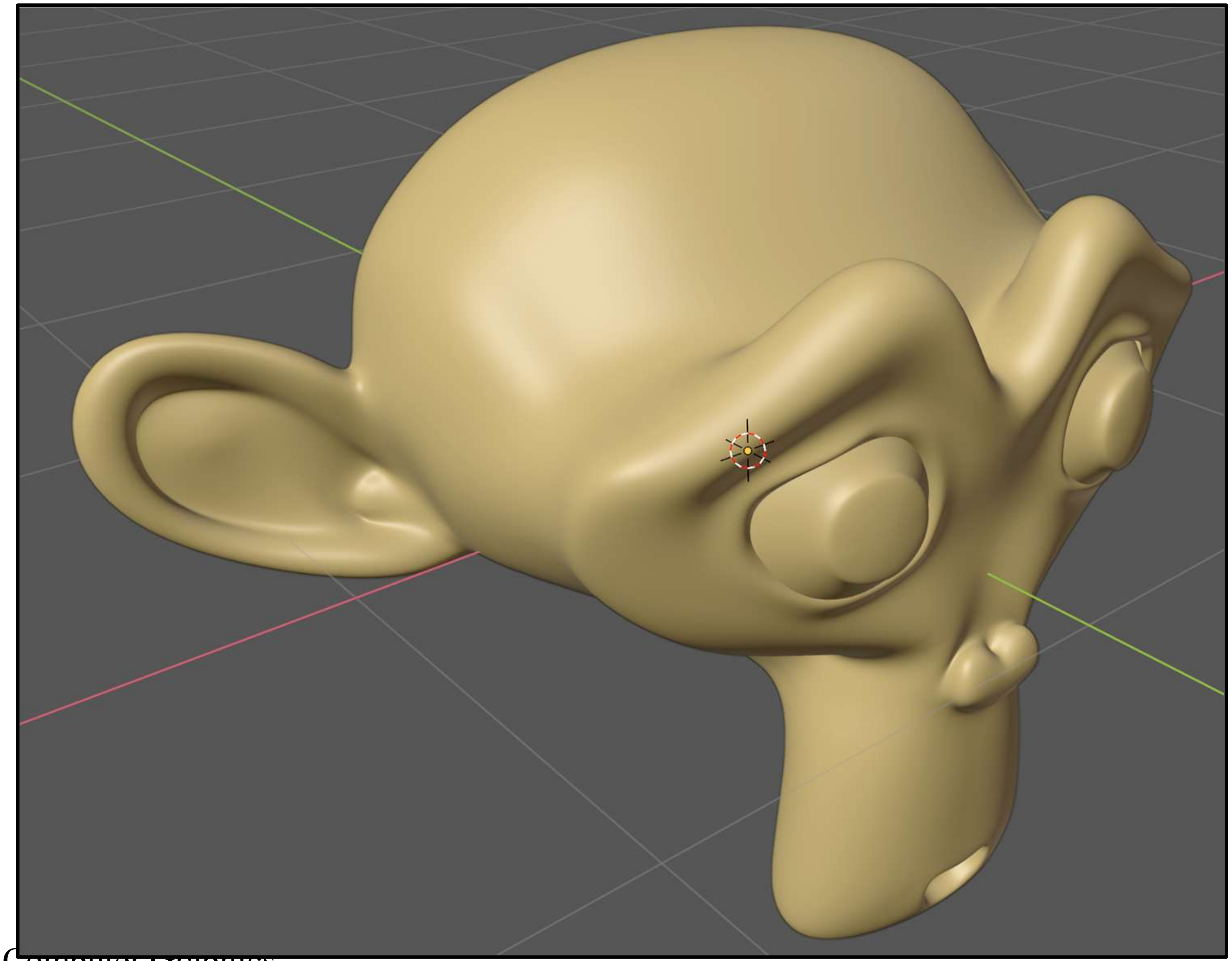
You have now changed the color of an individual face.



I especially like this for highlighting the results of Boolean operations:

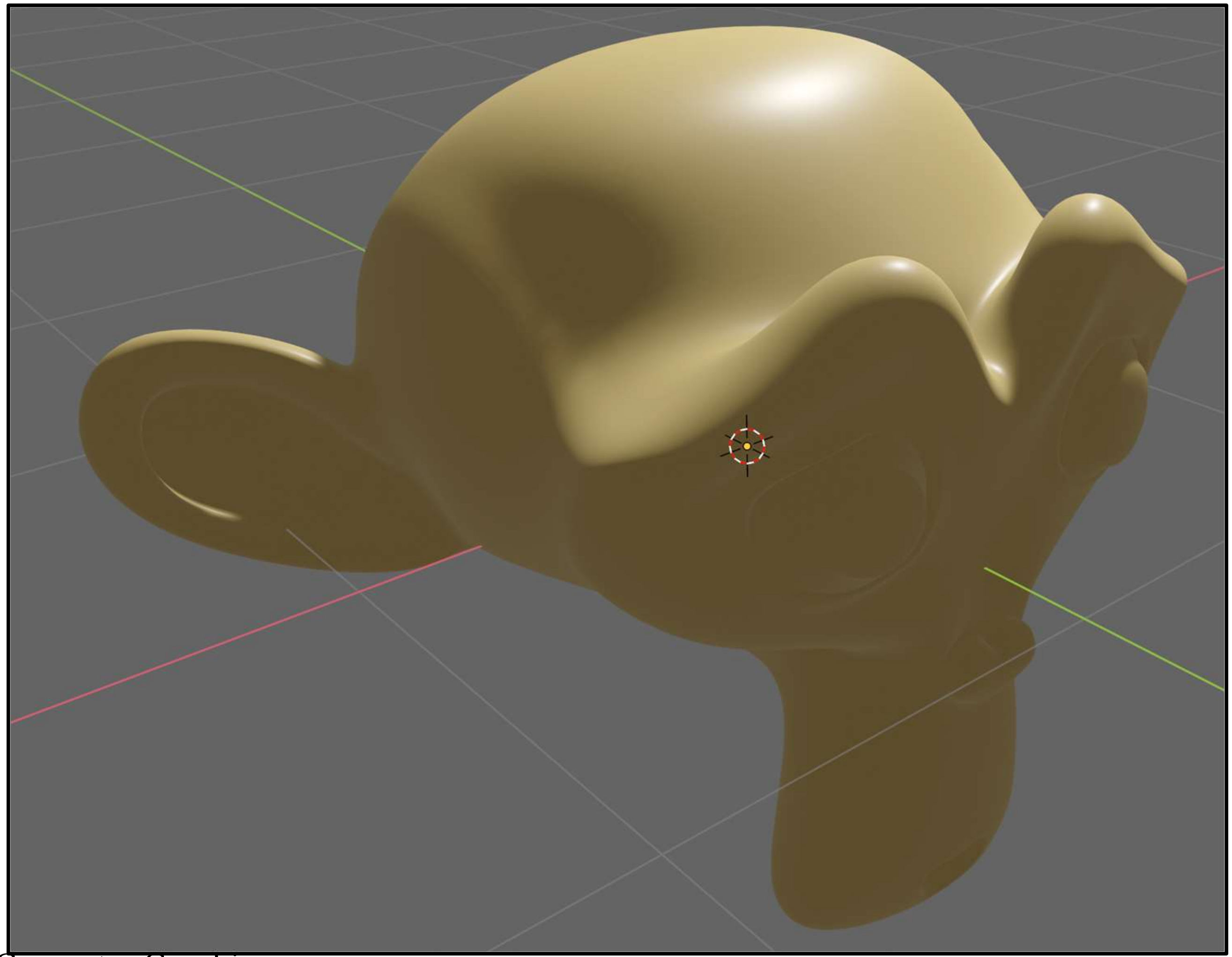


So Far We Have Been Using Viewport Shading



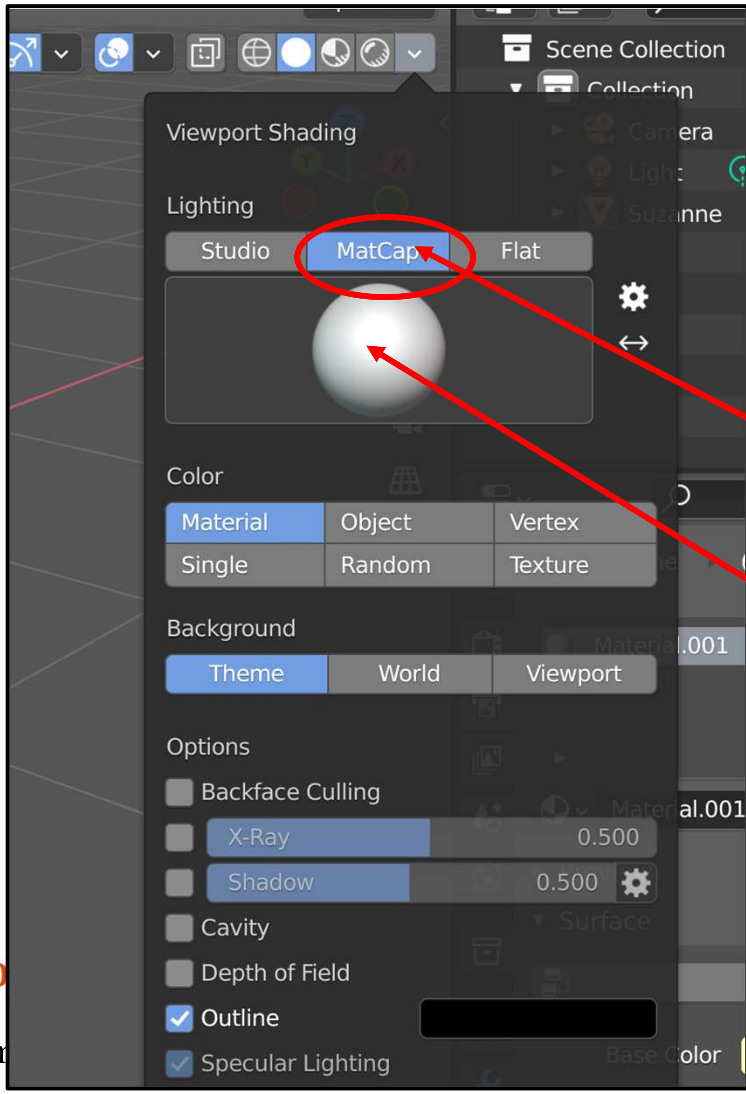
We have gotten pretty good views of our objects without having to position light sources, cameras, etc.

We Could Switch to Rendered Shading



But, that would *require* us to position light sources, cameras, etc. We're not ready for that yet.

But, here comes *MatCap*, a More Creative Use of Viewport Shading

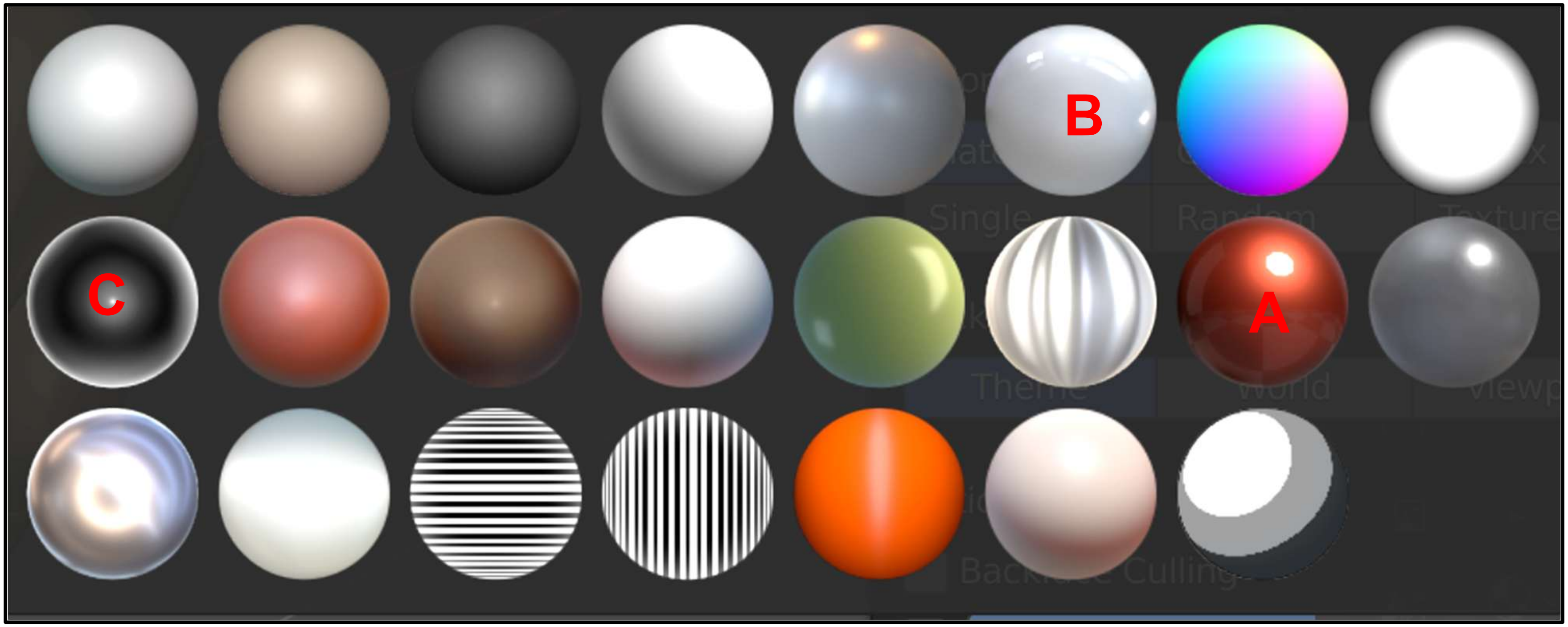


Click on **Viewport Shading** and then click on the **down-facing arrow**

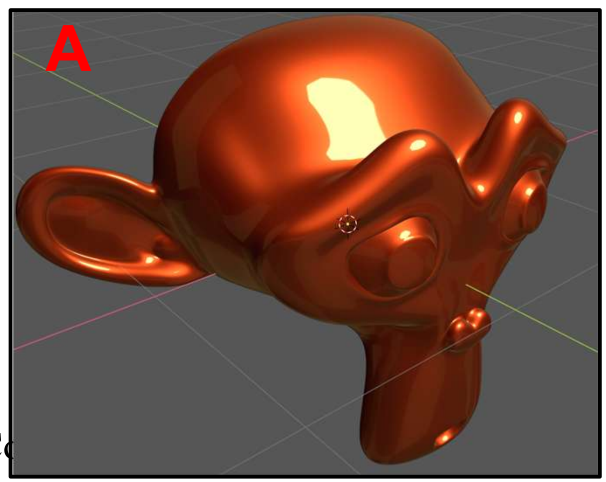
Studio Lighting is what you have been using. Instead, select **MatCap,** which stands for “Material Capture”.

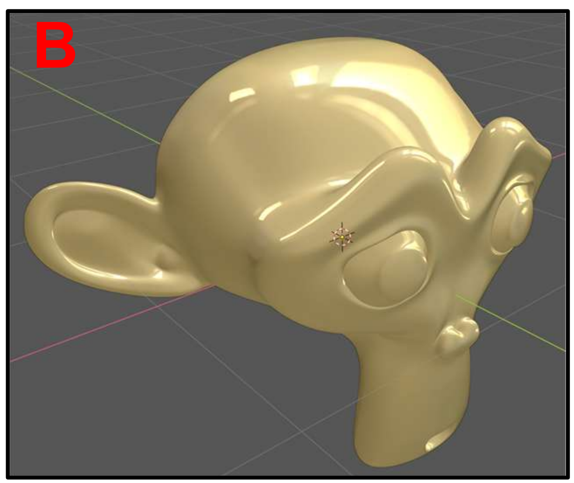
Then, click on the sphere.

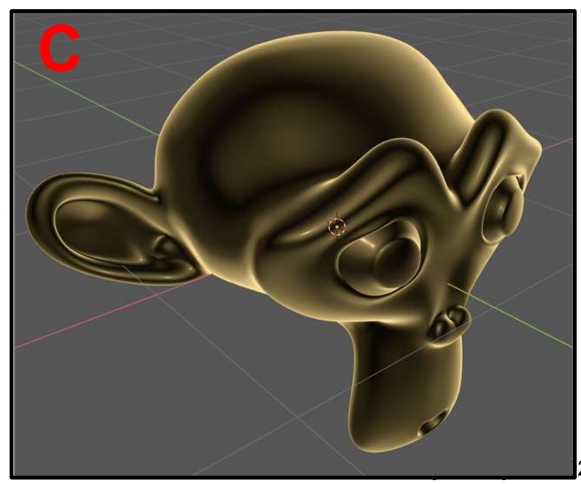
Up Pops a Lot of Material Options!



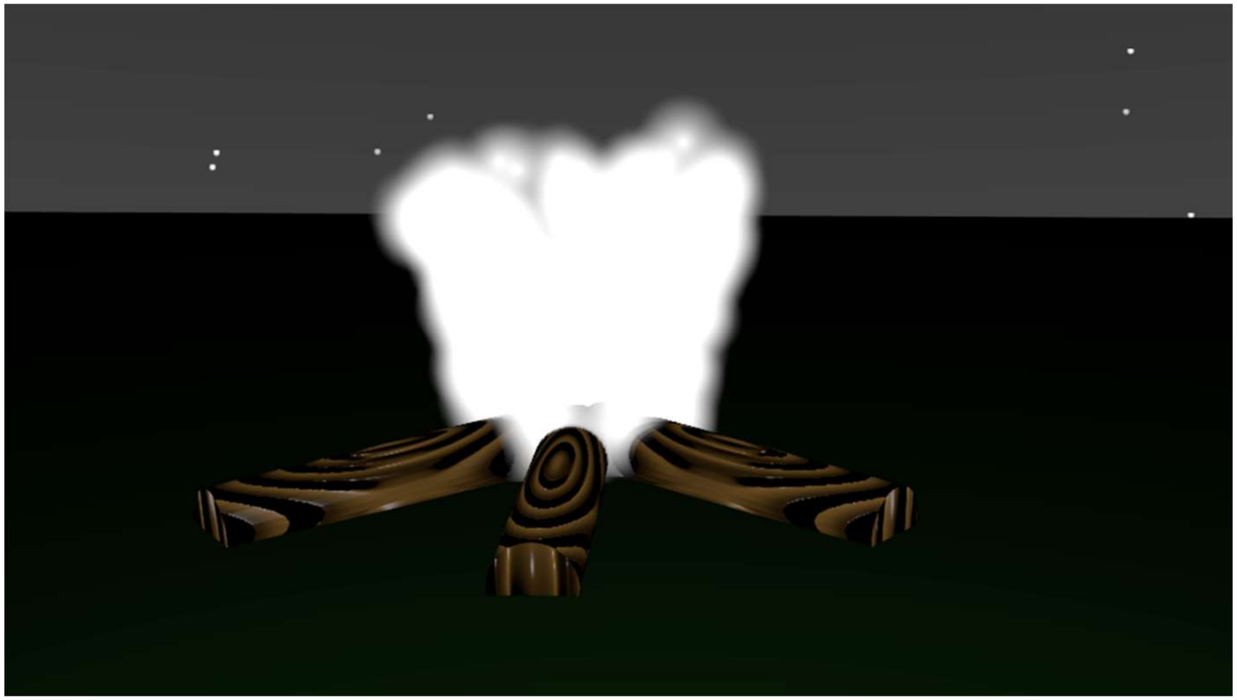
Try them, especially the shiny ones!





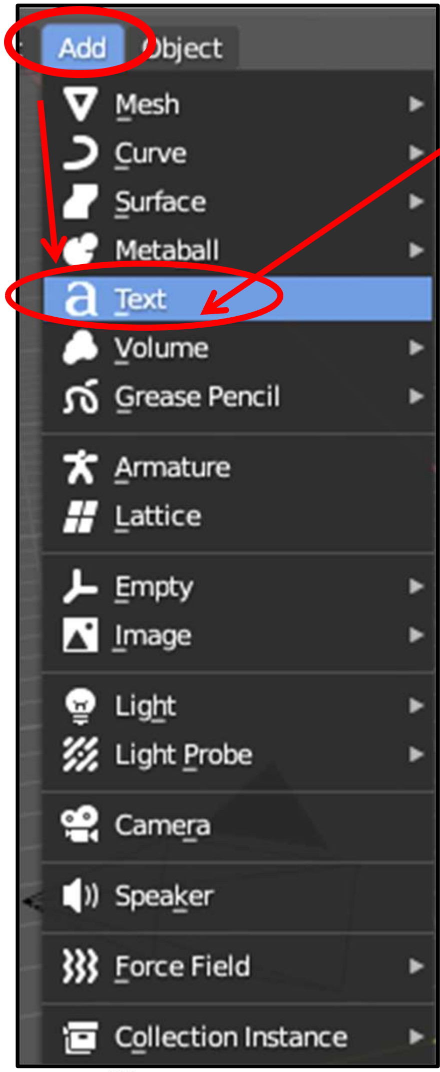


6. Modeling, II

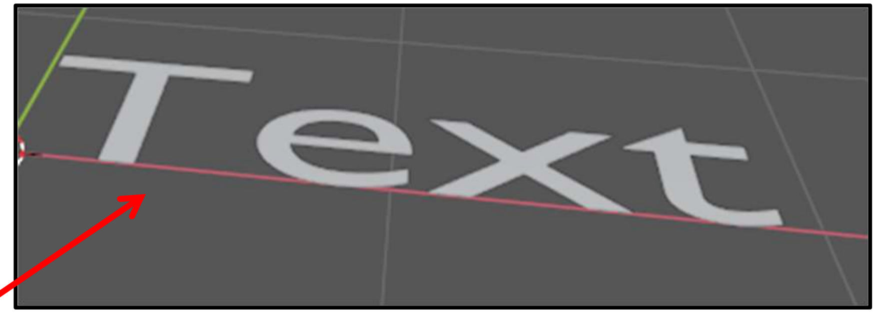


Oregon State University
Computer Graphics

Adding 3D Text

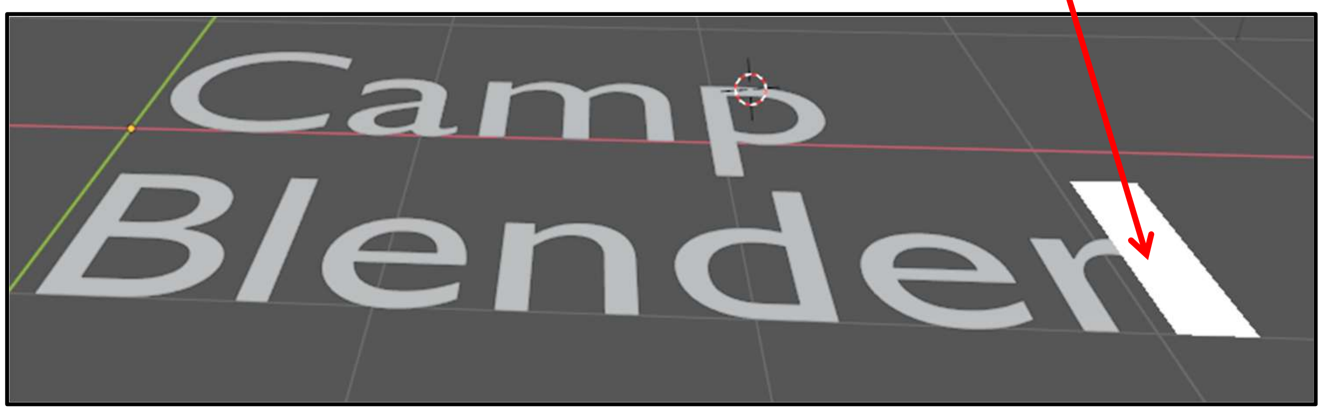


Select **Add → Text**



It ends up giving you the fairly-useless line “Text”

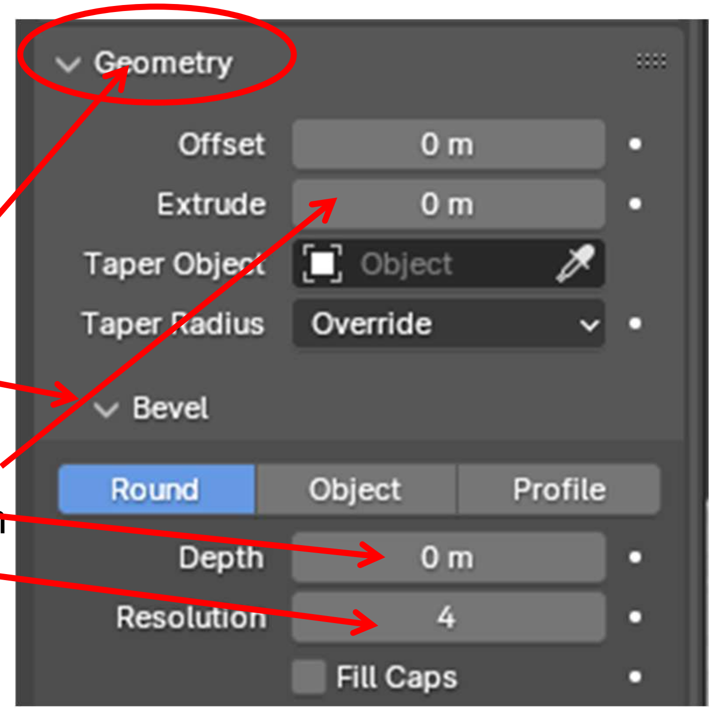
To change the text string, **tab into Edit mode**. The white rectangle acts as a text cursor. Backspace over “Text” and type your new text. The return key will let you enter multiple lines.



Changing the Style of 3D Text

So far, not very 3D, huh?
Tab back to **Object Mode**, click on your text, then click on this **Font button**

Try out the **Geometry** and **Bevel** sub-menus



Extrude: give the letters height
Depth: bevel the top and bottom
Resolution: round the bevel

Changing the Look of 3D Text

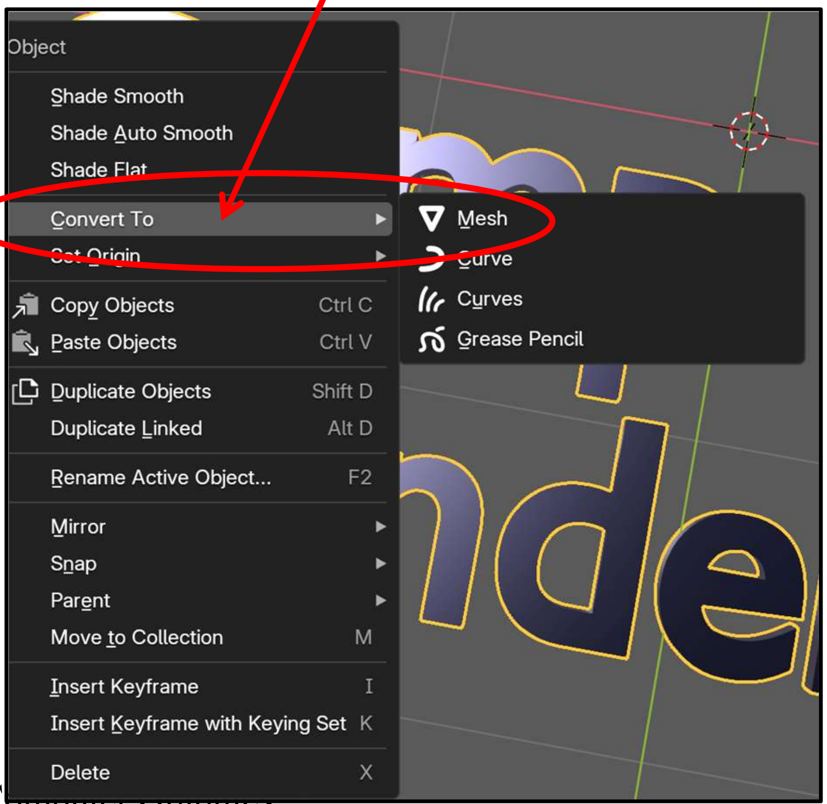
From here on, your 3D text acts like any other 3D object.
It can be grabbed (translated), rotated, and scaled.

It can be colored, too.

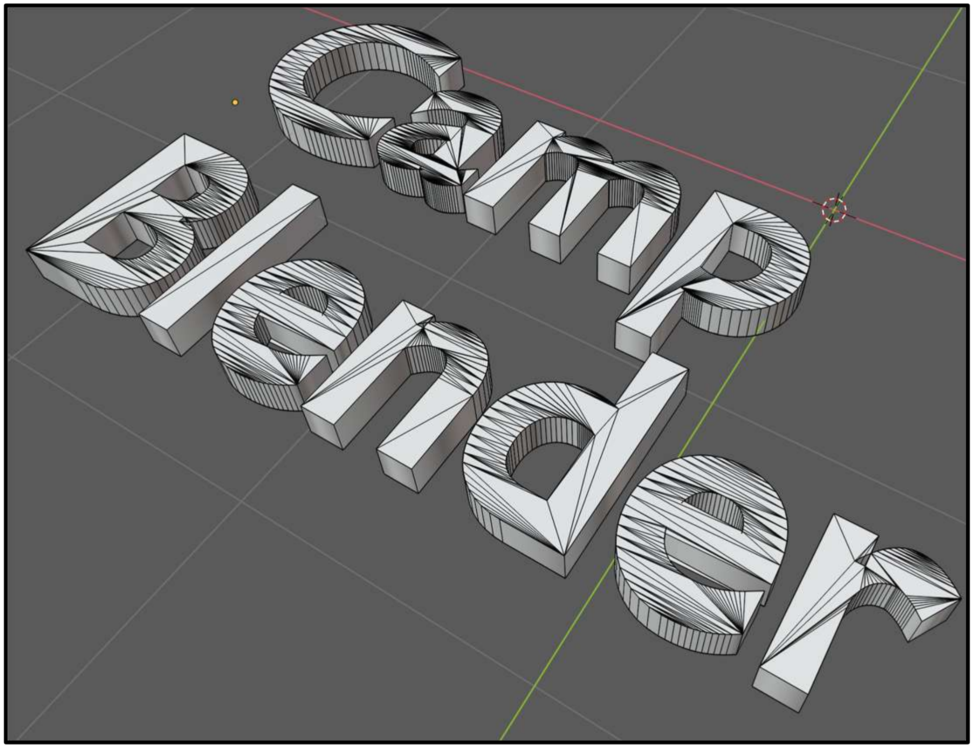
Changing the 3D Text to a Mesh

At this point, your text is, well, text. That is, it is characters, not vertices, edges, and faces. If all you want to do is look at it or change the characters, that's fine. But if you want to do Mesh-things to it, you can't because it is not a mesh.

To make it a mesh, right-click on the text in Object Mode and select
Convert To → Mesh



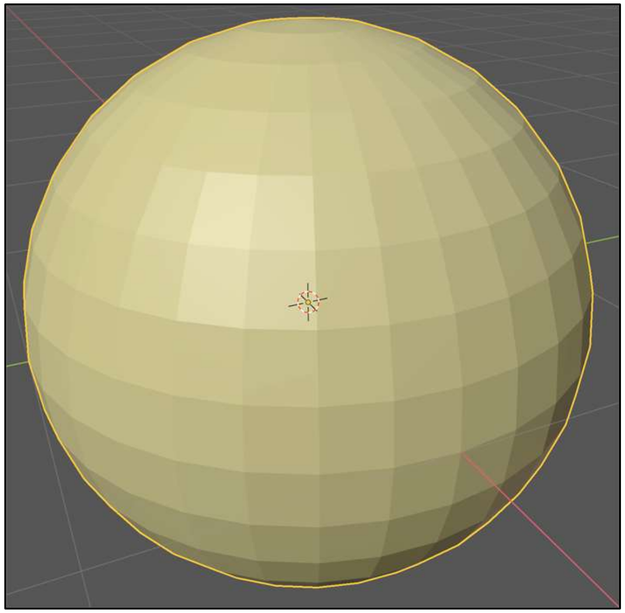
You can confirm that this worked by tabbing to Edit Mode and seeing all of the new vertices, lines, and faces:



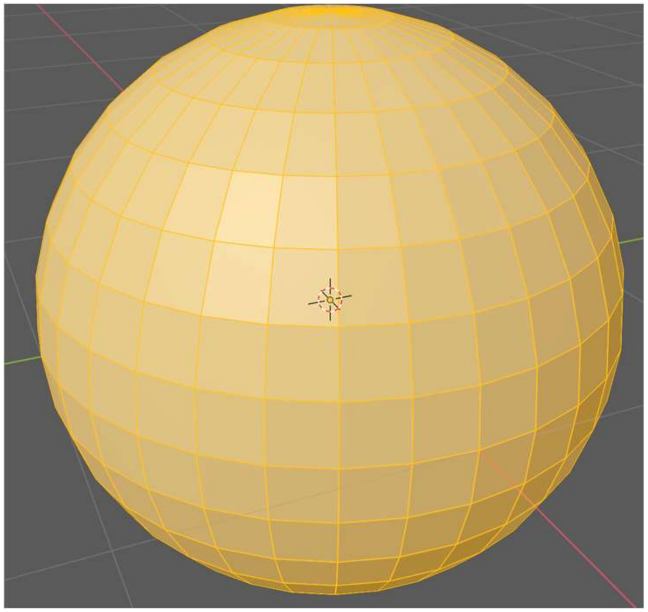
Edit Mode Subdivision

The Edit Mode subdivision feature adds more vertices, but doesn't do any sort of smoothing (like the Subdivision Surface Modifier does). So, when you are done, you will have more vertices to sculpt with, but, in Object Mode, your object will look exactly the same as it did before.

1. Object Mode



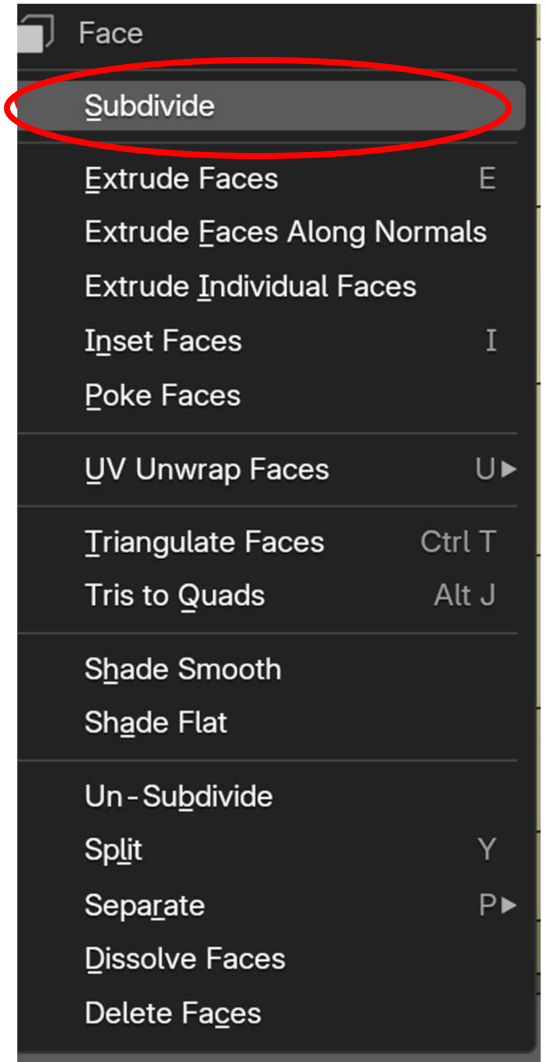
2. Tab into Edit Mode



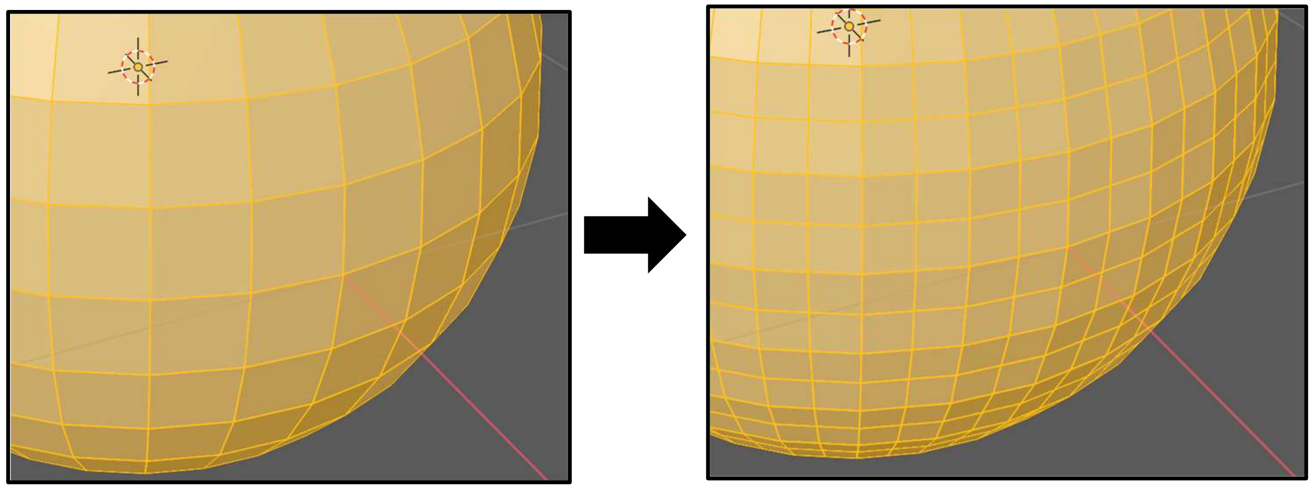
3. Get Ready to Edit Faces

Edit Mode Subdivision

4. Right-click Subdivide



5. You now have more vertices



6. Tab back into Object Mode

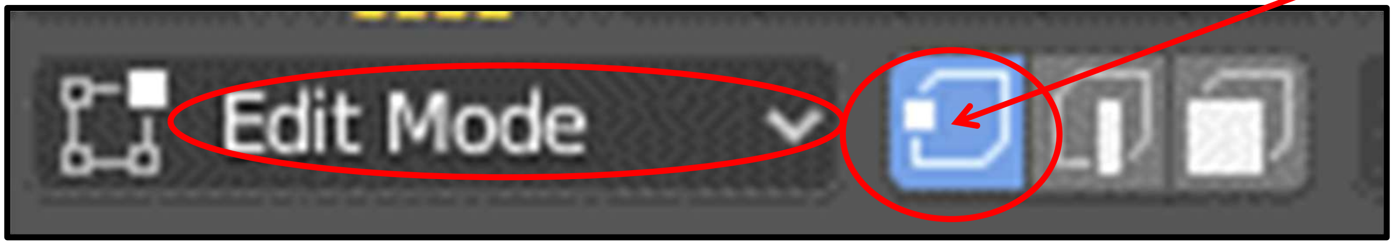
Note that the resulting sphere doesn't look any different from what it looked like before you subdivided. This is because subdividing flat planes gives you more flat planes. This operation is meant to add more vertices for editing, not smooth your object. (There is a Modifier for exactly that.)

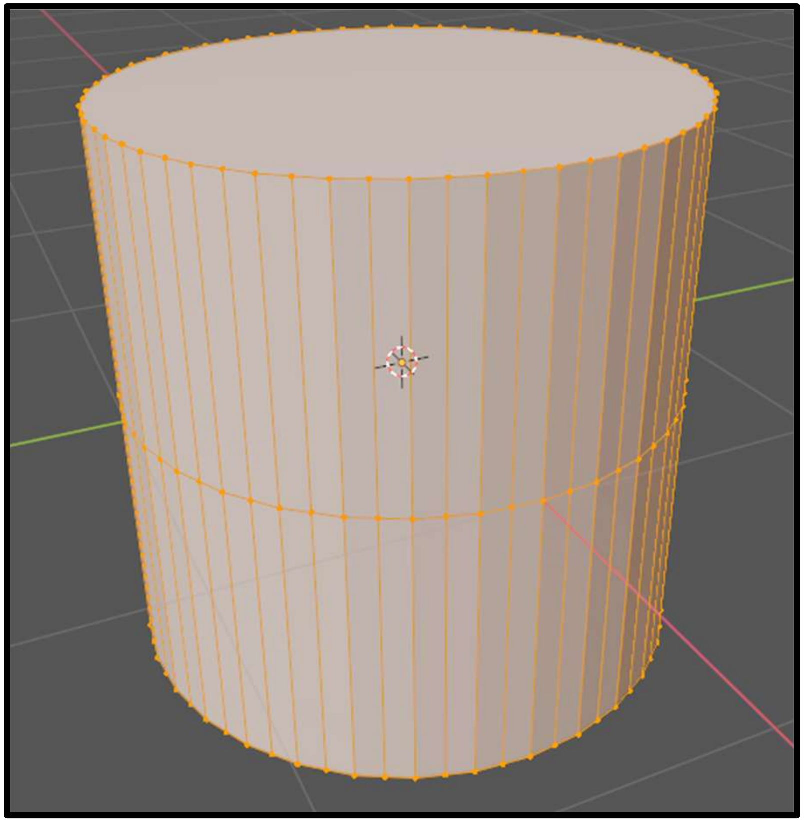
A Multi-Vertex Picking Hint

First, make this model:

1. **Object Mode → Add → Mesh → Cylinder**
2. Tab to **Edit Mode → RMB → Subdivide**

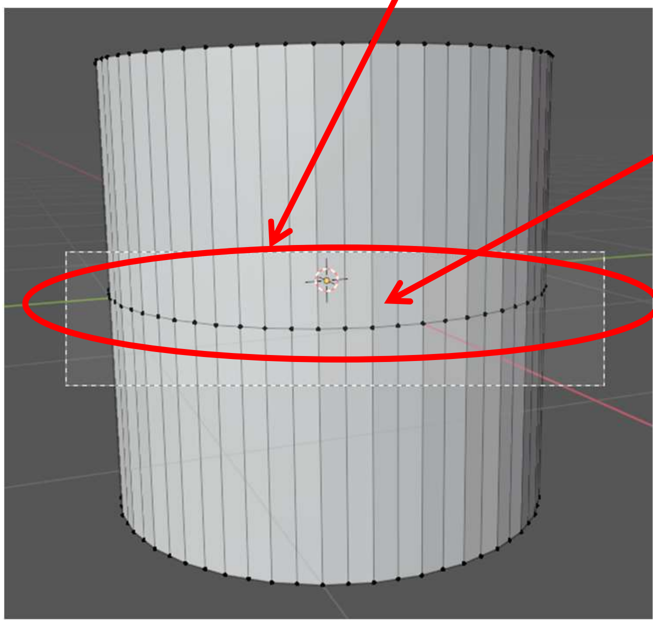
Edit a vertex





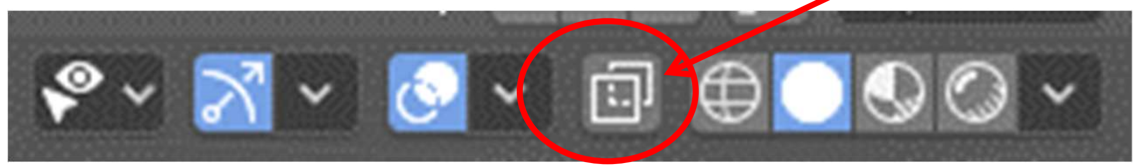
A Multi-Vertex Picking Hint

Now, **LMB-sweep** over these vertices. (I call them the “equator” or the “belt”.)

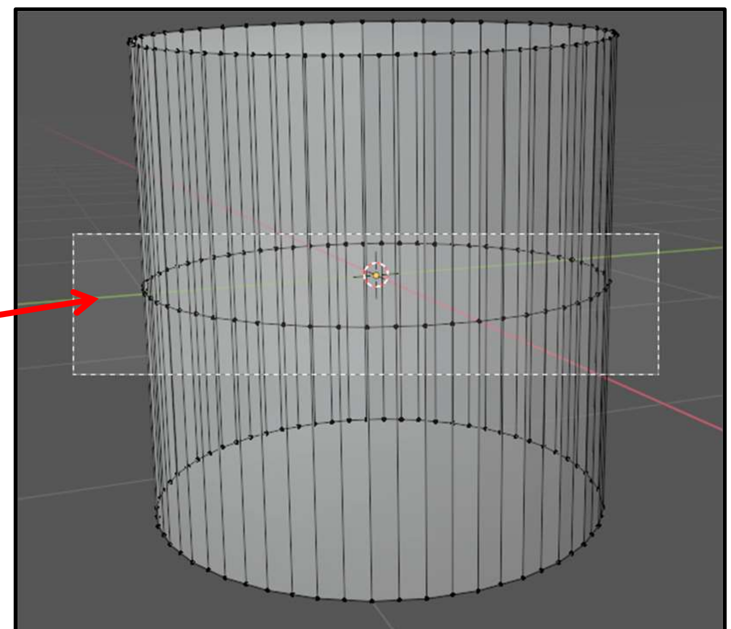


But, if you do that, you will only end up selecting the front vertices, that is, *the ones you can see*.

The trick is to go into **X-ray Mode**, by clicking here.

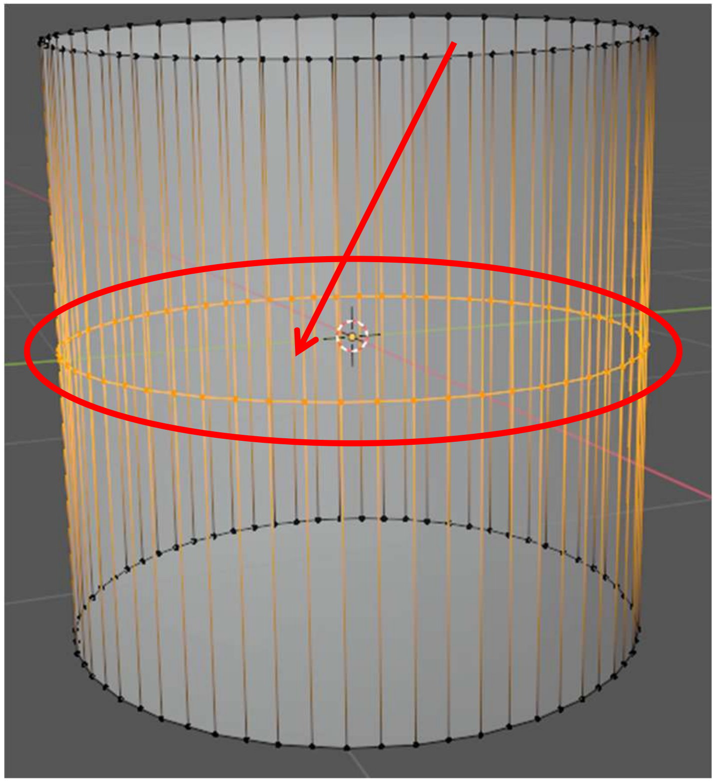


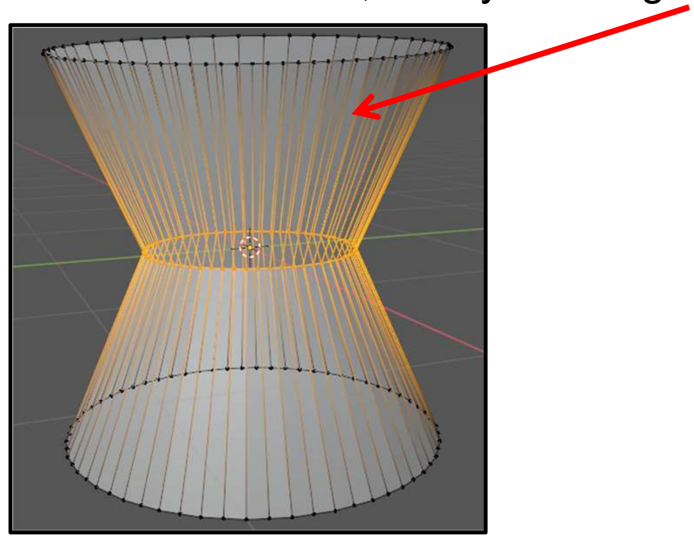
This will now let you select *all* the points in the belt.



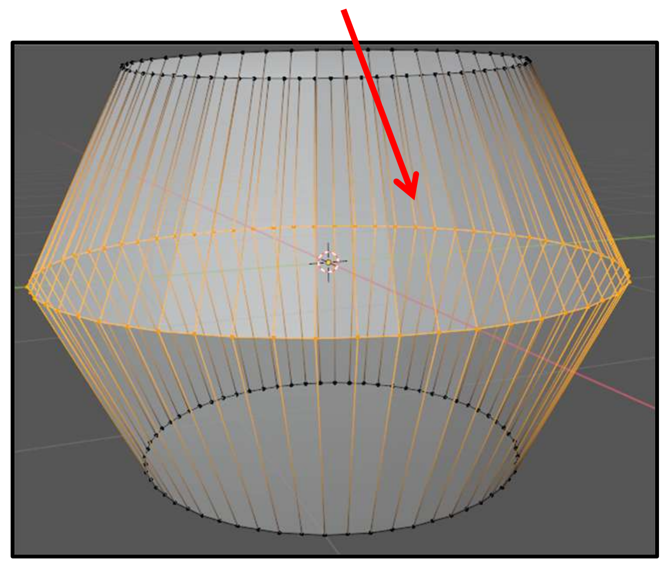
A Multi-Vertex Picking Hint

Why do that? Well, if you have those vertices selected and you hit the **s** key (for **s**cale) and move the mouse, then you can get this:

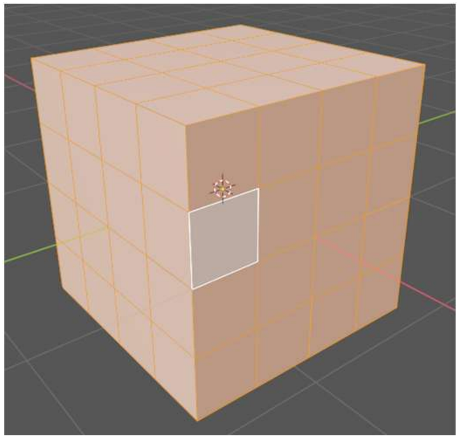




Or, this:

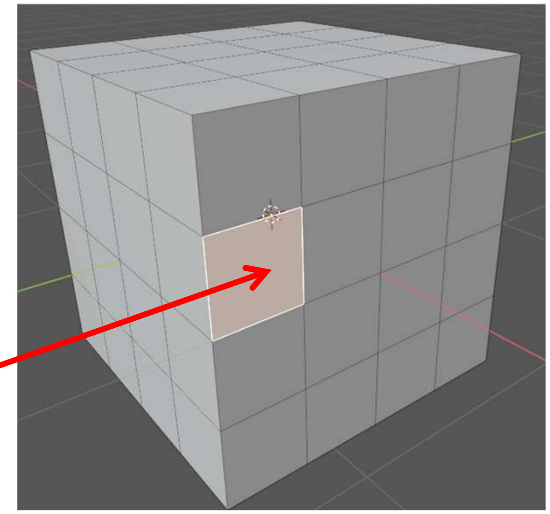


A Multi-Face Picking Hint



To create this model:

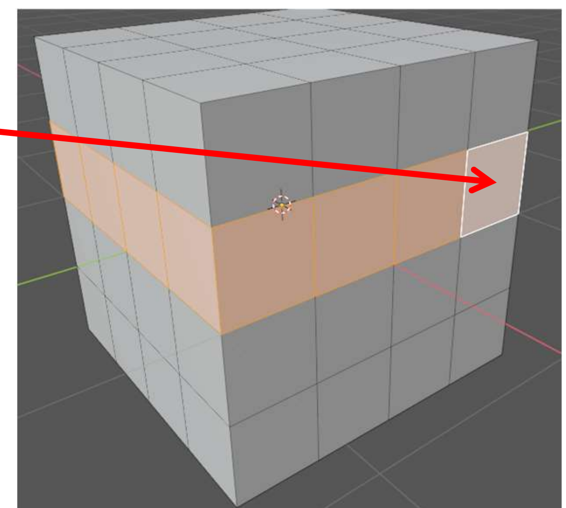
1. **Add → Cube**
2. Tab to **Edit Mode → RMB → Subdivide → Subdivide**



Suppose you want to select an entire row of faces in order to "fatten the belt". You could select all the faces individually (**LMB → Shift-LMB**). But, here's a better trick

1. Click on one face in the row

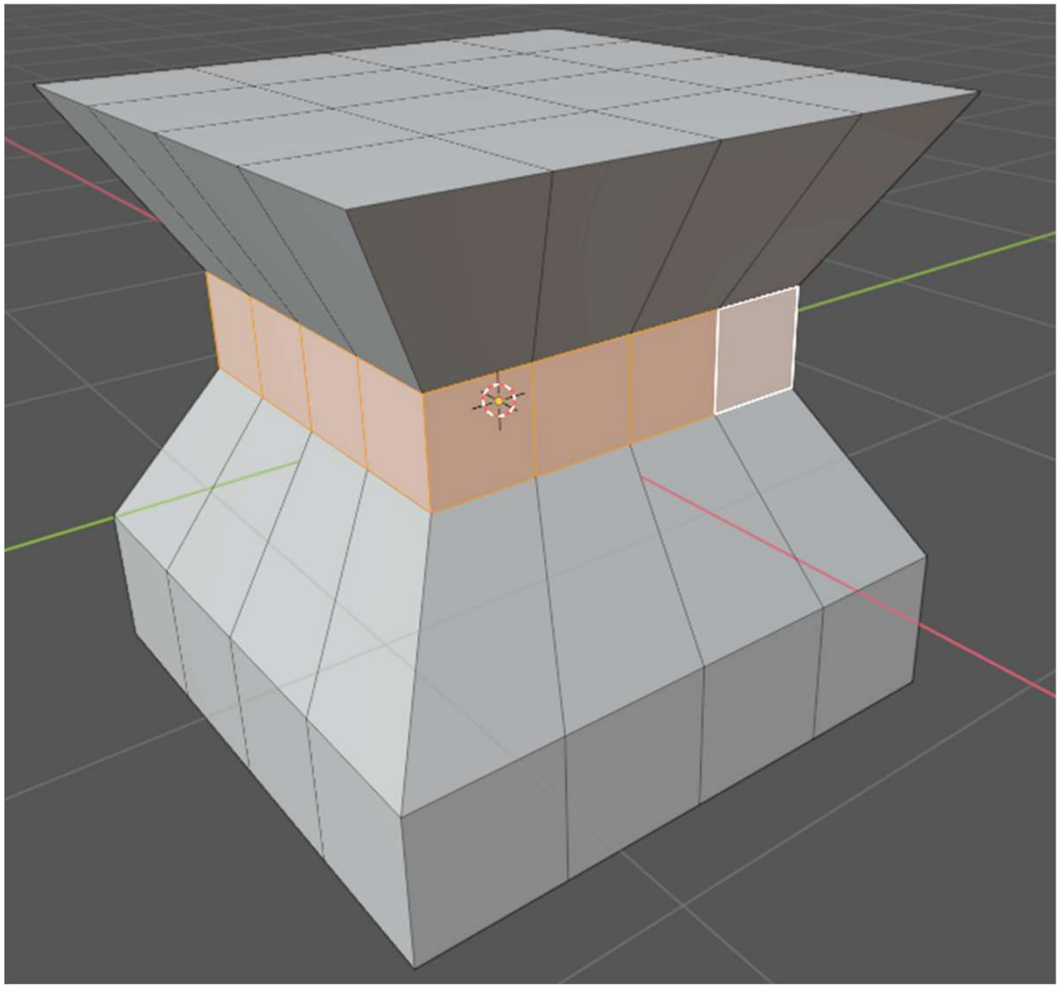
2. **Alt-LMB** on another face down the row



Face Select Mode

Oregon State University
Computer Graphics

A Multi-Face Picking Hint

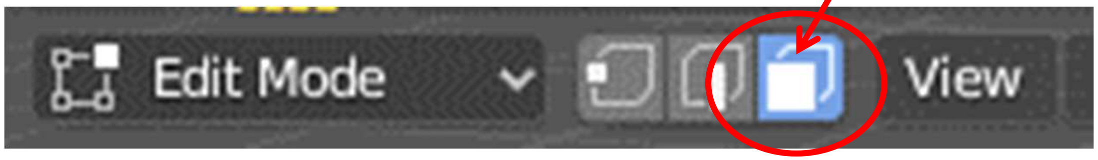


Scaling ('s')

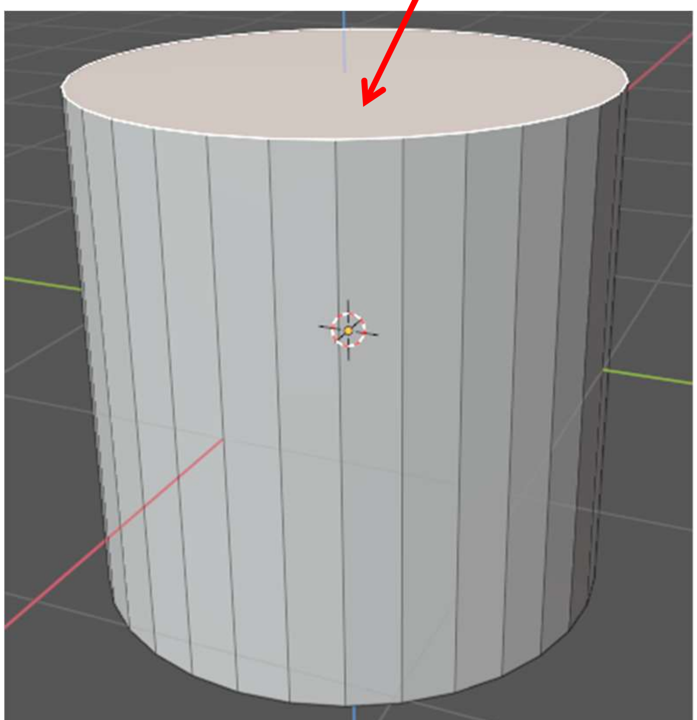
Oregon State
University
Computer Graphics

A Face Picking Hint

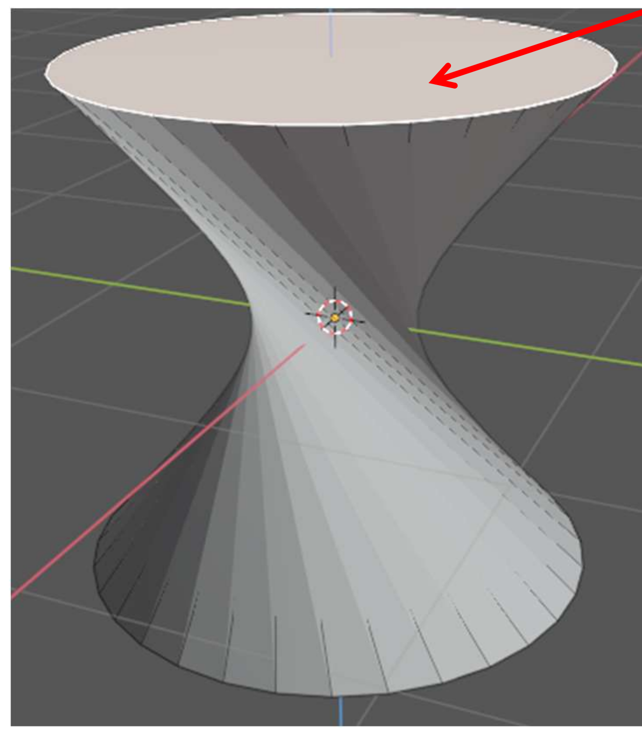
Similarly, if you put yourself into face-picking mode:



And click on the top face of the cylinder (you don't need the belt and don't need to be in X-ray Mode for this):

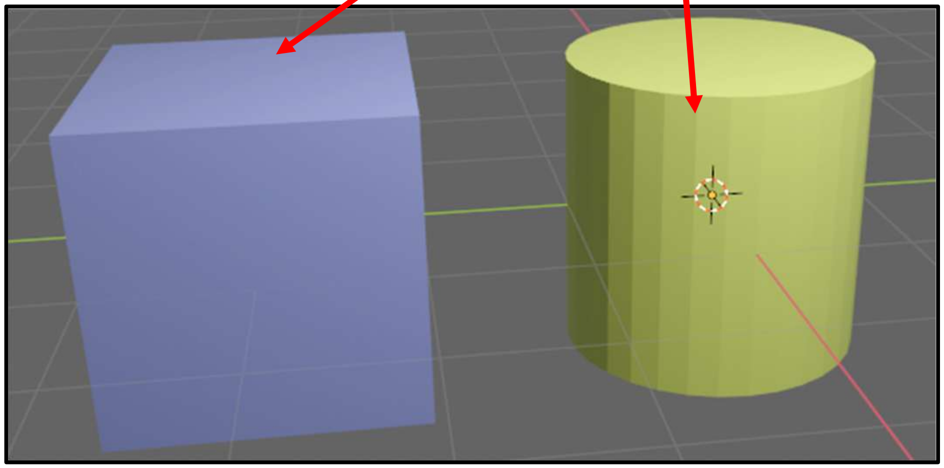


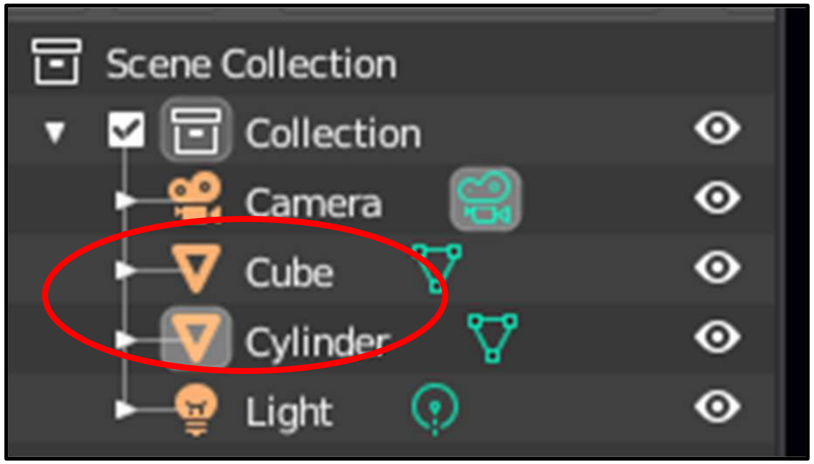
And hit the **r** and **z** keys (for **r**otate about the **z** axis) and move the mouse, then you get this:



Intentionally Joining Two Objects

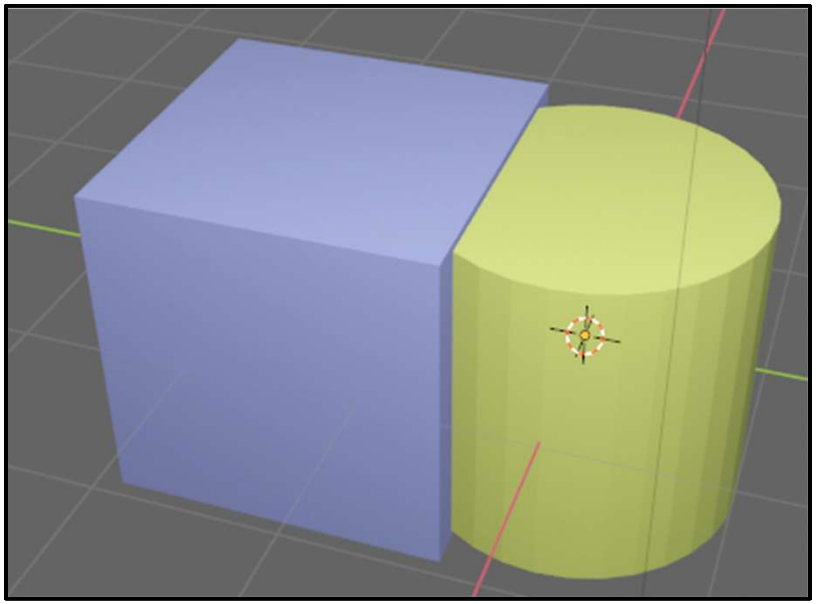
Let's say that you have two objects and want to join them together so that you can act on them as one object.

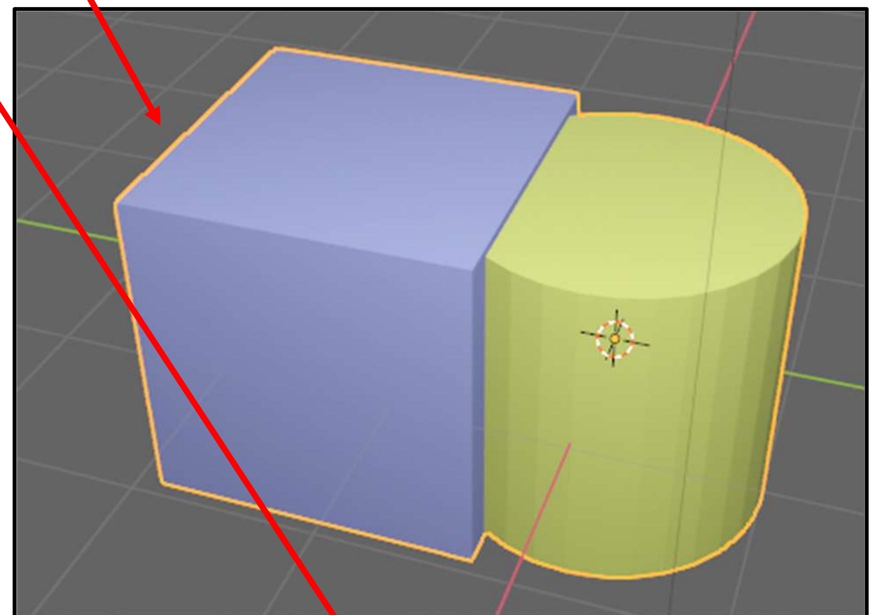


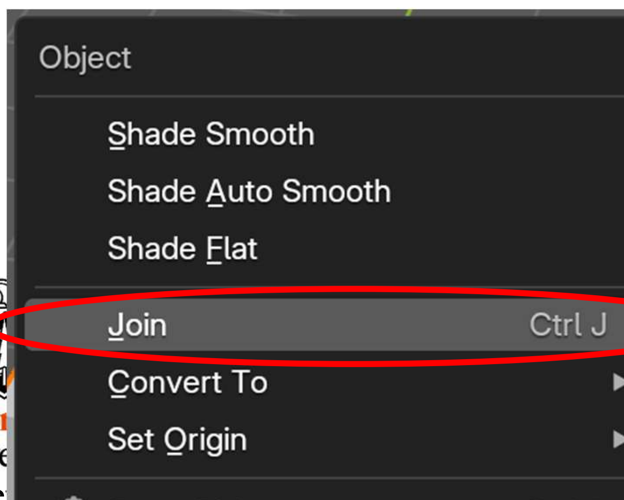


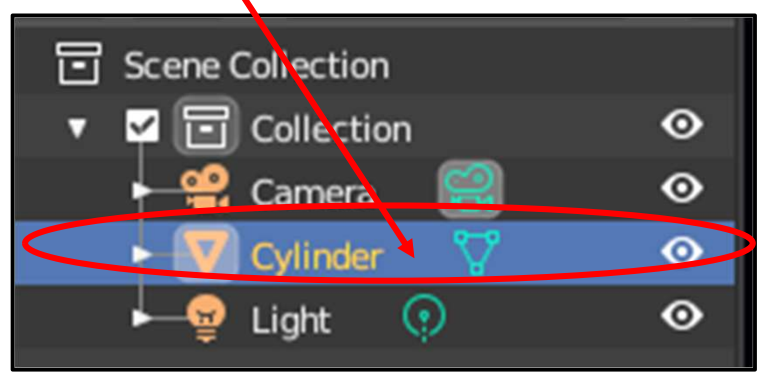
Intentionally Joining Two Objects

Easy! **LMB** on one, then **Shift-LMB** on the other, then hit **RMB** → **Join** (or **Control-'j'** on the keyboard). The orange "selection outline" now goes around both objects and the outliner shows just one object.



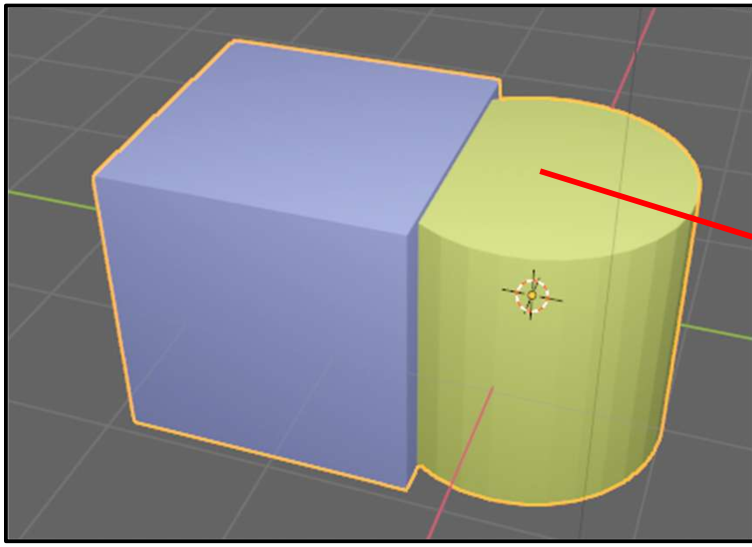


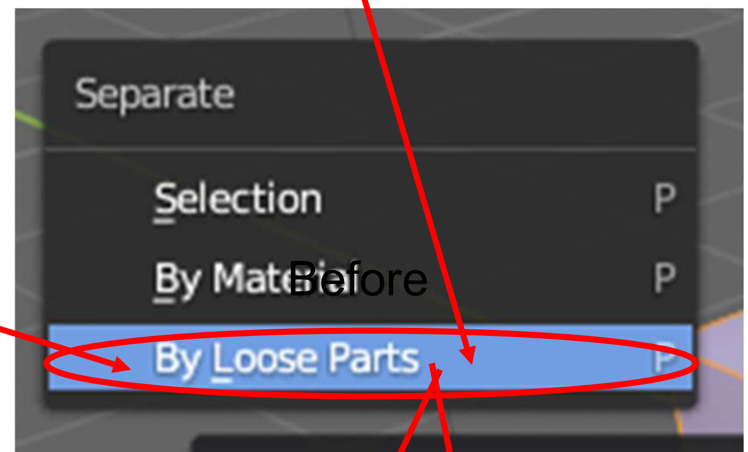




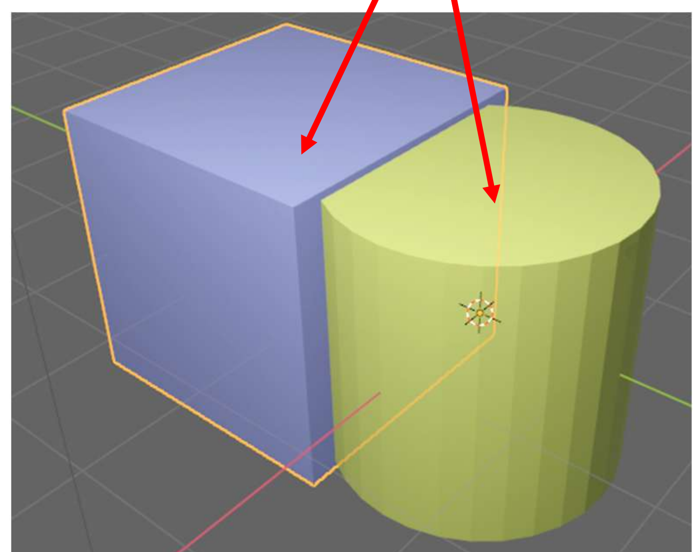
Separating Objects By Loose Parts

Select the Joined object. Tab over to **Edit Mode**. Then hit the **'p' key** ("Partition"). You will then have three options on how to partition the joined object. If you select **By Loose Parts**, then the Joined object will be partitioned based on the original primitives that made it up.



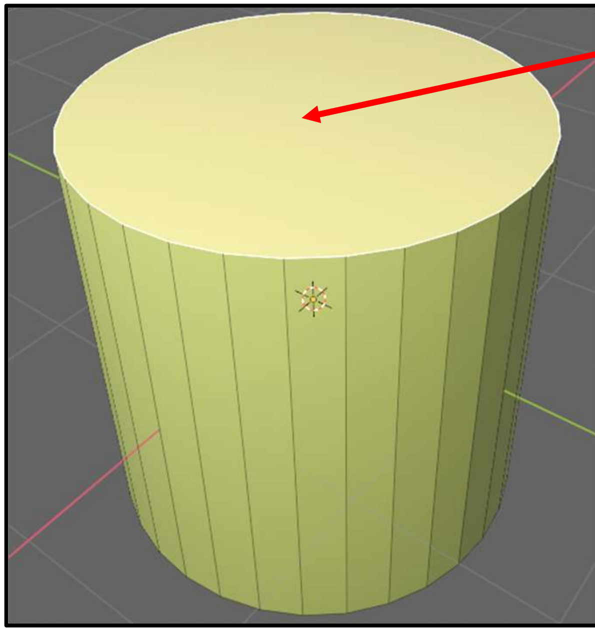


Before



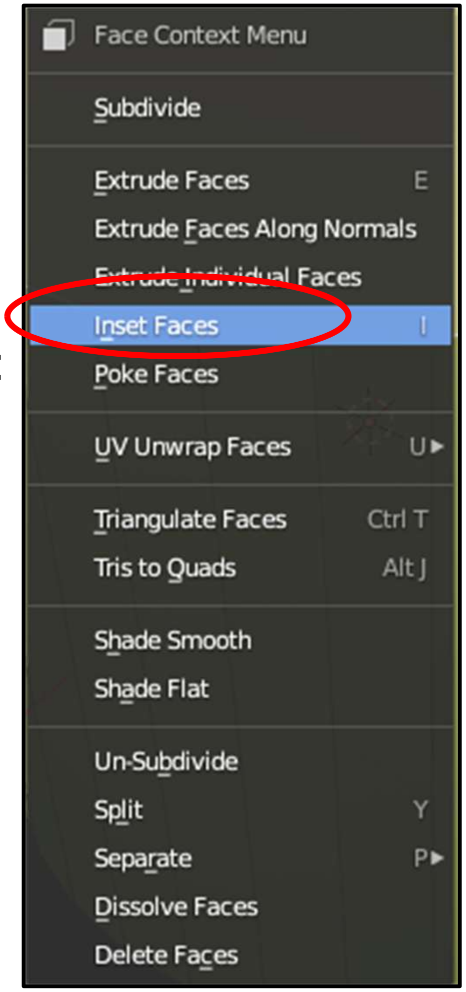
Inset Faces (aka, Offset Curves)

Often you want to create a "face-within-a-face". In Blender, this is called an **Inset Face**. (CAD systems often call this sort of thing an **Offset Curve**.)



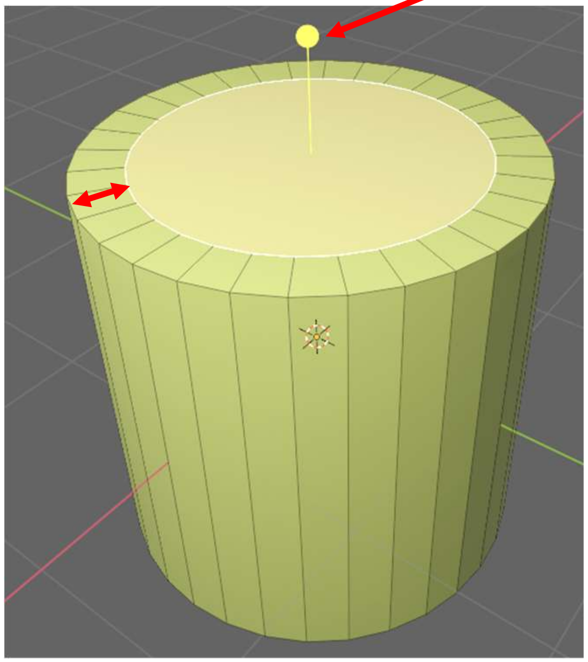
In **Edit Mode**, select the top face.

Then, either **RMB → Inset Faces**, or click on this icon on the left side:

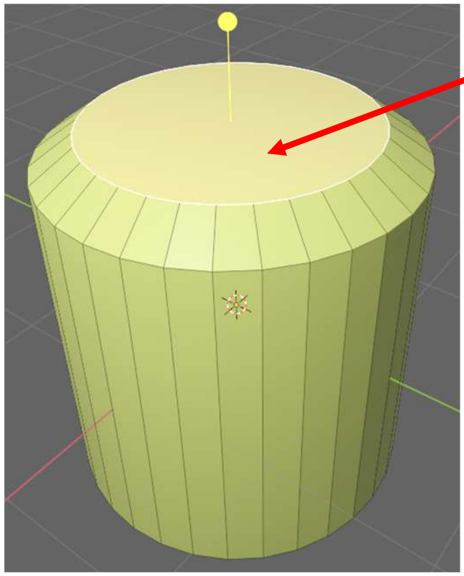


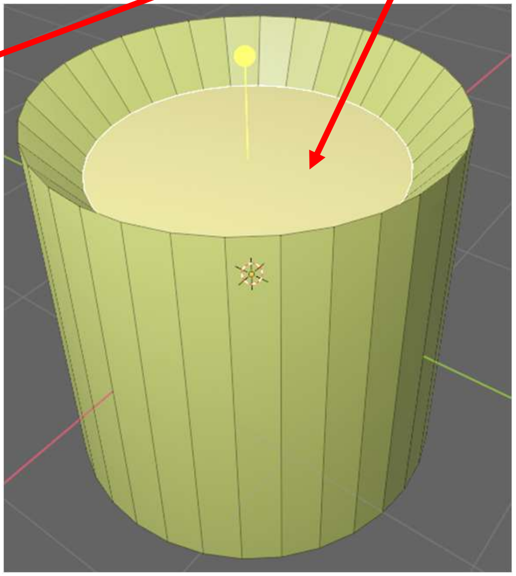
Inset Faces (aka, Offset Curves)

With the LMB, push the little handle down until the Inset Face is the size you want.



At this point, you can select the inner face and hit **g** and **z** (**g**rab in the **z** direction) to do this, or this.



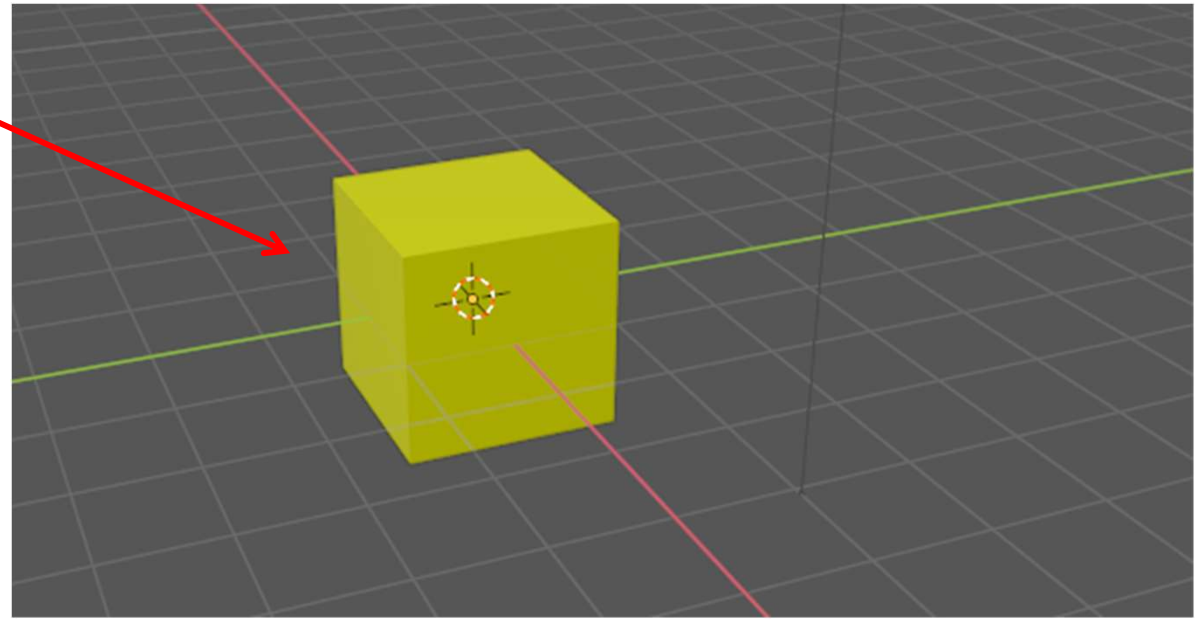


Try rotating or scaling the inner face.

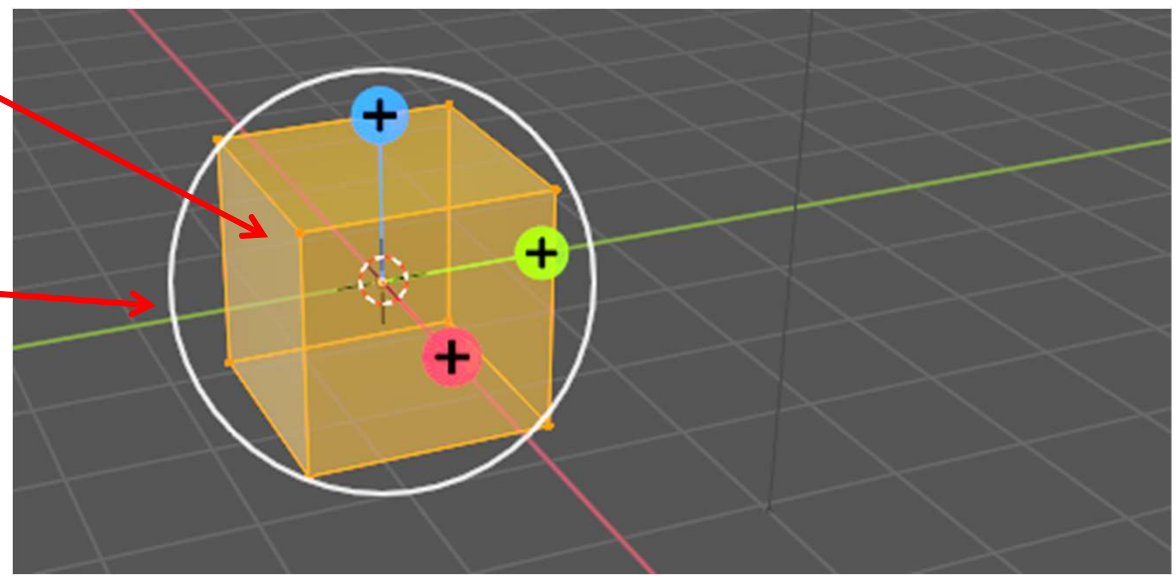
You can also create a new inset face inside the inset face you just created.

Extrude Tool

Start with a cube



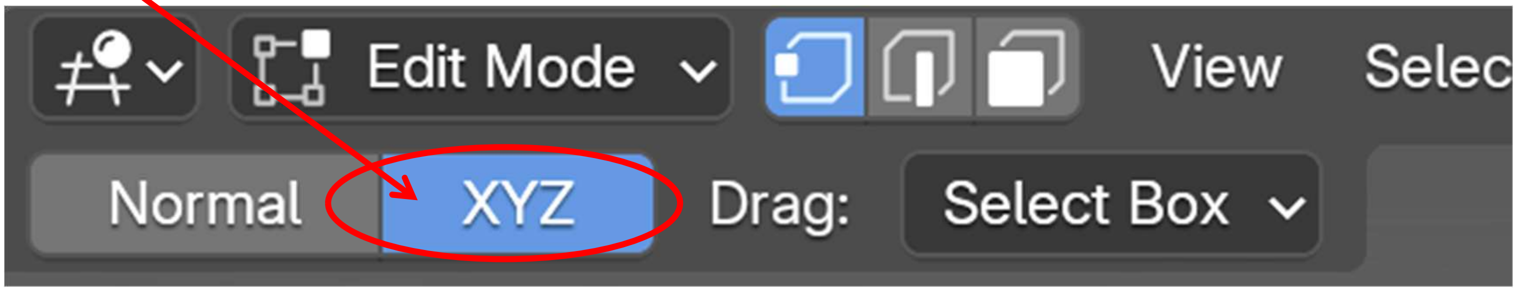
Select **X-ray mode** and select all the vertices



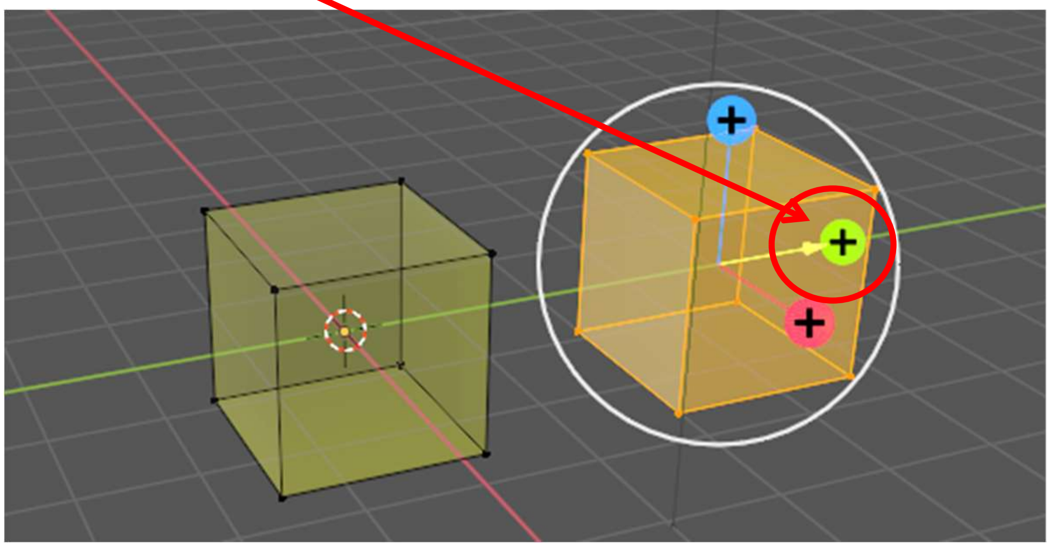
Tab into Edit Mode.
Click on the **Extrude Tool**

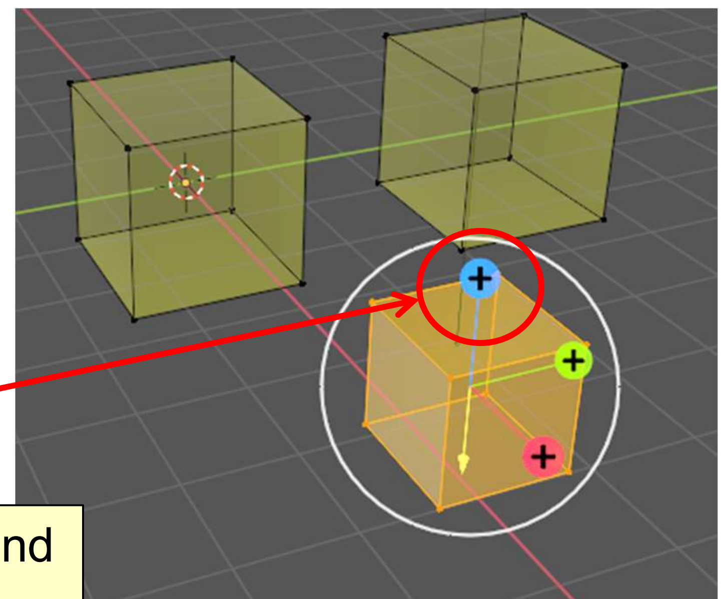
Extrude Tool

I like **XYZ mode** so that you can extrude in any direction



Grab one of the **+**’s and pull



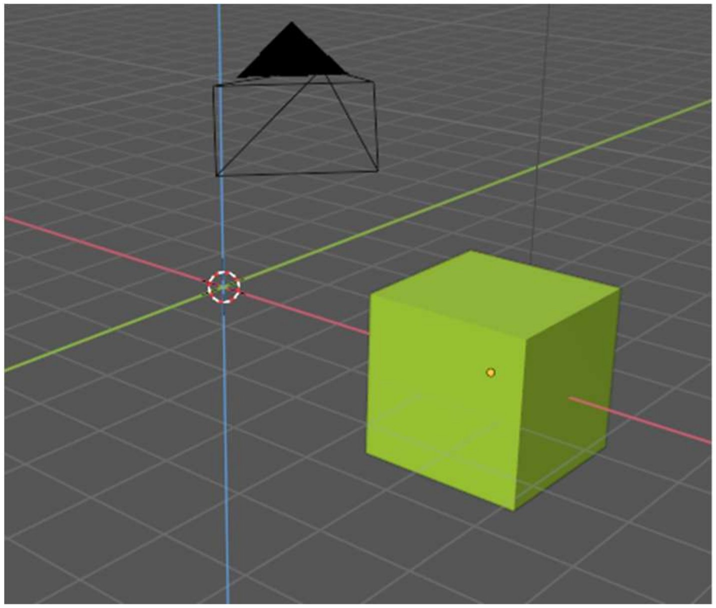


You can even keep doing it

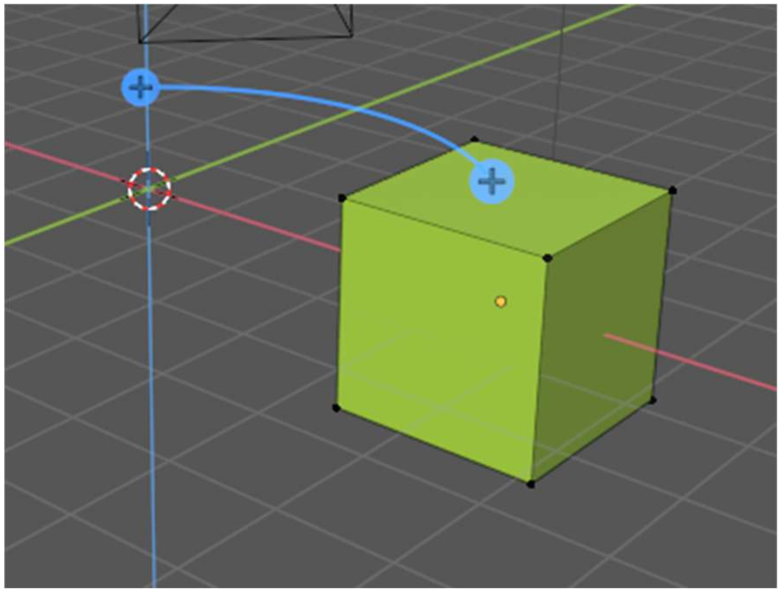
When you get back to Object Mode, you will find that all of these are part of the same object.

Spin Tool

Start with a cube translated along the x axis (**gx**)



Tab into **Edit Mode**.
Click on the **Spin Tool**



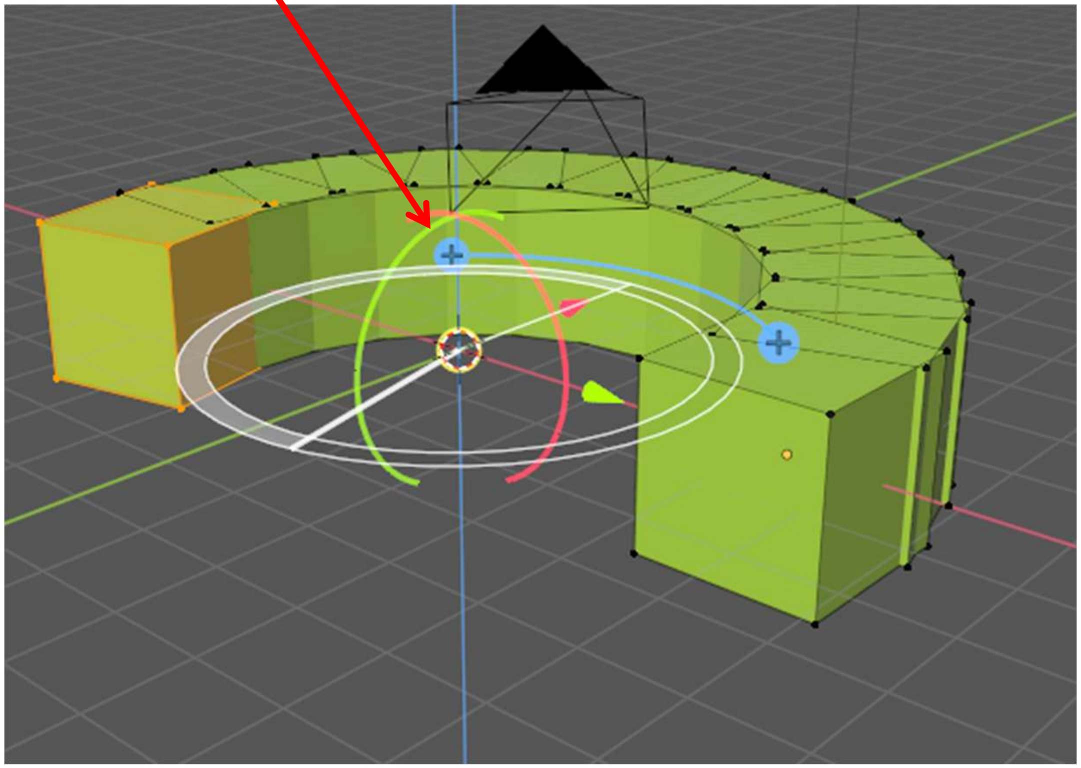
Spin Tool

Pick the number of duplicates to make

Pick the axis/axes about which to spin

Be sure all of the object's vertices are selected.

Grab one of the blue ✚'s and rotate

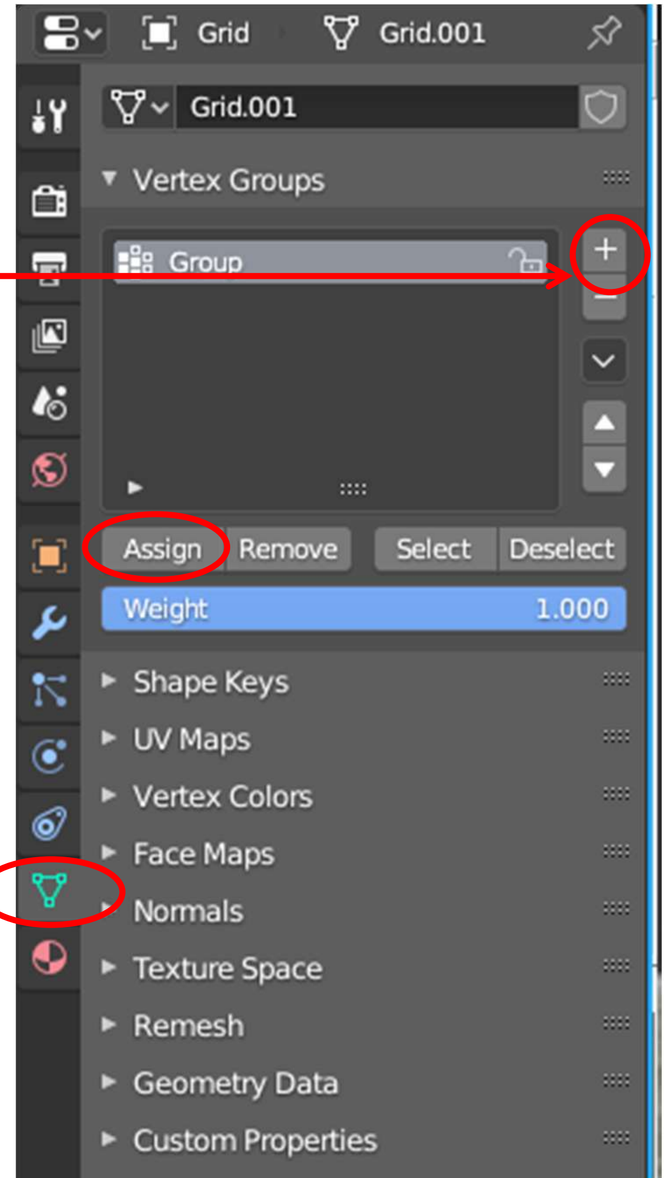


Vertex Groups

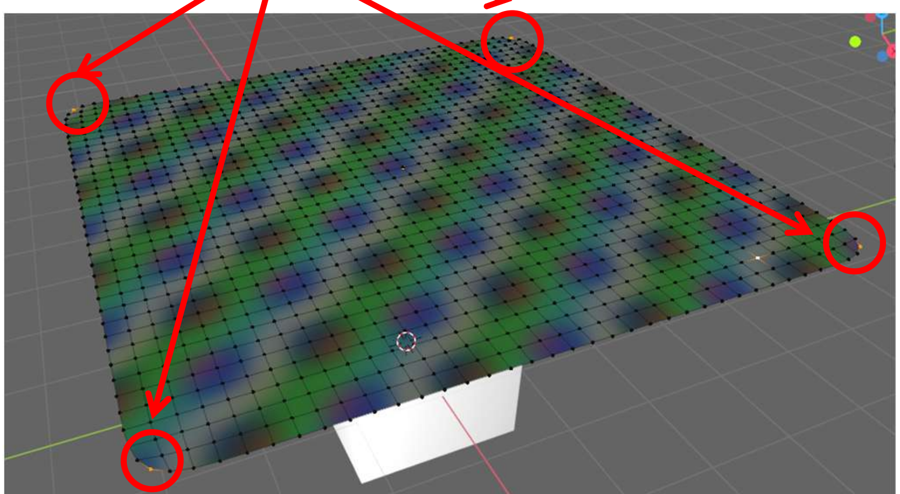
Using a group of vertices together is very useful. It is used for editing (like we are doing here), but also to pin certain vertices for cloth animation, to grow hair for hair simulation, and to rig objects for animation.

For that reason, Blender allows you to select the group and give them a name for later. This is called a **Vertex Group**.

3. Click the **+** to add this as a new Vertex Group

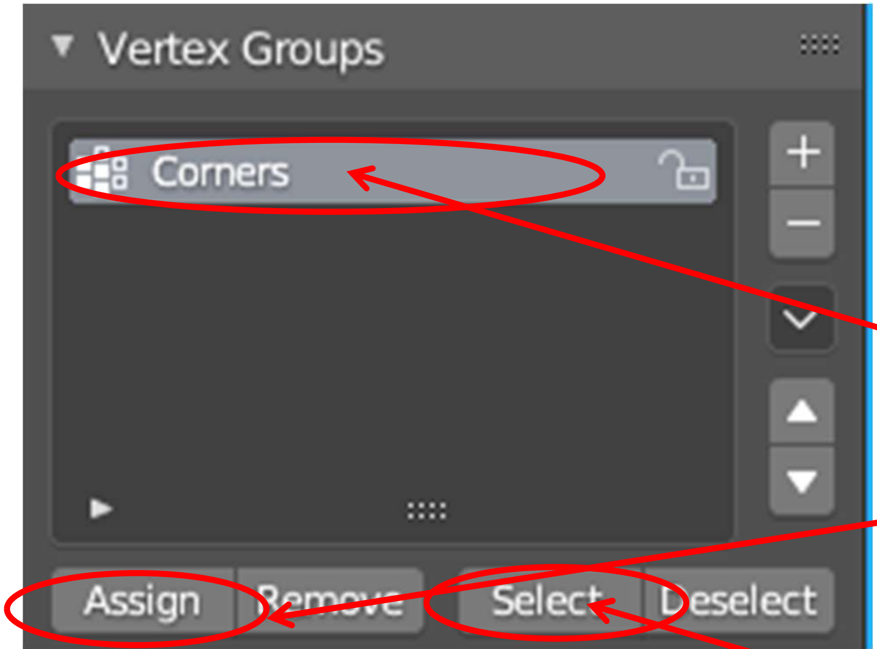


1. Select the vertices in Edit Mode (Shift-LMB)



2. Select the **Object Data Properties** button

Vertex Groups



4. Double-click on whatever the default name is ("Group" in this case) and type in a descriptive name for this Vertex Group

5. Click **Assign**

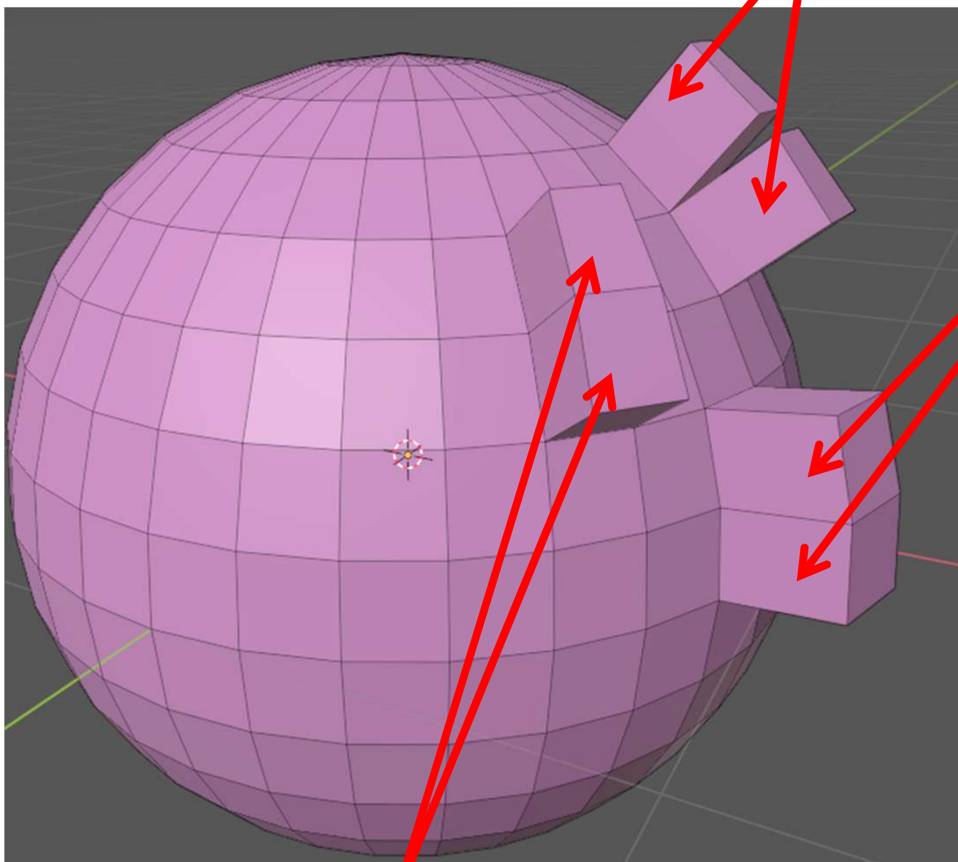
From now on, this group of vertices can be selected just by selecting the name from the list of Vertex Groups and clicking **Select**.

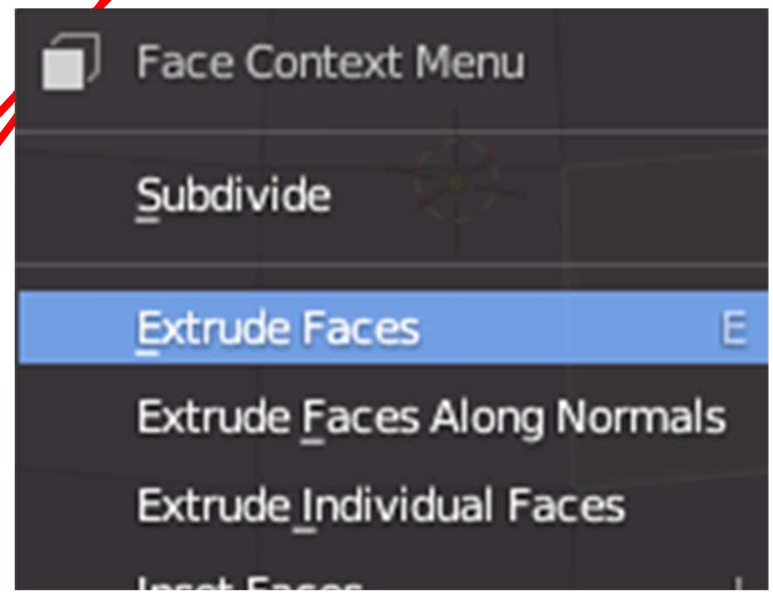
Extruding Faces – three ways

First, tab into **Edit Mode**. Then select one or more faces. Then right-click and select:

Extrude Individual Faces (cracks in between skyscrapers)

Extrude Faces Along Normals (push each face perpendicular to the surface)





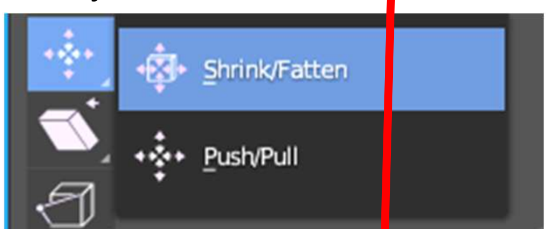
Extrude Faces (push each face along the group average perpendicular to the surface)

Face Select Mode

Shrink/Fatten and Push/Pull

Find this edit icon in the column on the left side of the screen. Click it with the LMB and leave the button down for a couple of seconds.

It will then expand into both of these commands, and you can pick the one you want:



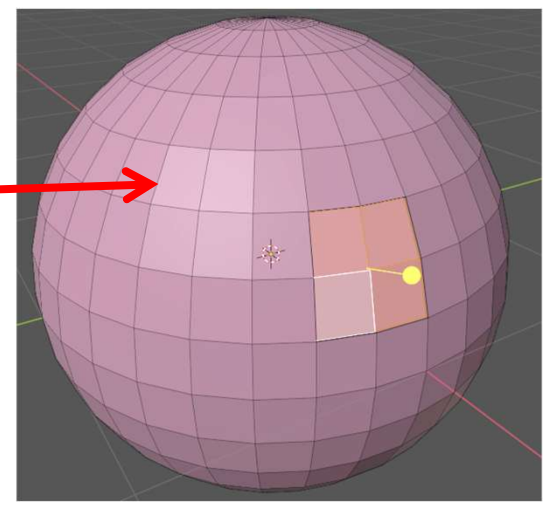
Shrink/Fatten and Push/Pull are very much like extruding faces. Here are the differences:

Extruding lifts the selected faces along their normals. It leaves behind a “cliff” that connects them to the surrounding faces.

Shrink/Fatten lifts the selected faces along their normals, but leaves behind a “ramp” connecting those faces to the surrounding ones.

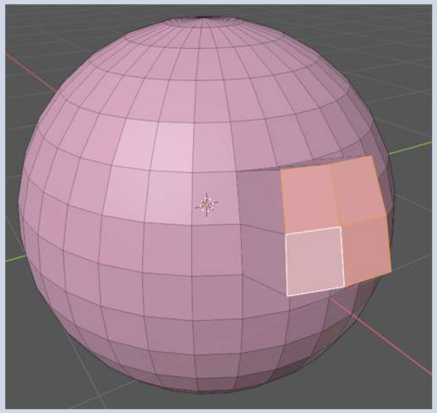
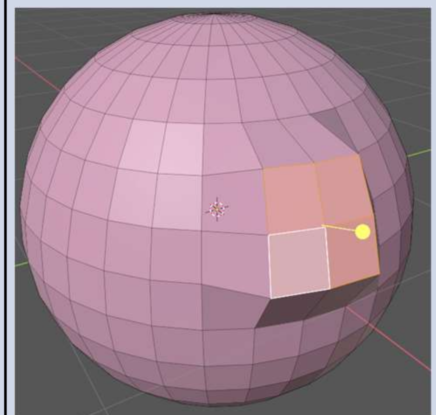
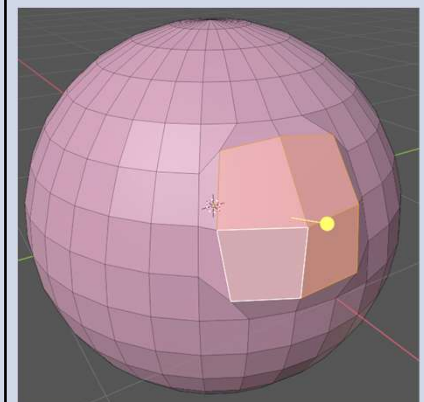
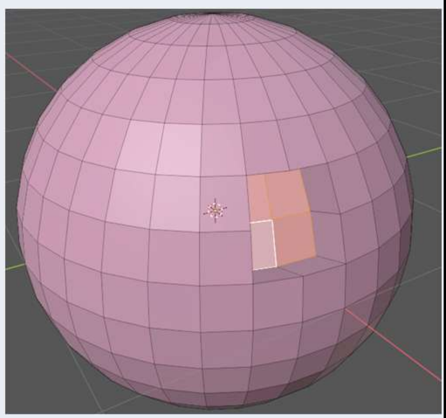
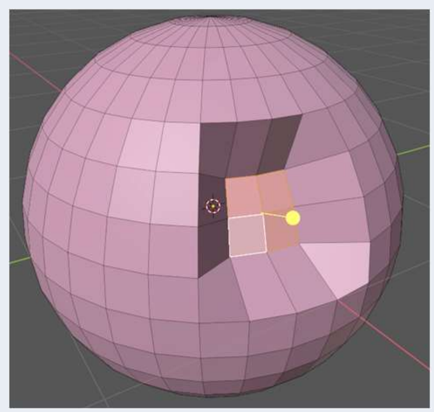
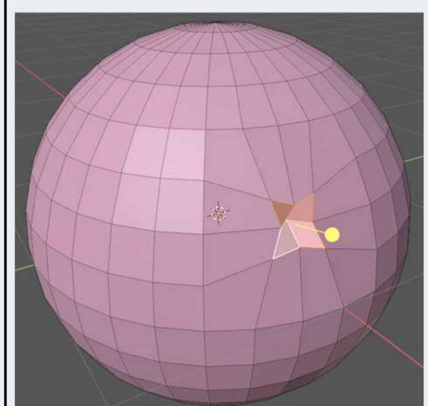
Push/Pull essentially scales the selected faces around their centroid.

For example, suppose we start with this object and these selected faces

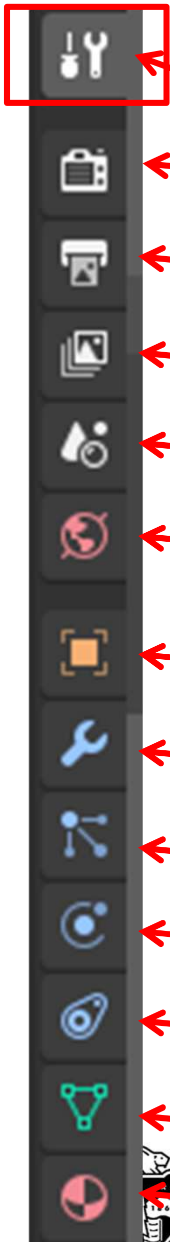


Every one of the edit-icons that has a little arrow in the lower-right corner expands in this same way. Check ‘em out!

Extrude, Shrink/Fatten, and Push/Pull

	Extrude	Shrink/Fatten	Push/Pull
Out			
In			

The Button Properties Menus, Again



Tells you that we are in the Button Properties Menu

Render Properties

Output Properties

View Layer Properties

Scene Properties

World Properties

Object Properties

Modifier Properties

Particle Properties

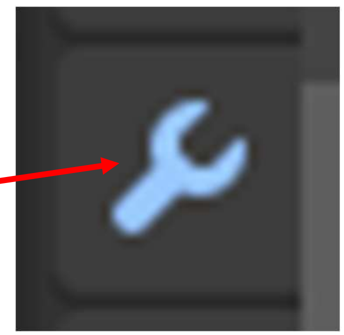
Physics Properties

Object Constraint Properties

Object Data Properties

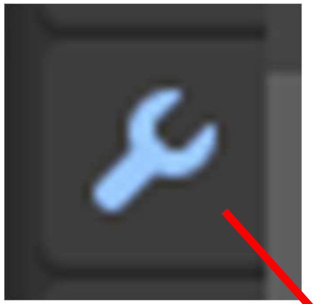
Material Properties (colors)

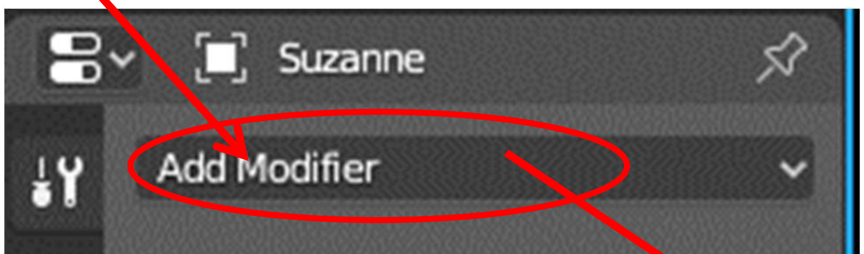
Clicking one of these brings up a much more detailed menu of options

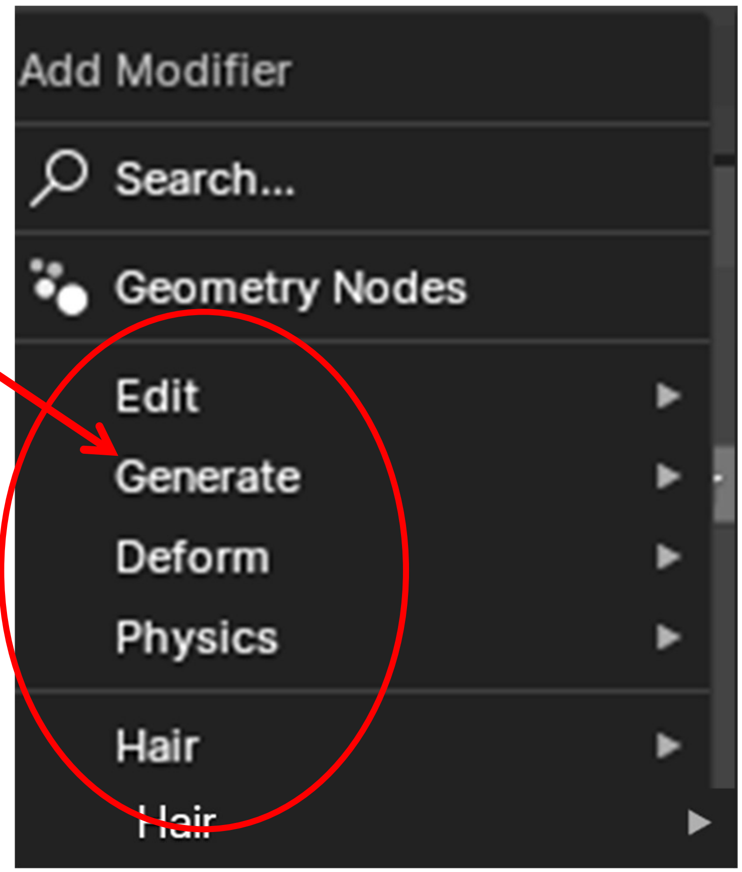


The Modifiers Menu

Modifiers don't actually change an object's *permanent geometry* – just the object's *appearance* on the screen. The geometry only gets permanently changed if you click the **Apply** button







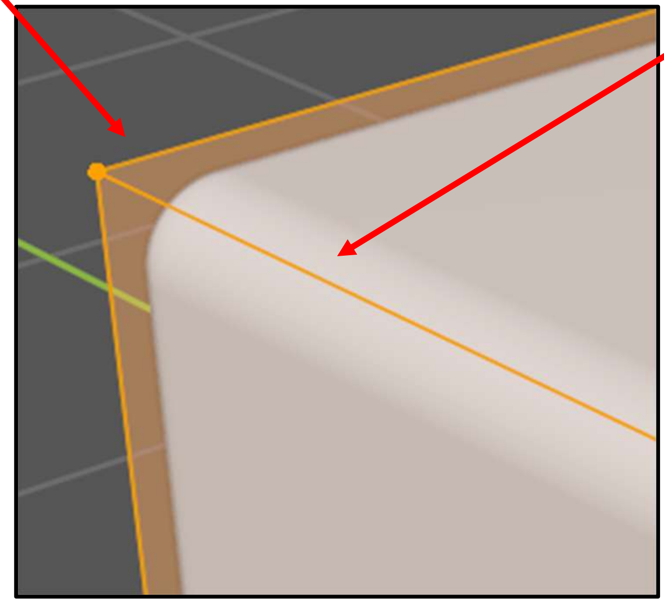
Blender Modifiers

Modifiers don’t actually change the object’s *permanent geometry* – just the object’s *appearance* on the screen.

You Create an Original Object

You Apply a Blender Modifier

You *See* a Modified Object on the Screen

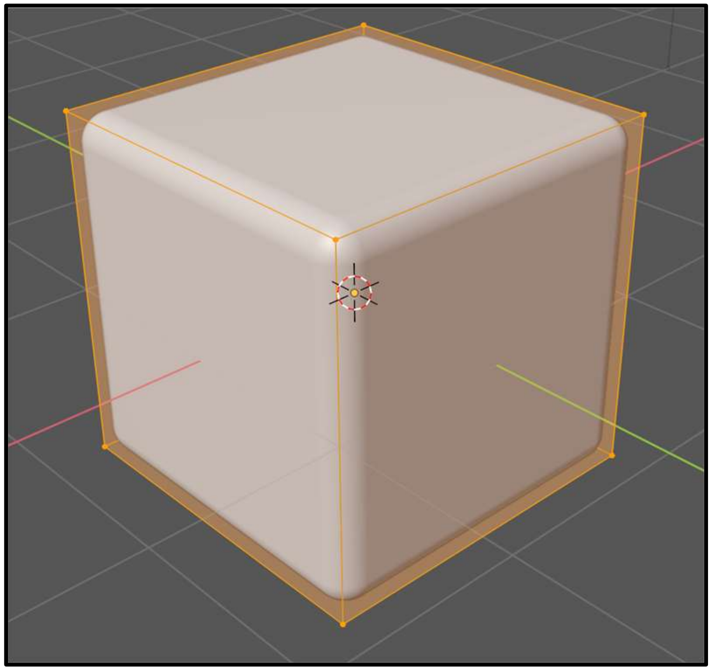


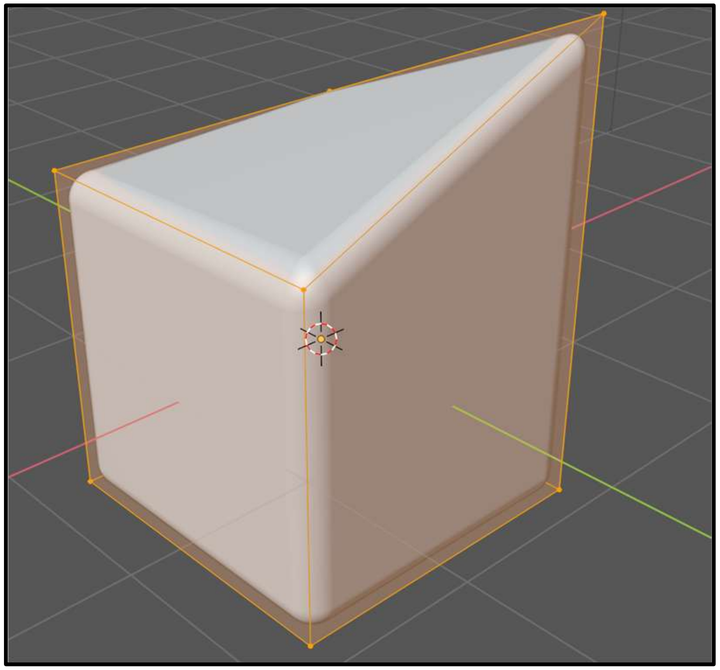
Cube with Bevel Modifier in Edit Mode

The Modifiers Menu

Modifiers don’t actually change the object’s *permanent geometry* – just the object’s *appearance* on the screen.

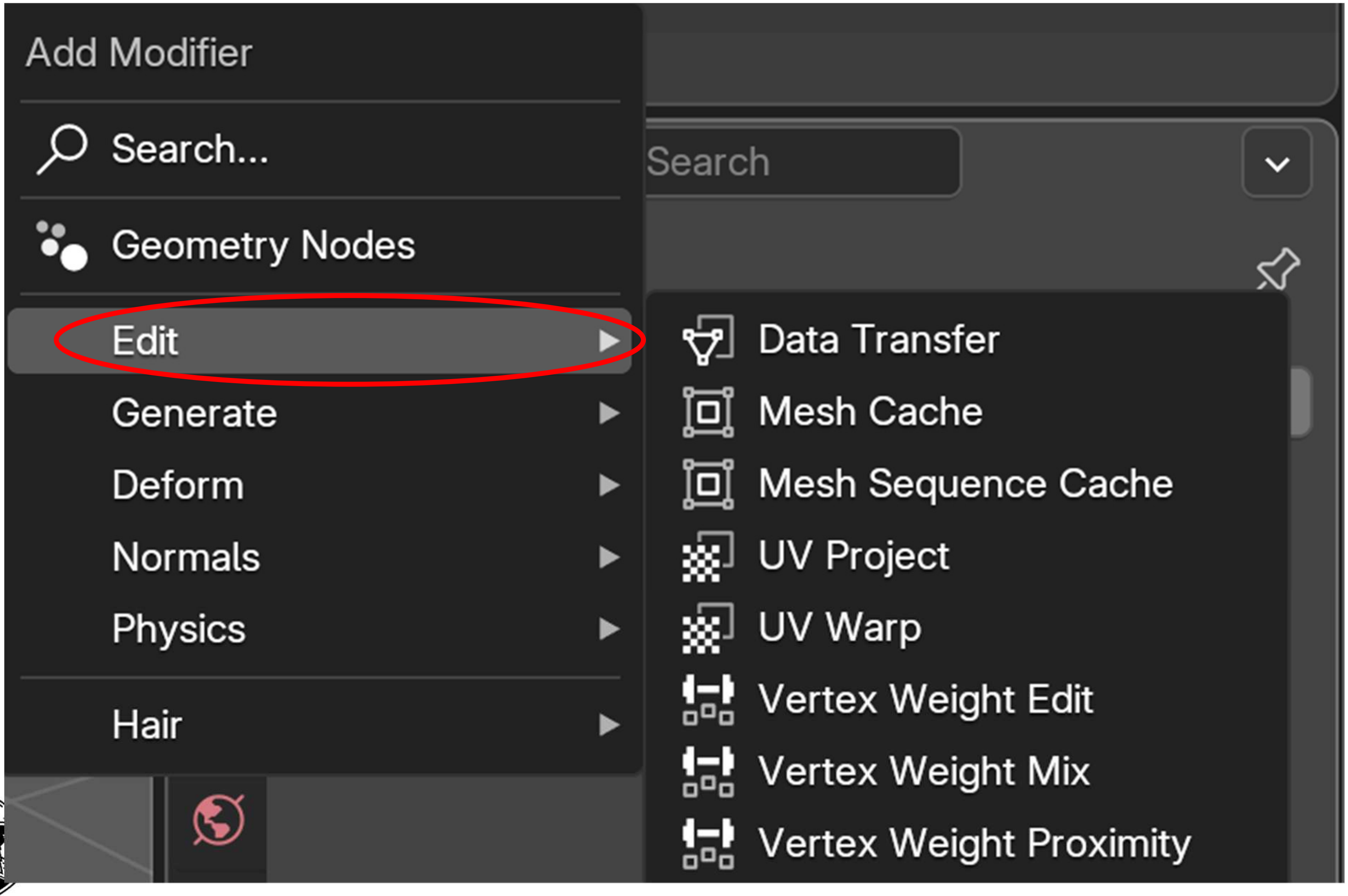
Example: Here a cube has been beveled (one of the Modifiers). In **Edit Mode** you can see both the beveled cube and the original cube. You can edit the vertices and the new shape will get beveled as you edit.



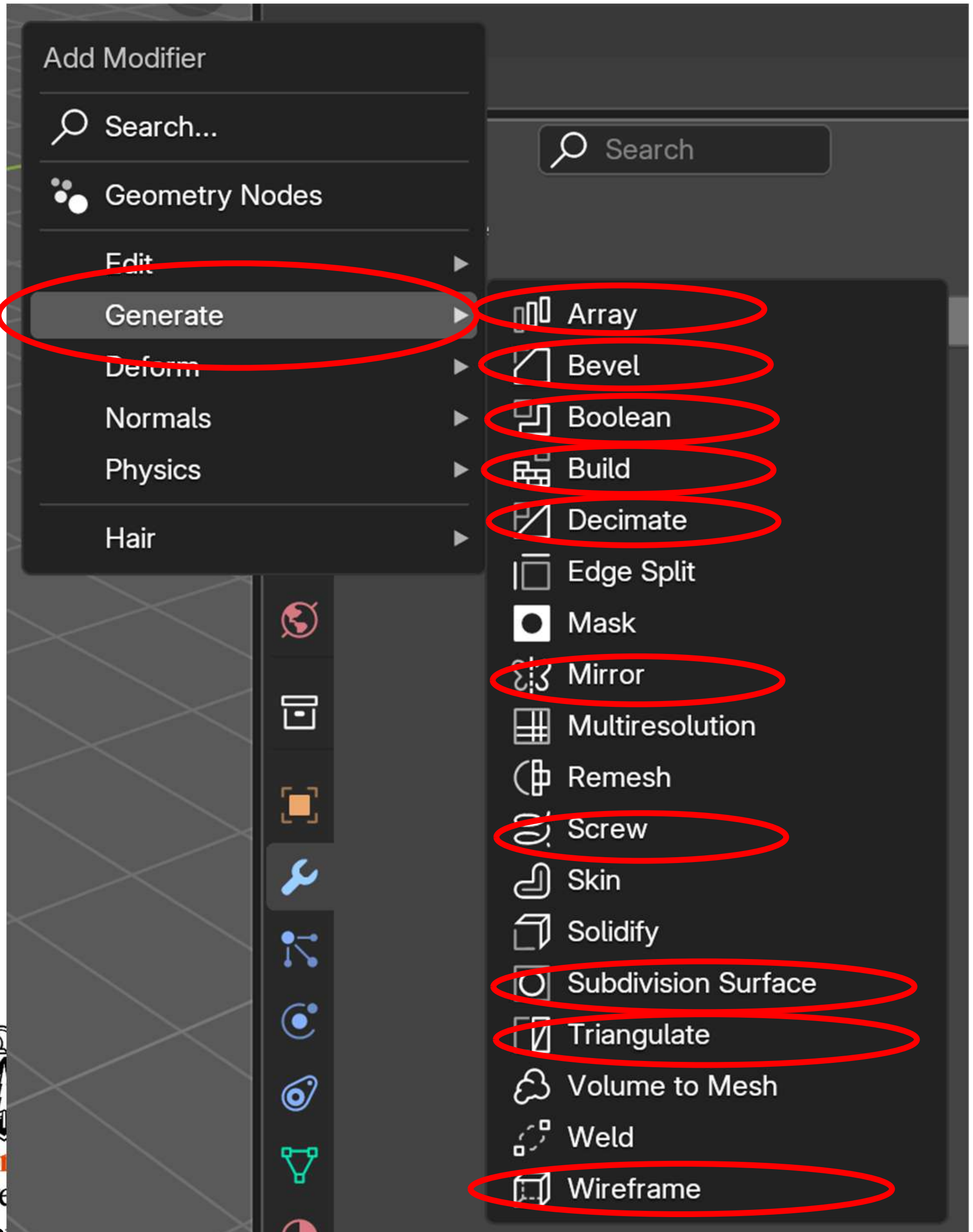


You can eventually **Apply** the Modifier so its geometry becomes permanent, but I recommend you hold off on this as long as possible.

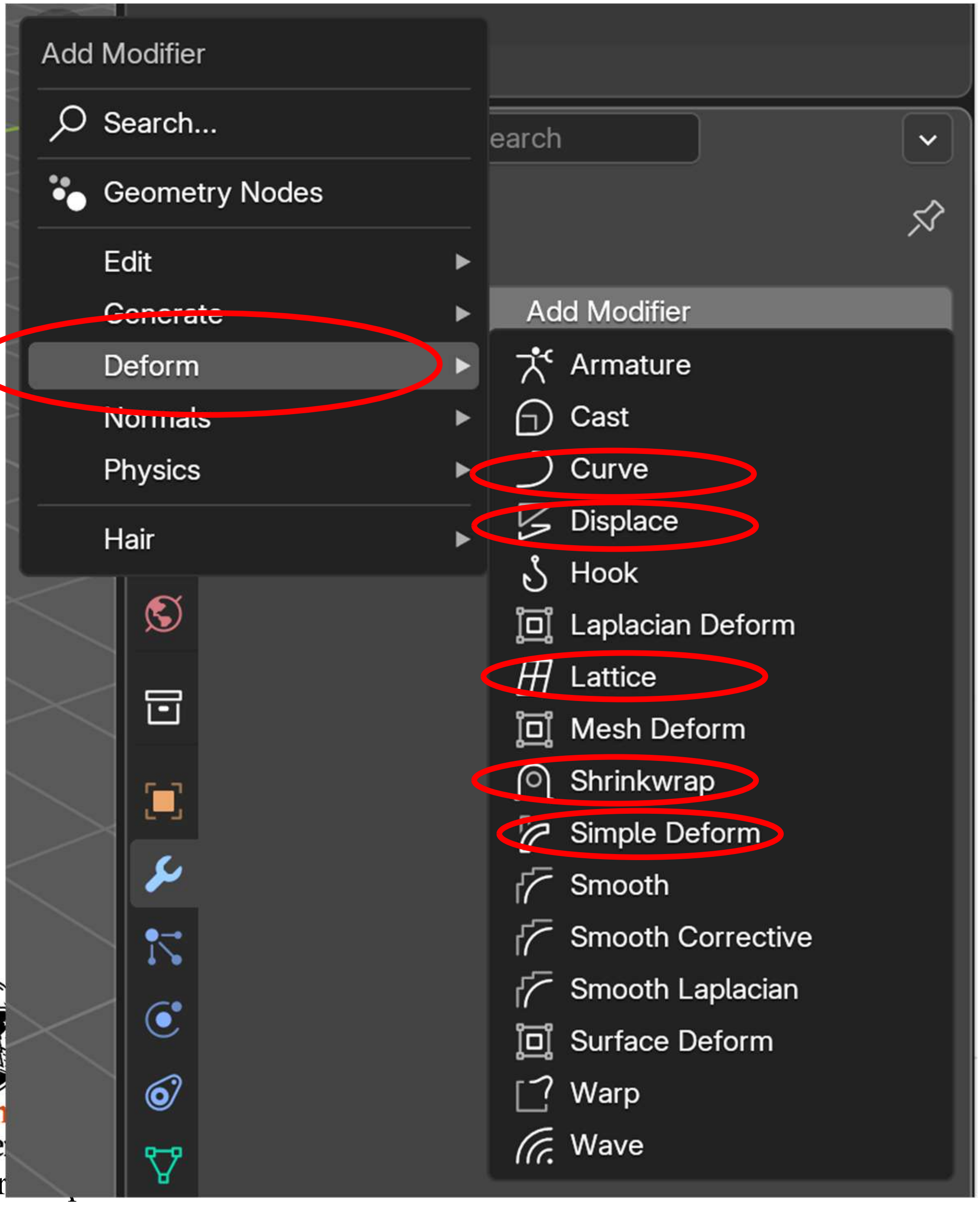
The *Edit* Modifiers



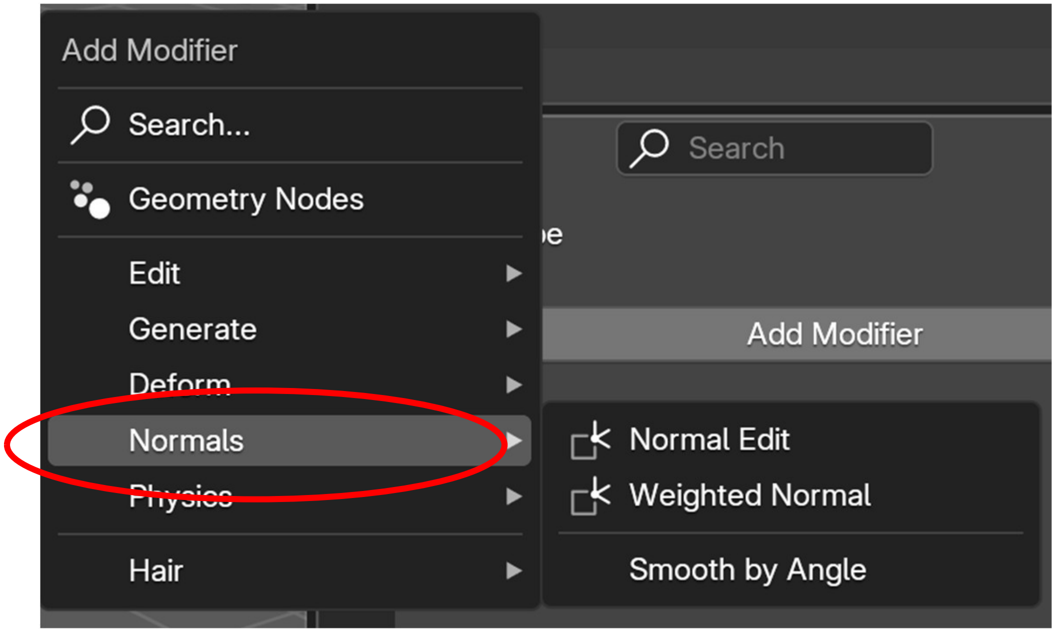
The *Generate* Modifiers



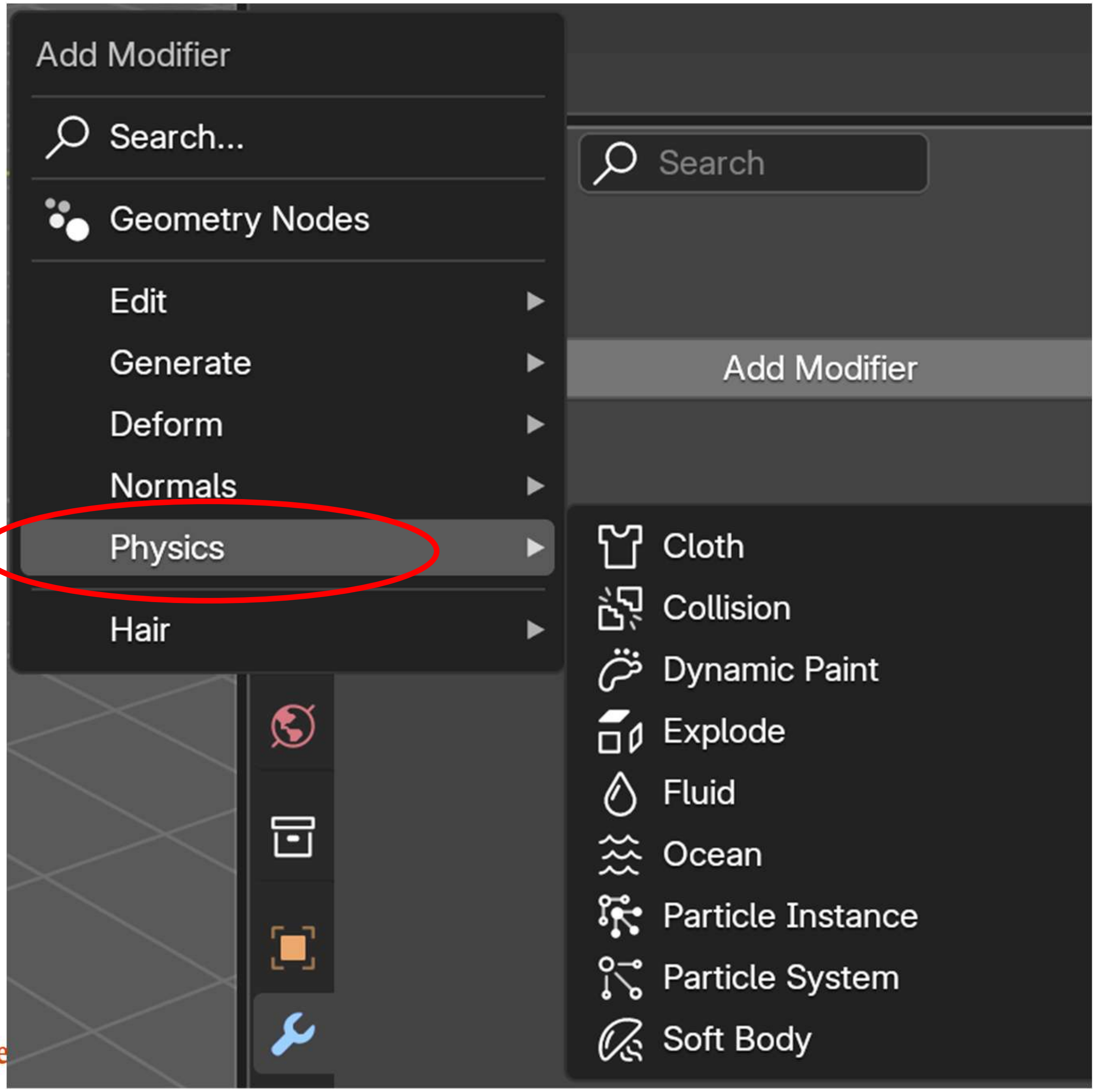
The *Deform* Modifiers



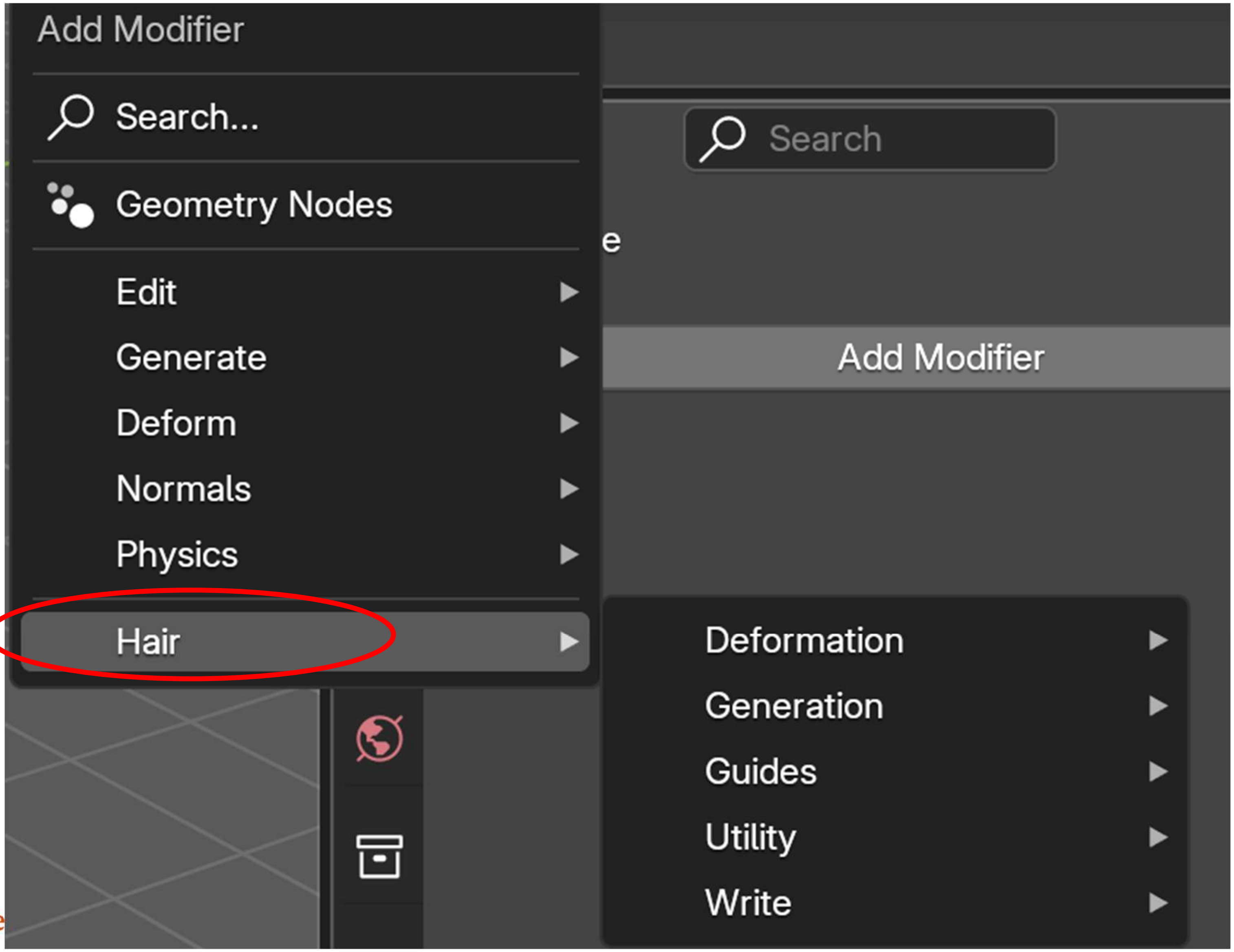
The *Normals* Modifiers



The *Physics* Modifiers

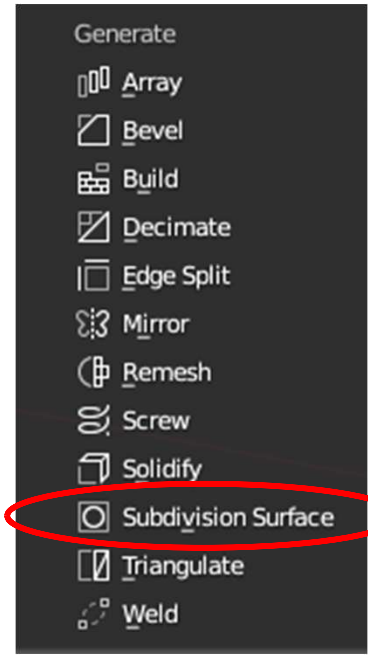


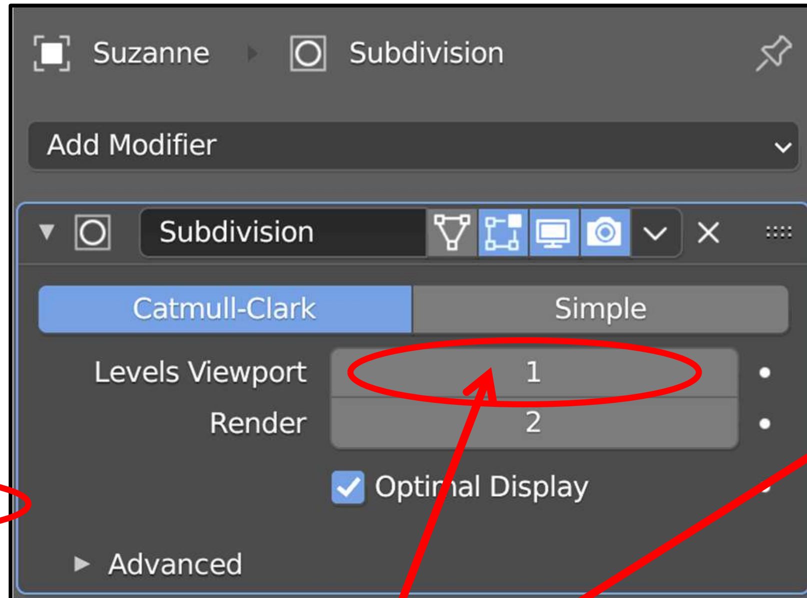
The *Hair* Modifiers

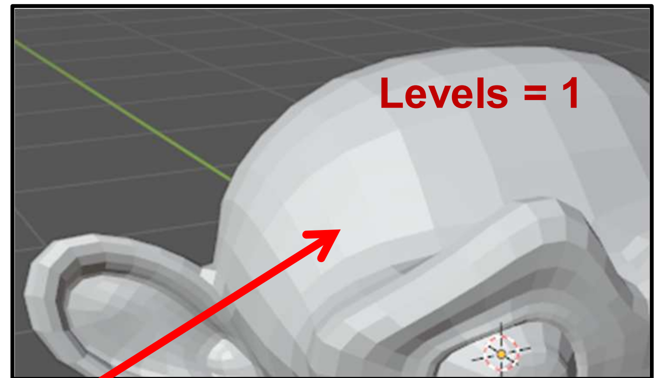


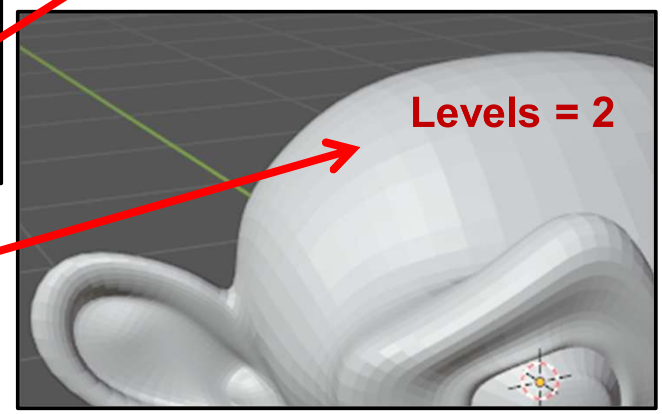
My Favorite Modifier -- Subdivision Surface

This modifier increases the number of polygons in your object. At the same time, it smooths your object out. Be careful! It very quickly increases your polygon count.









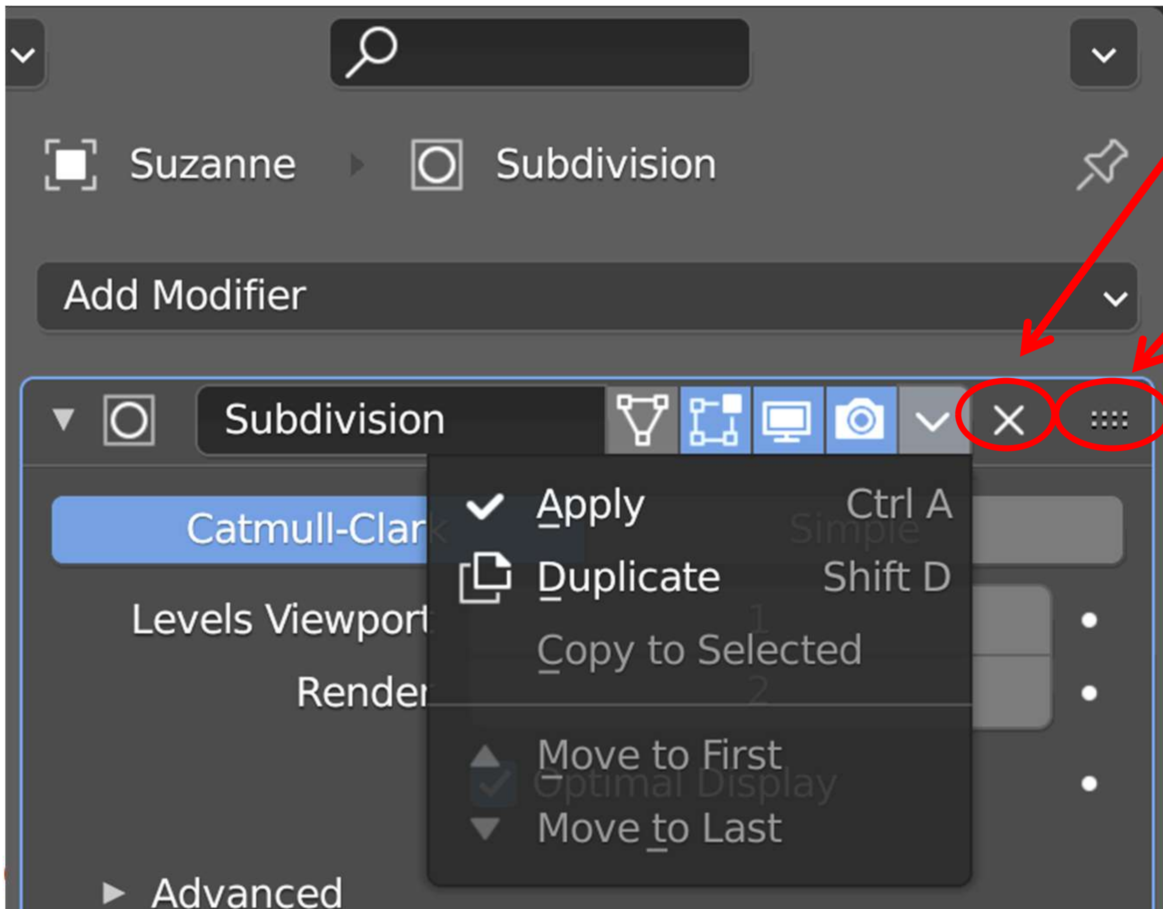
This controls how much to subdivide.
Here we've changed this value from 1 to 2

Fun: try it on a cube!

Deleting and Moving Modifiers

Oftentimes you have a list of several Modifiers that are used with a single object. The Modifiers take effect in the order that they are in the list. To change this, you can:

- Delete a Modifier
- Move a Modifier elsewhere in the list and thus change how it modifies the object

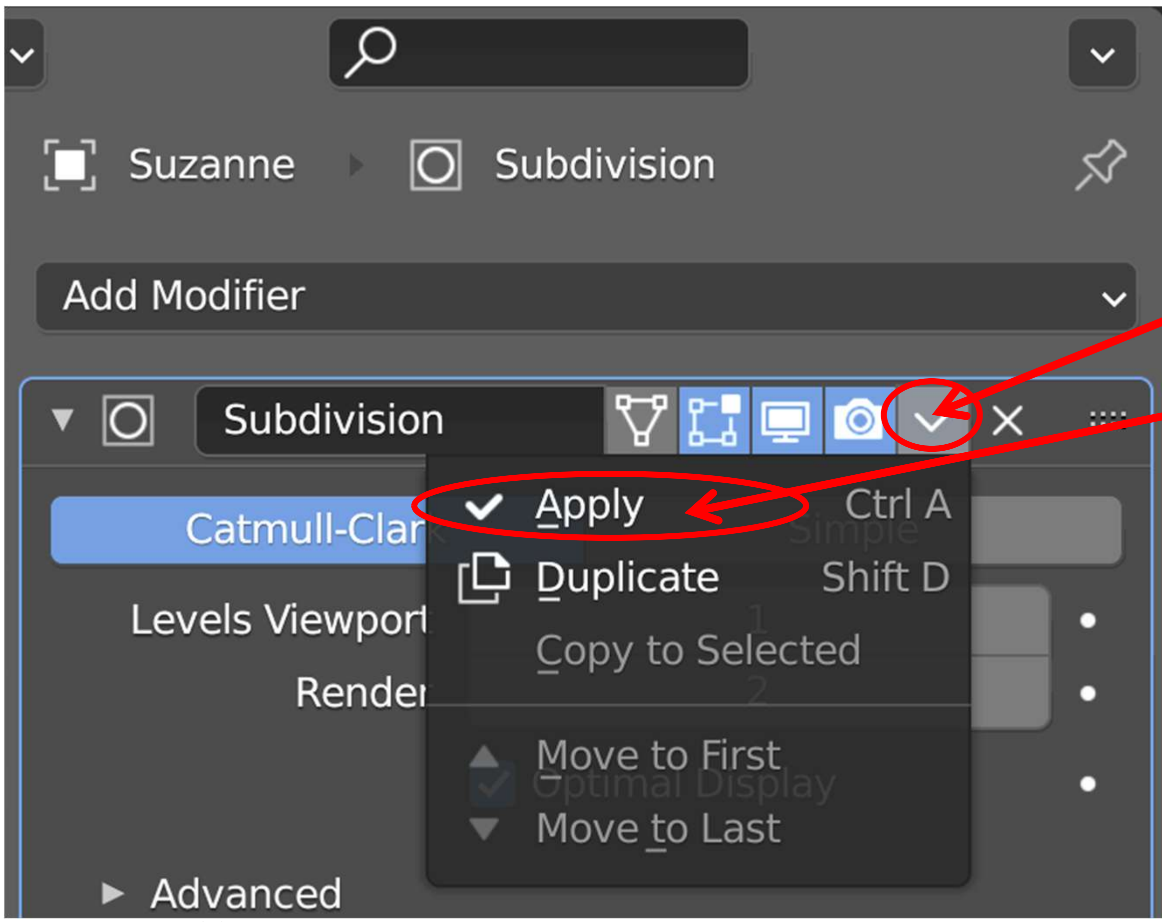


Delete this Modifier

Move this Modifier elsewhere in the list of Modifiers

Making Your Modifier Effect Permanent

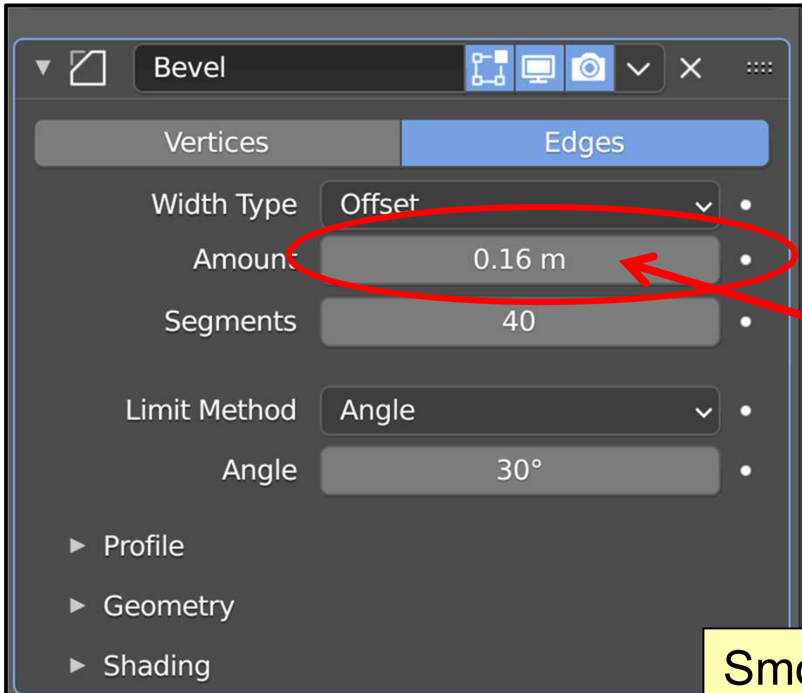
Despite the name, Modifiers do not actually modify the object's underlying coordinates. They create an "alternate representation" that you can see. Most of the time, this is good. It lets you edit the underlying coordinates and have the Modifier then use them. If you want the Modifier to change the object's underlying coordinates *permanently*, bring up this sub-menu and click on **Apply**.



Click here

To bring up this menu.
Then click on **Apply**.

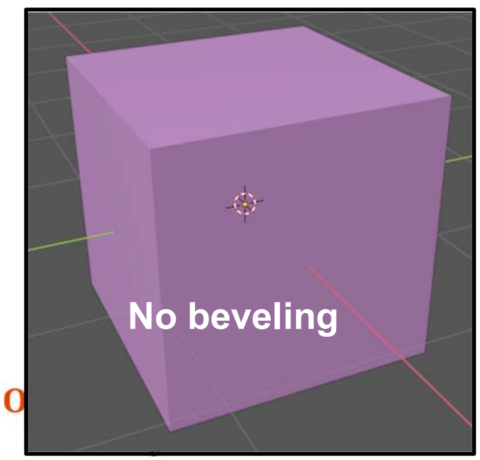
Bevel Modifier

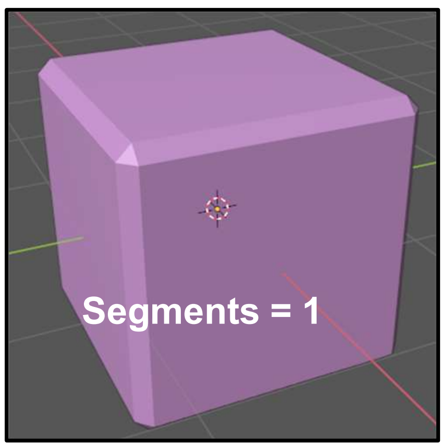


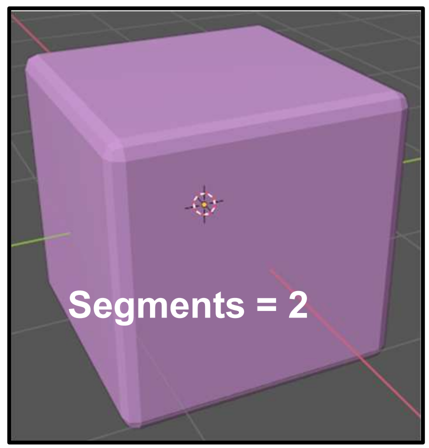
Beveling causes edges to be rounded instead of sharp

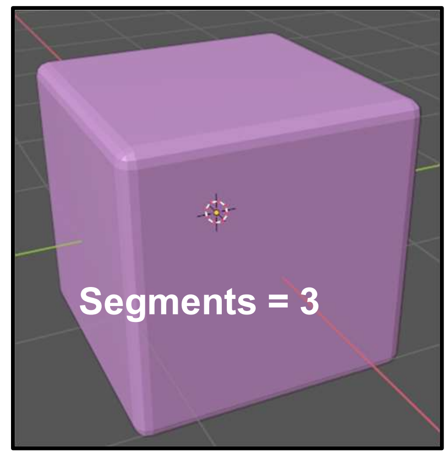
How much to bevel

Smooth shading makes bevels look much better!

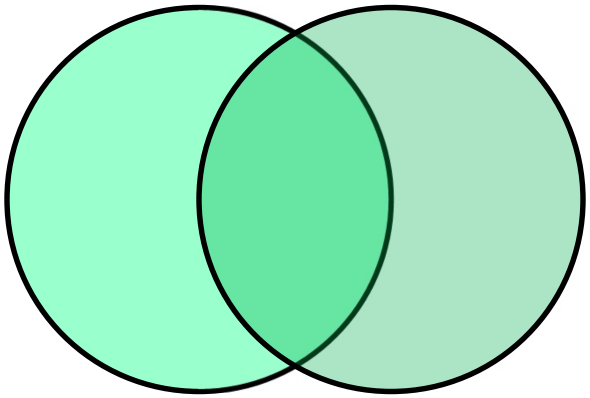




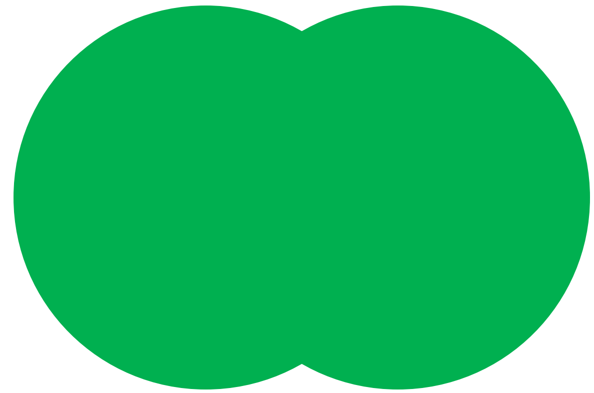




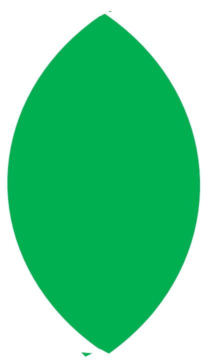
Remember Venn Diagrams (Boolean Operators)?



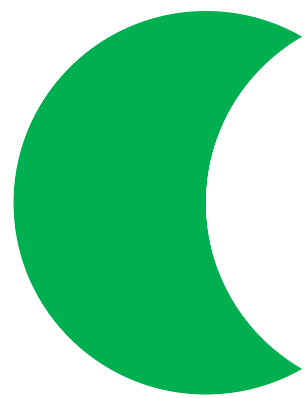
Two Overlapping Shapes



Union



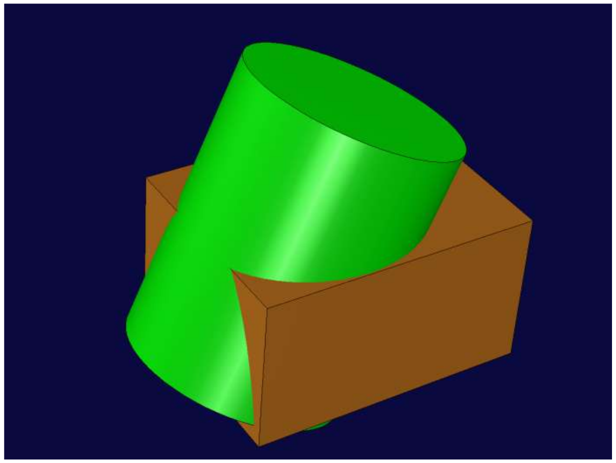
Intersection



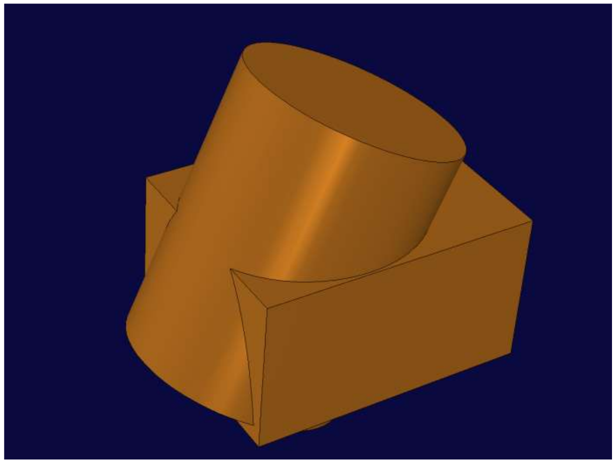
Difference

Booleans (also known as Constructive Solid Geometry)

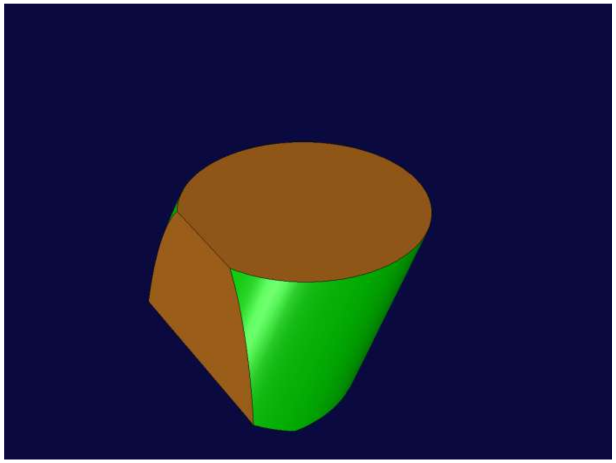
Think of them as Venn diagrams in 3D!



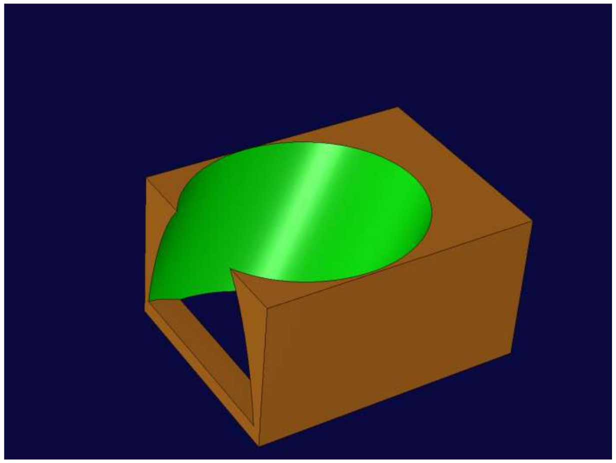
Two Overlapping Solids



Union



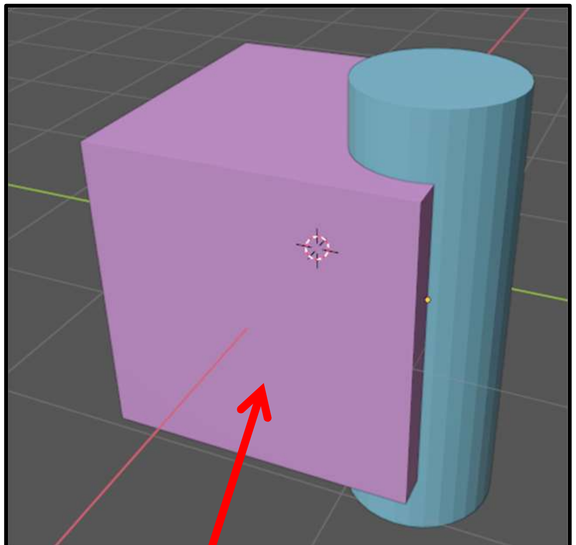
Intersection

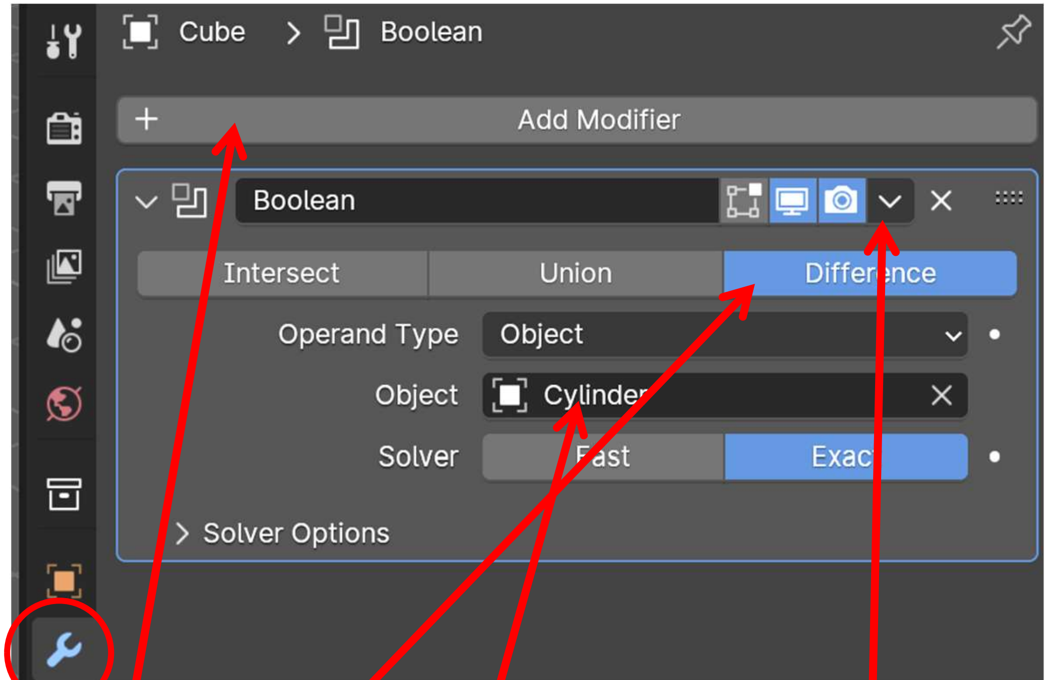


Difference

Boolean Modifier

"Block minus Cylinder"

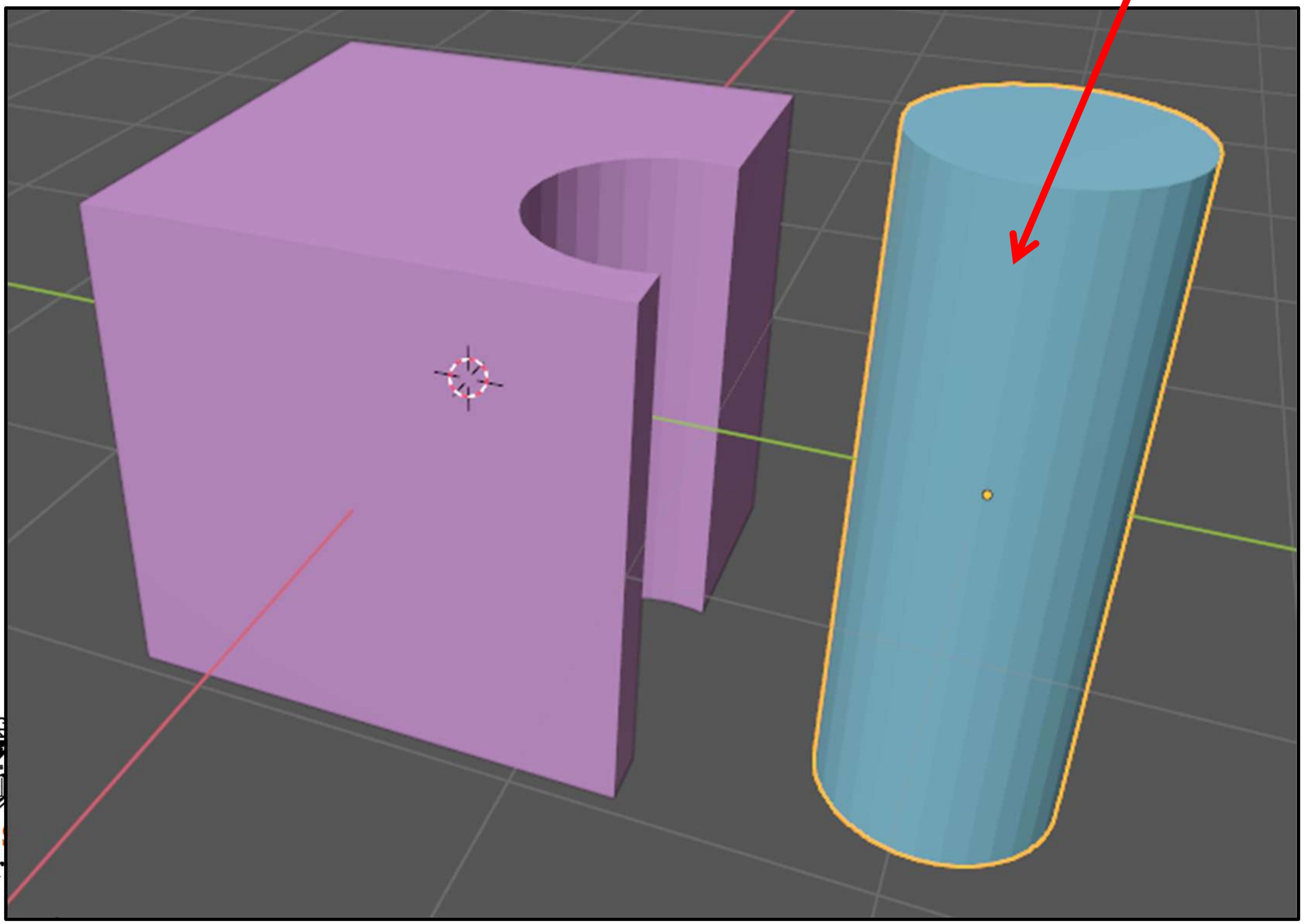




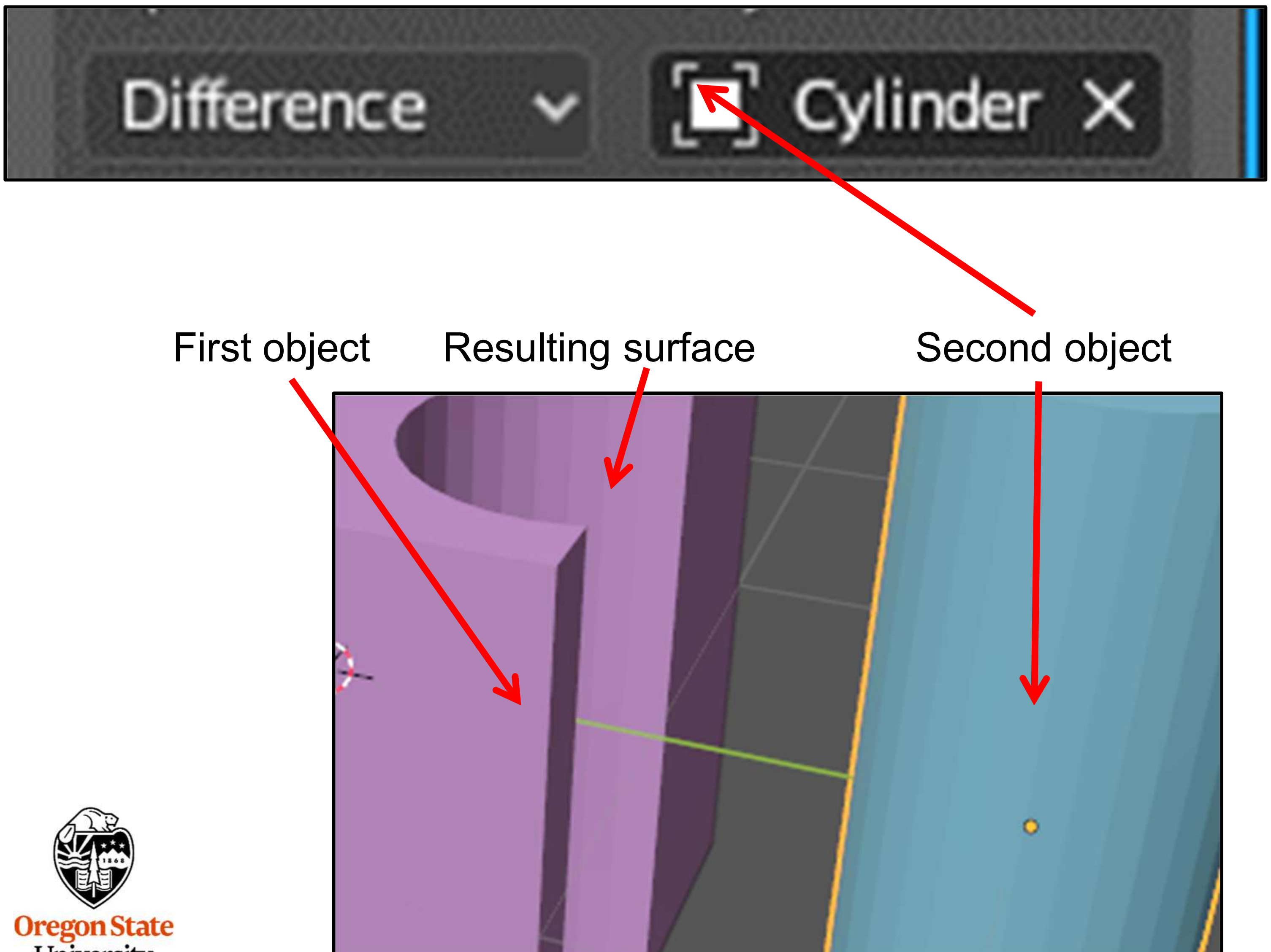
1. Select the cube
2. Click on **Modifiers**
3. Click on **Add Modifier→Generate →Boolean**
4. Specify the **Difference** Operator
5. Specify the **Cylinder** as what to the difference with
6. Click **Apply**

Boolean Modifier

Select the cylinder, hit it **g** (grab) and slide the cylinder away

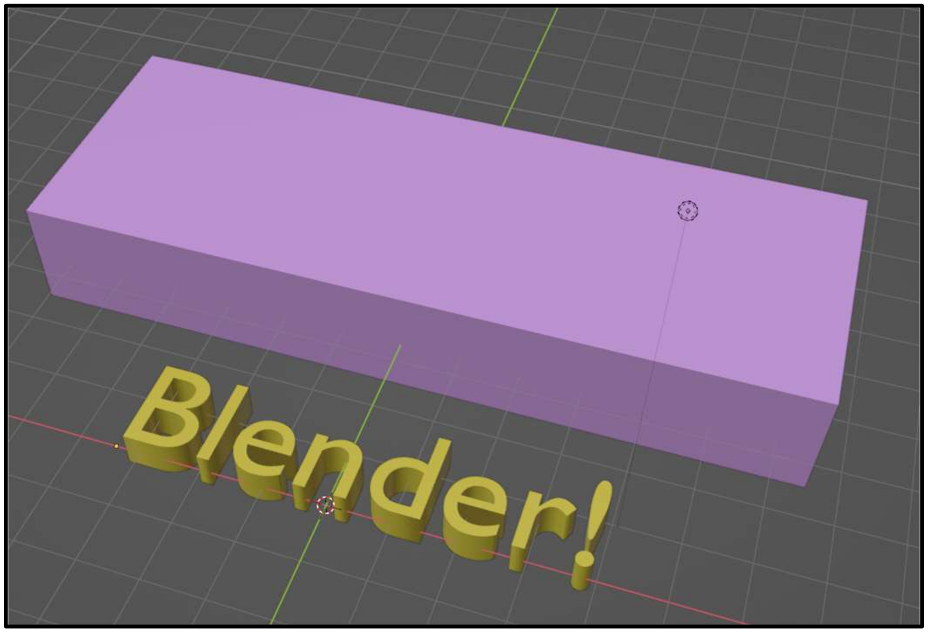


The Resolution of the Second Object Determines the Resolution of the Resulting Surface

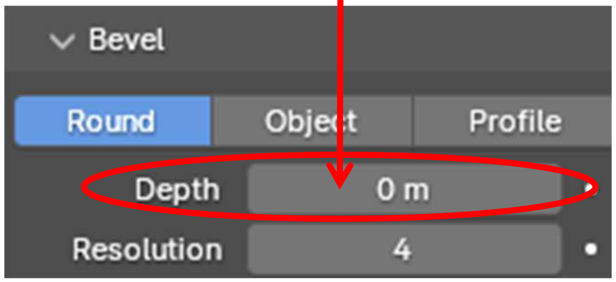


Remember 3D Text? One Fun Thing to do with Booleans is to Attach Text to a Block

Start with a block and the text:

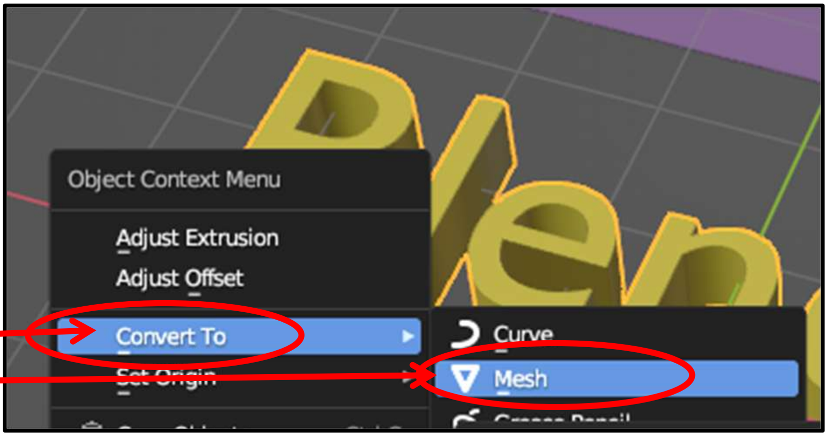


Warning: if you want to use text with Booleans, do not Bevel the text. That is, leave the Bevel→Depth setting equal to 0.



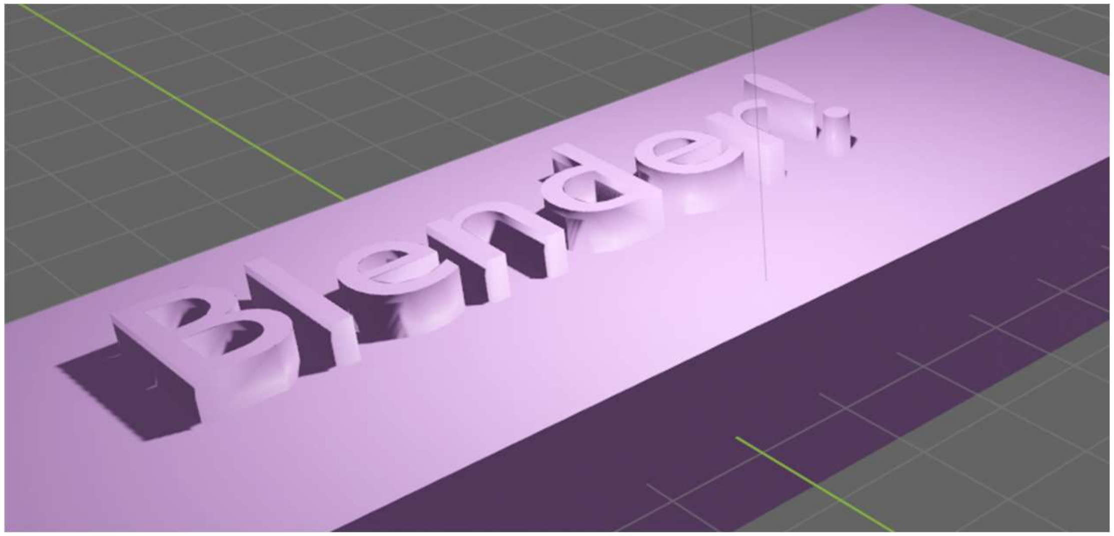
You cannot directly Boolean with text, so you must first convert the text to a mesh:

RMB → Convert To → Mesh

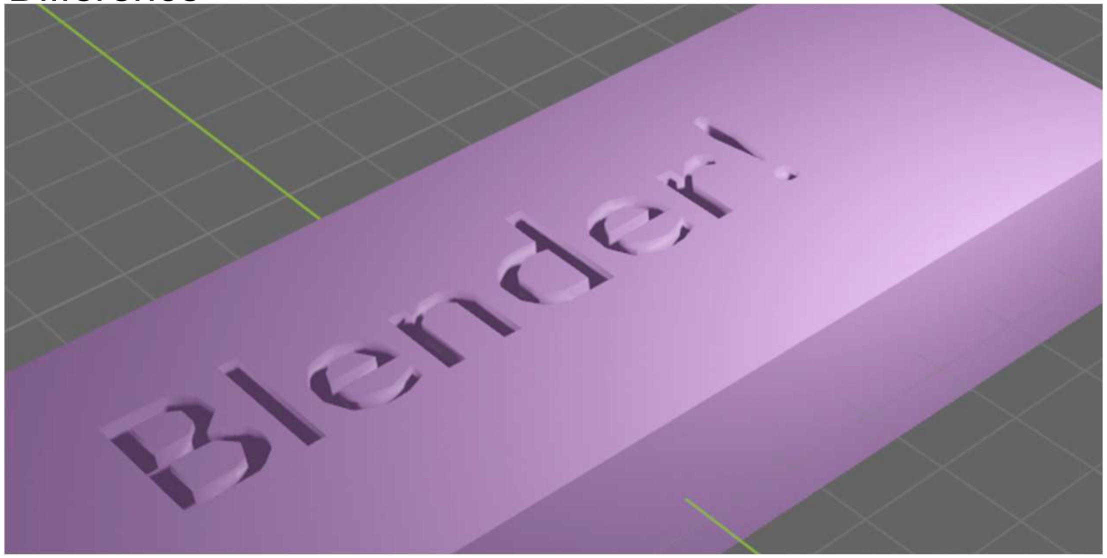


Now Boolean the Text with the Block

Union



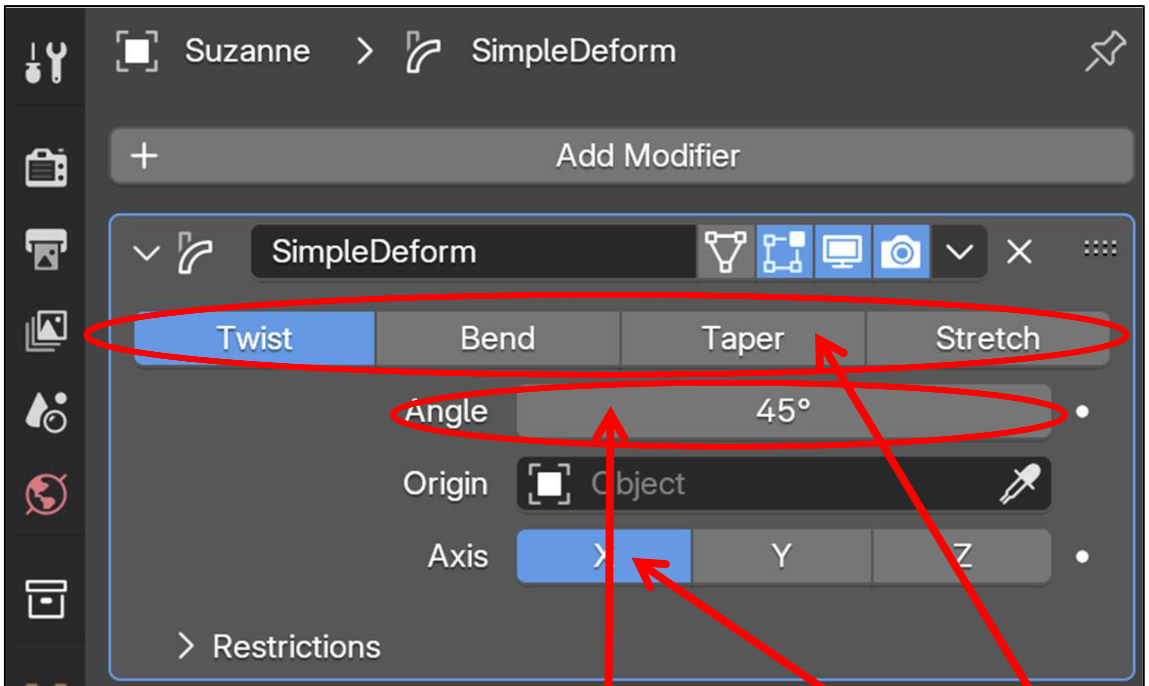
Difference



The Simple Deform Modifier

With an object selected, go to **Modifiers → Add Modifier → Deform → Simple Deform**

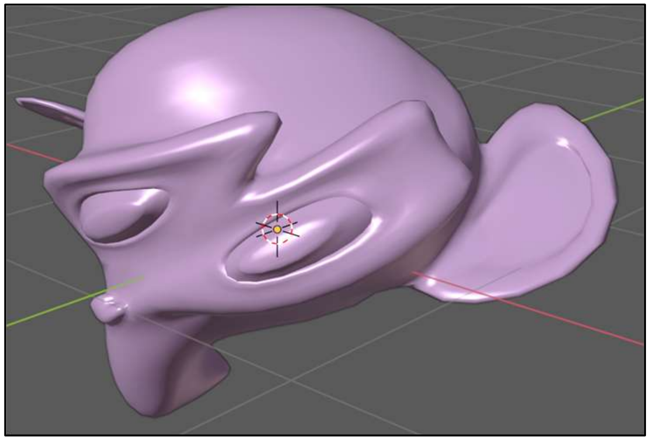
You will then see this:



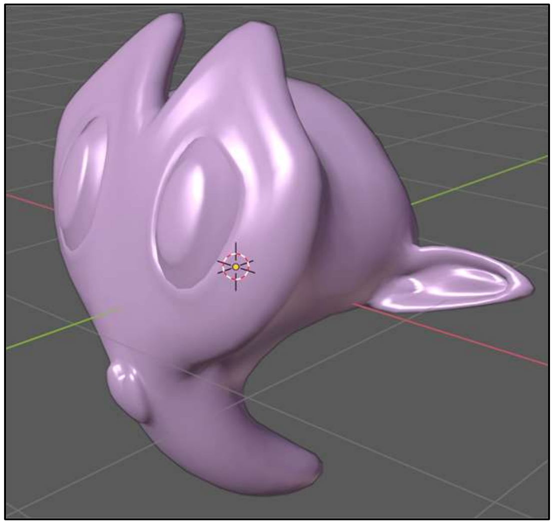
You get to pick one of four deformation types: **Twist**, **Bend**, **Taper** and **Stretch**. You also get to pick the axis about which that deformation will take place: **X**, **Y**, or **Z**.

After you've picked those, you get to change this value to control how much deformation you get.

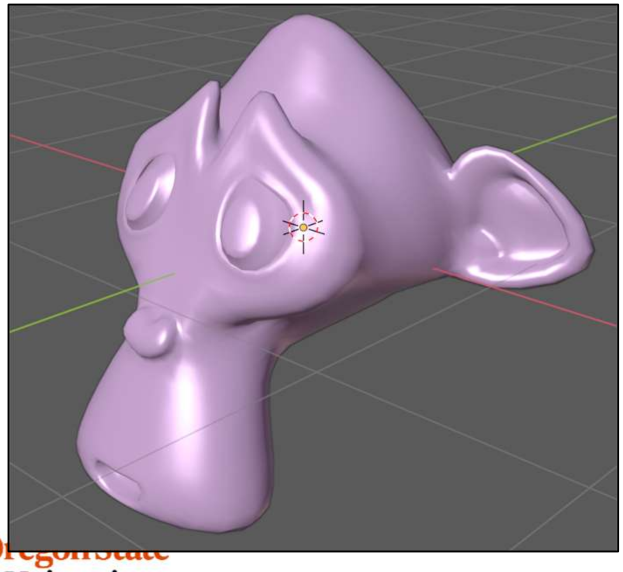
The Simple Deform Modifier



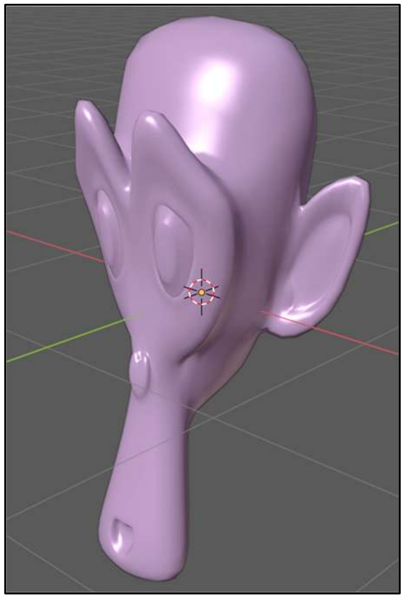
Twist about Z



Bend about X



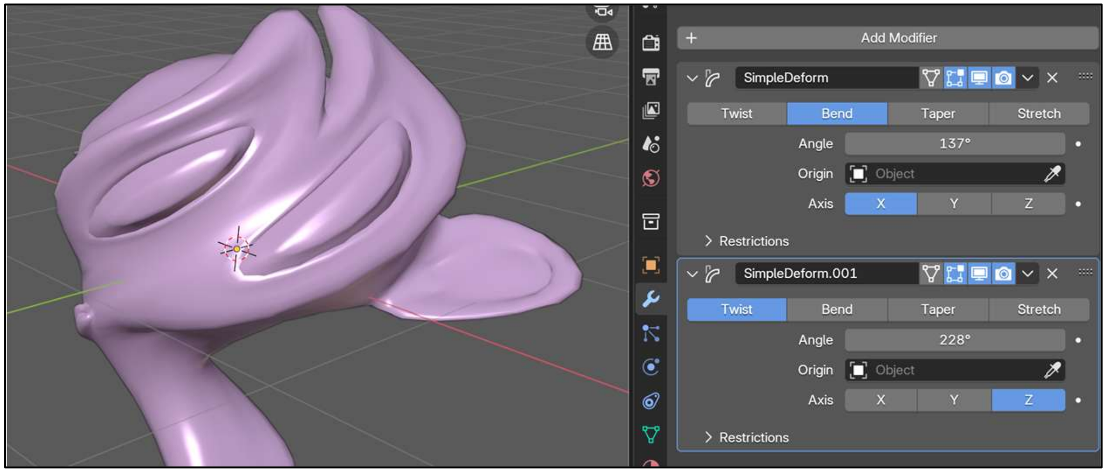
Taper along Z



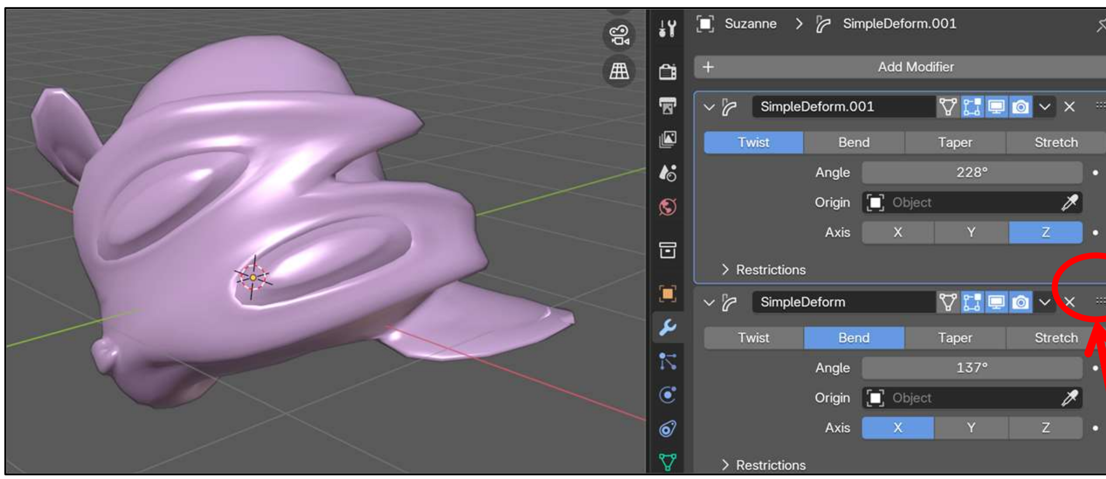
Stretch along Z

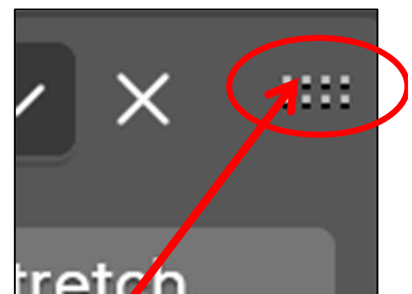
The Simple Deform Modifier

You can also compound multiple deformations just by repeating the modifier:



Bend, then Twist



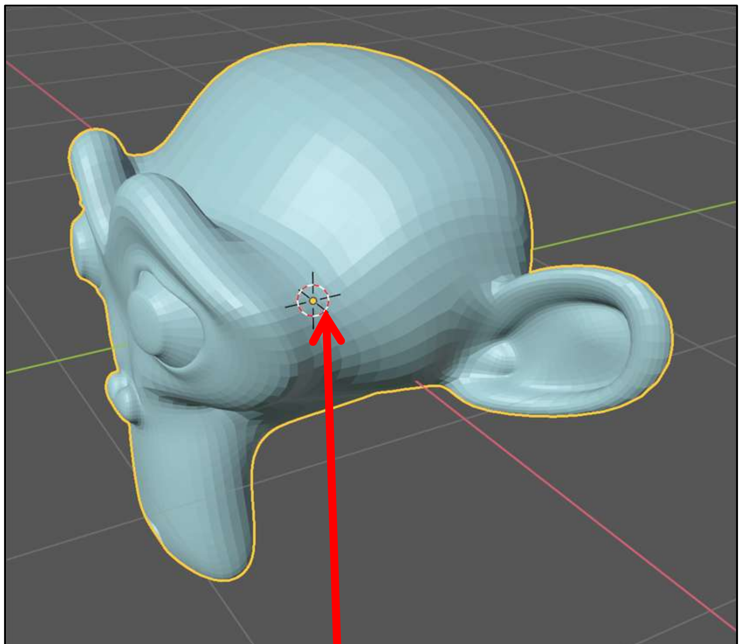


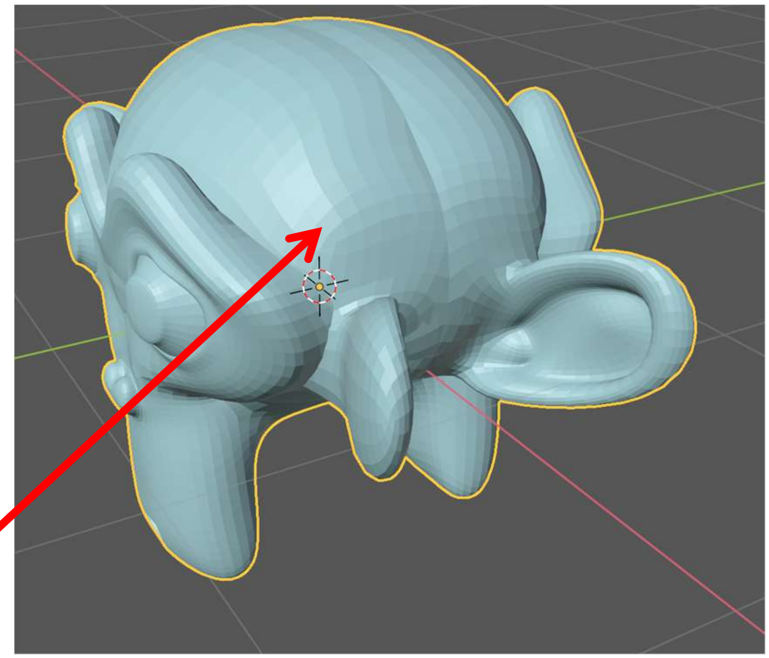
Twist, then Bend

The order counts! Click here and drag to change the order of the two modifiers.

The Mirror Modifier

Let's say that you want to create a mirror image of the monkey, but by using a Modifier, the mirror monkey will be linked to the original monkey so that any edits you do to the original will automatically end up in the mirror object.

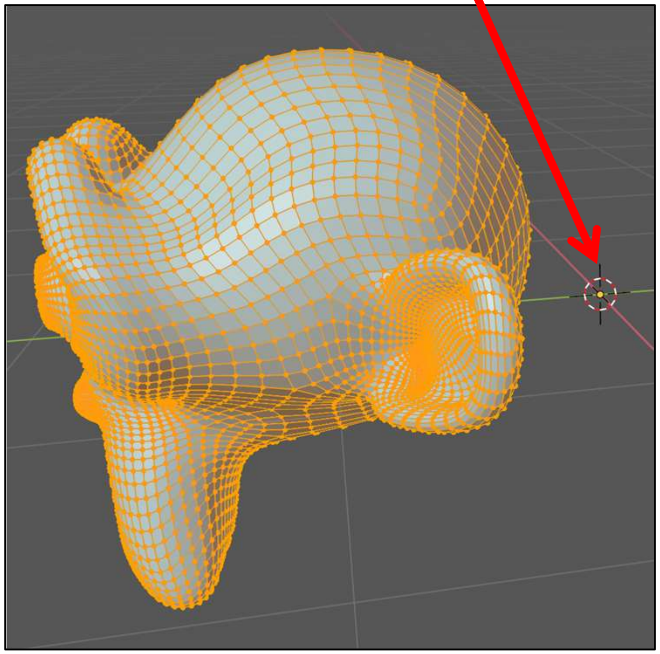




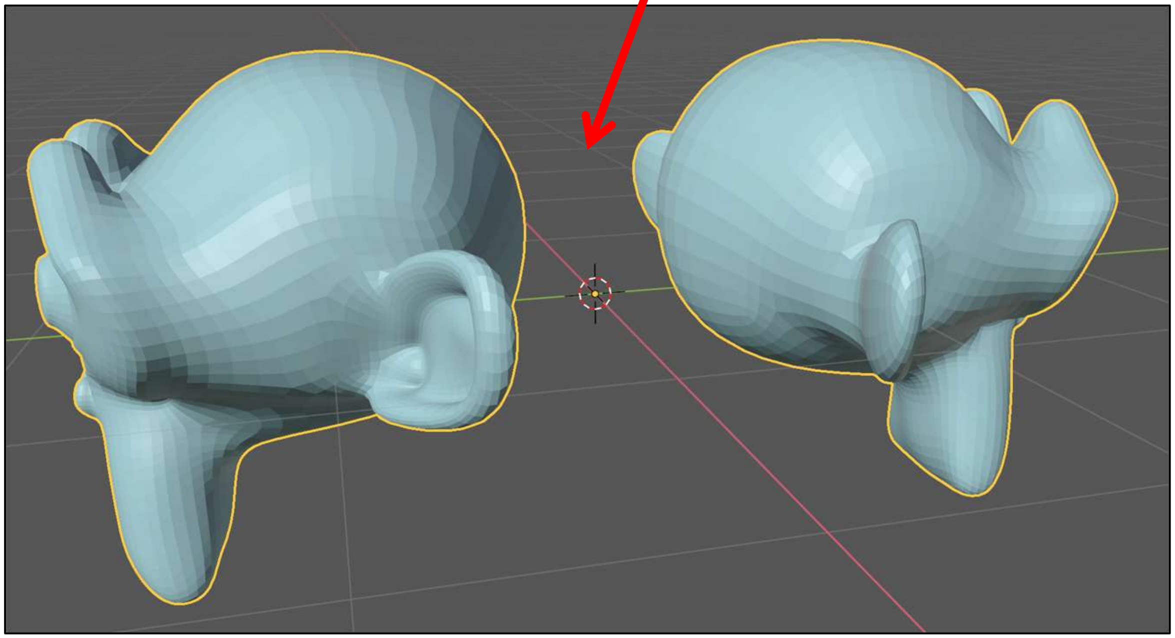
But, that mirrored object will reflect about the object origin, this little dot right here. Which means that you will end up with something like this, which is probably not what you wanted.

The Mirror Modifier

So, the first thing we need to do is to move the object away from the little dot.
You do this by Tabbing into **Edit Mode** and grabbing all the vertices and sliding them (**gy**).
In Edit Mode, the dot doesn't move when you do this:

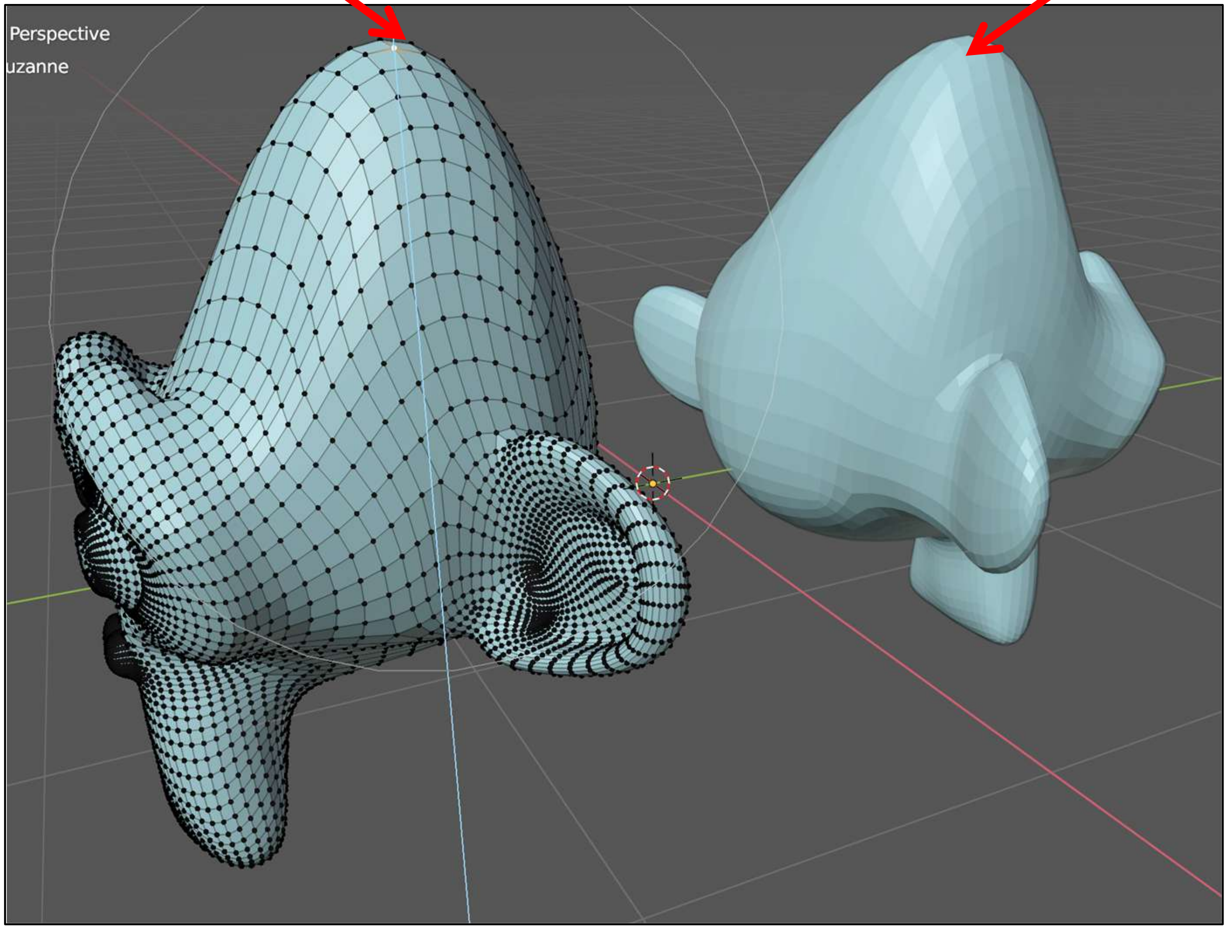


Now, Tab back to **Object Mode**, add the **Mirror Modifier**, and select **Y**.



The Mirror Modifier

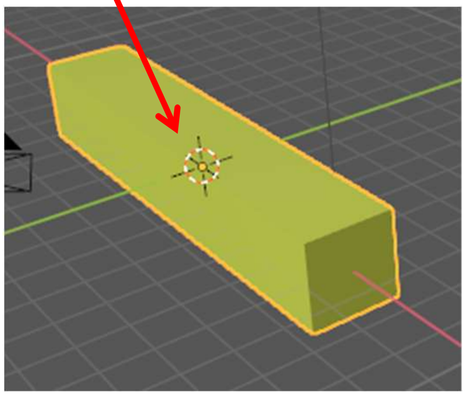
So, now if you sculpt the original object, the mirrored object will get the same edits.



This is often good for creating a full object by only creating one half of it (e.g., a car) and mirroring it.

Array Modifier

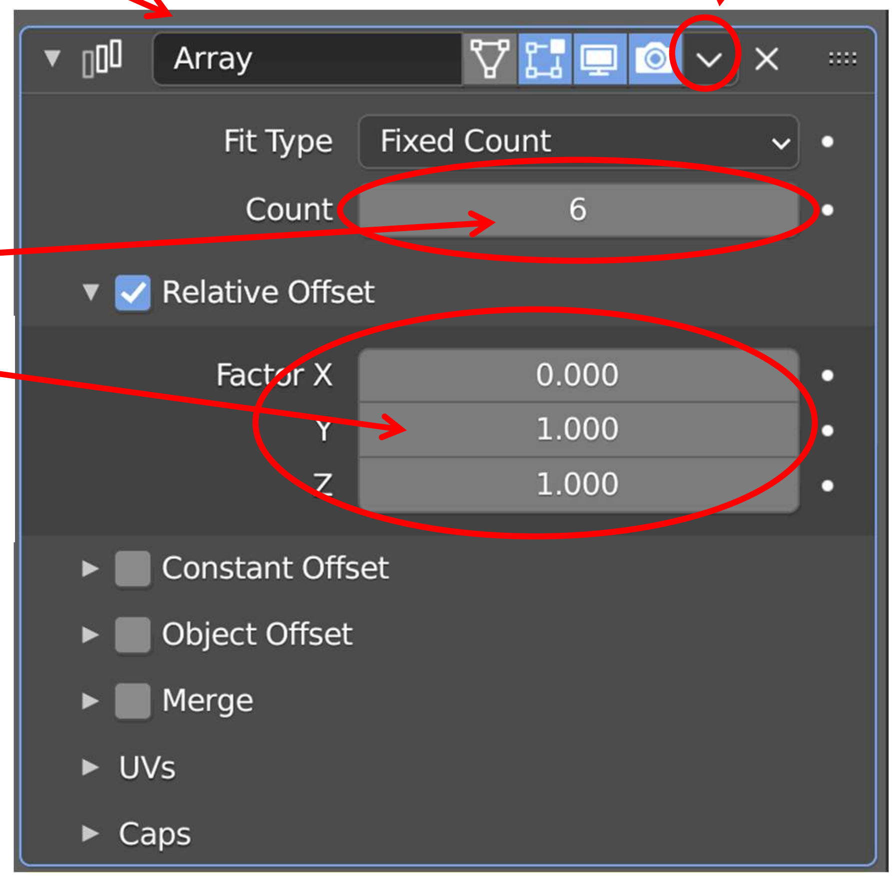
The Array Modifier is used to duplicate an object according to a particular pattern. Suppose we want to turn a block into a staircase. We start with the block and add an Array modifier.



Apply button (if we want to make this permanent)

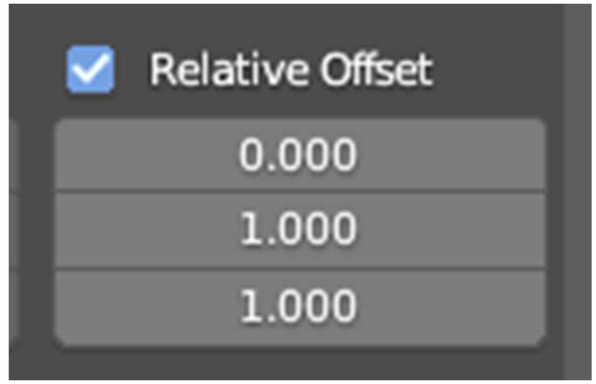
The duplication count

How much to offset each duplication. It can be Constant, that is, based on a number of units. Or it can be Relative, that is, based on a number of size-of-this-object

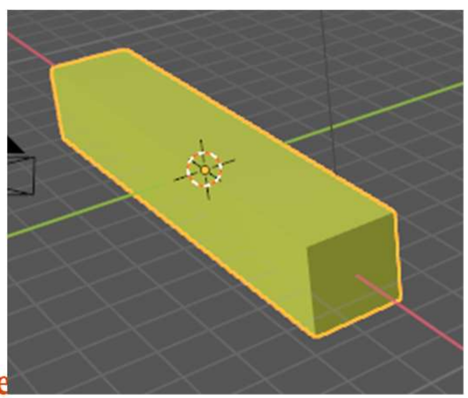


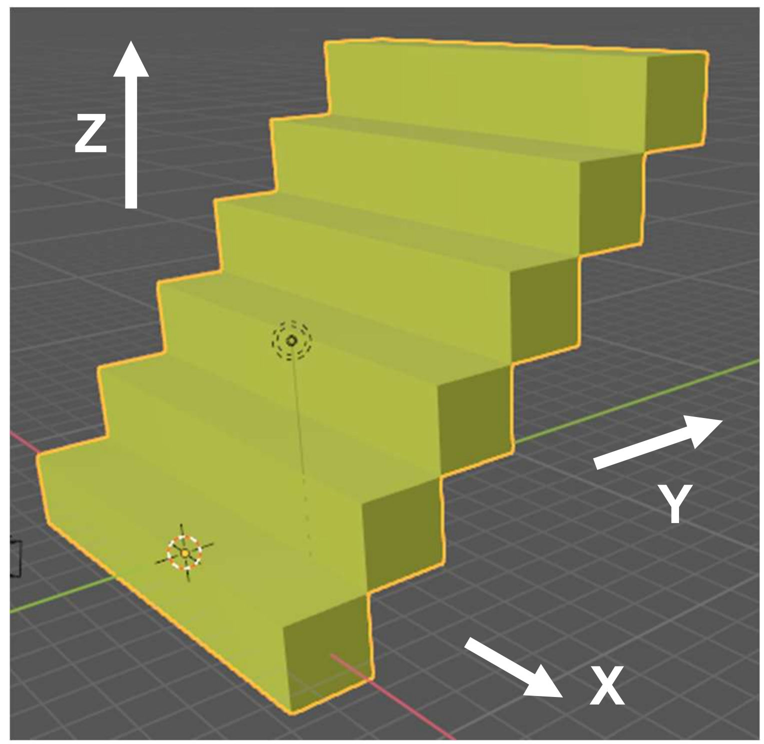
Array Modifier to Make Stairs

Move each block in Y and Z
to make the next stair step

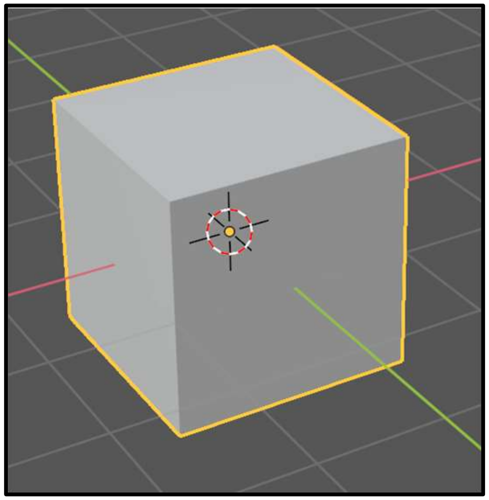


How many total steps to make

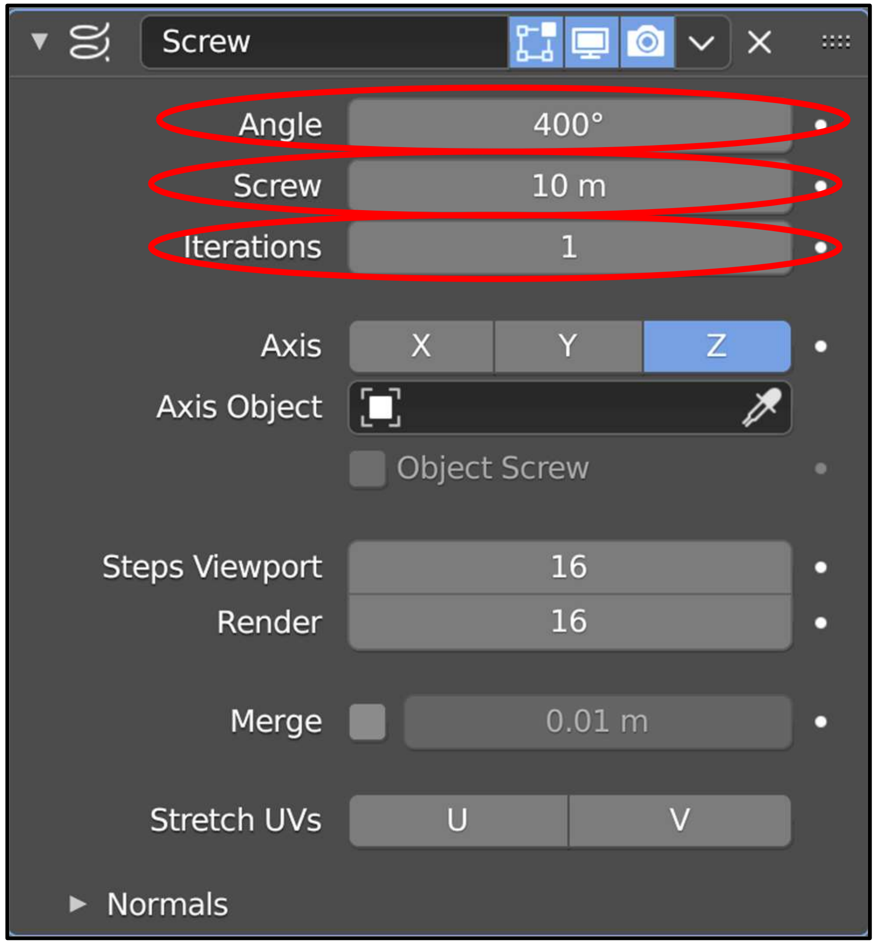


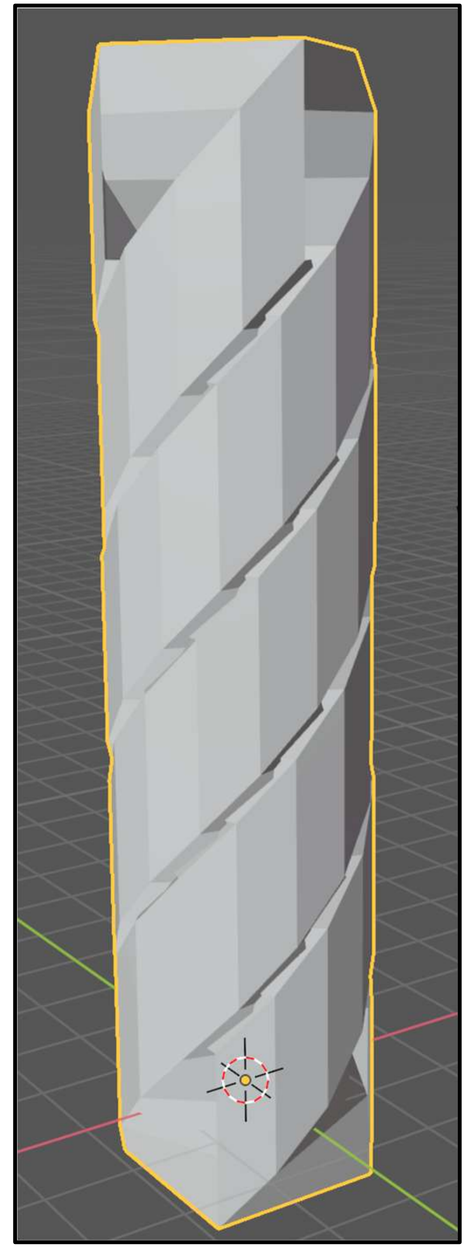


Screw Modifier



Before

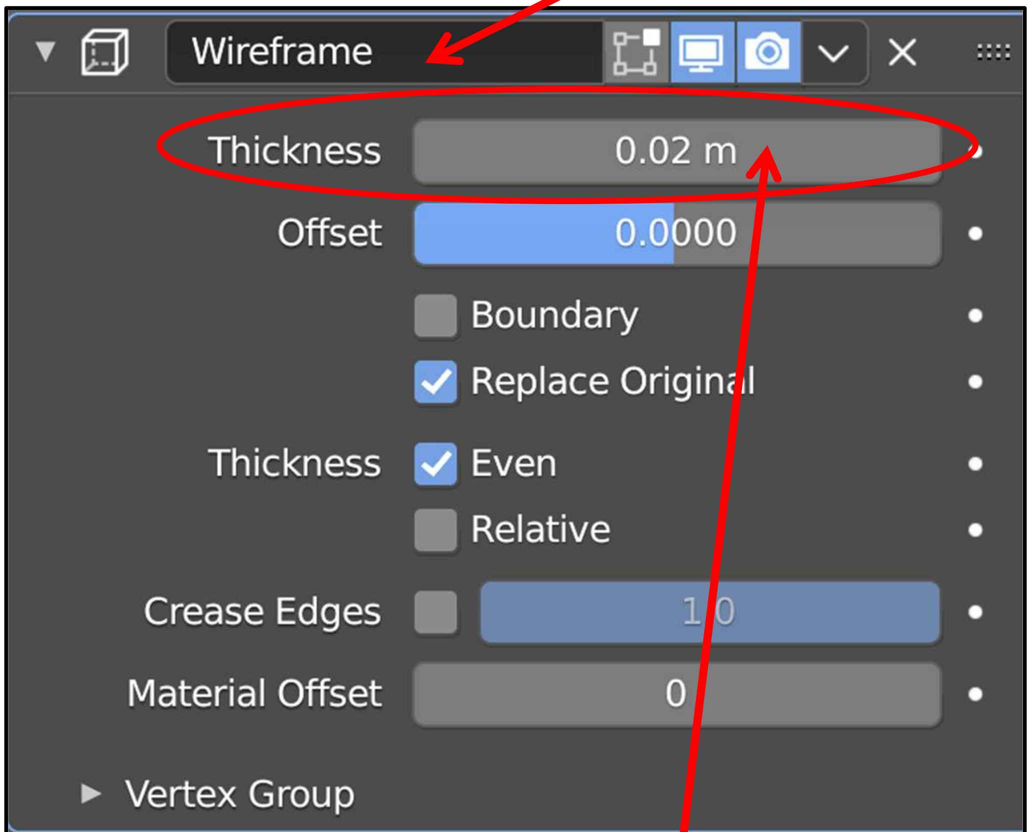


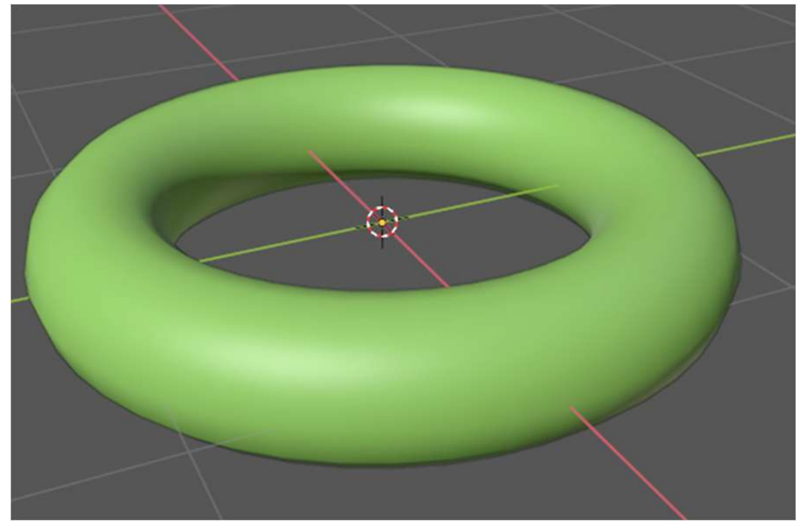


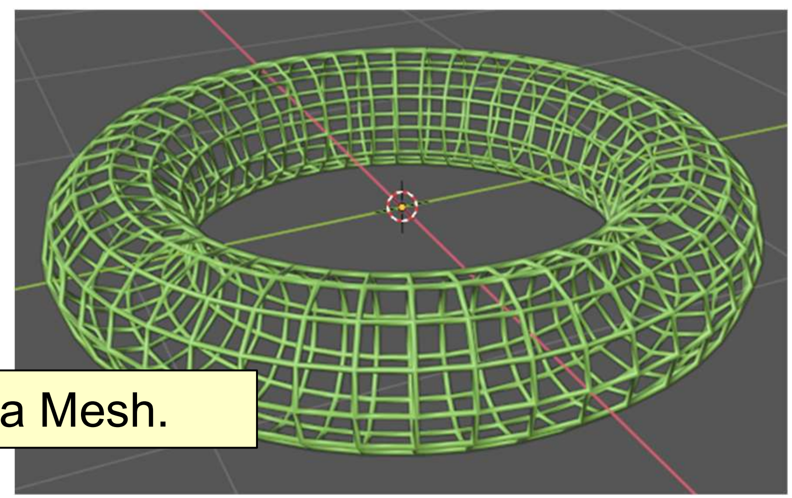
After

Wireframe Modifier

Turns each polygon into thick lines outlining each polygon





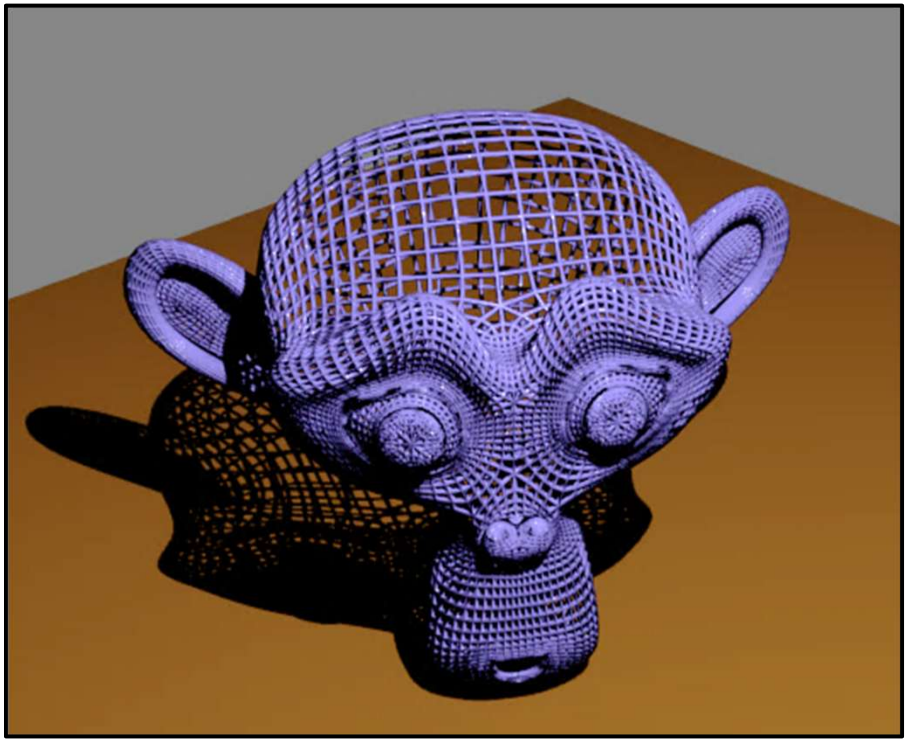


How thick to make the thick lines

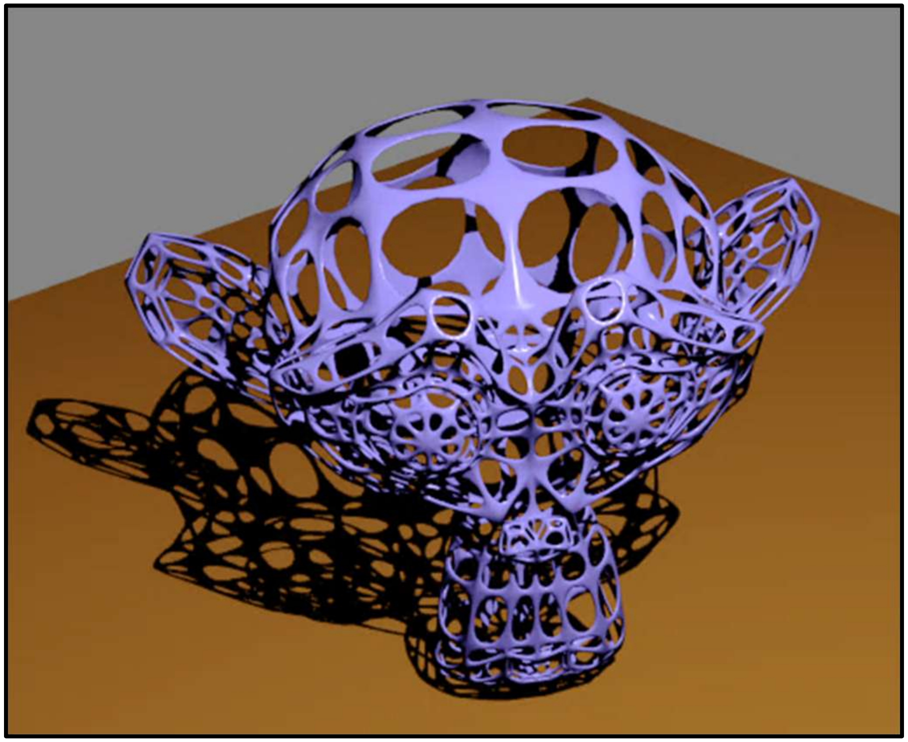
But, these lines have thickness, keeping this as a Mesh.

Modifier Order Matters !

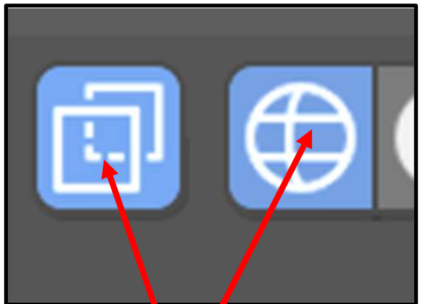
Subdivision Surface, then Wireframe



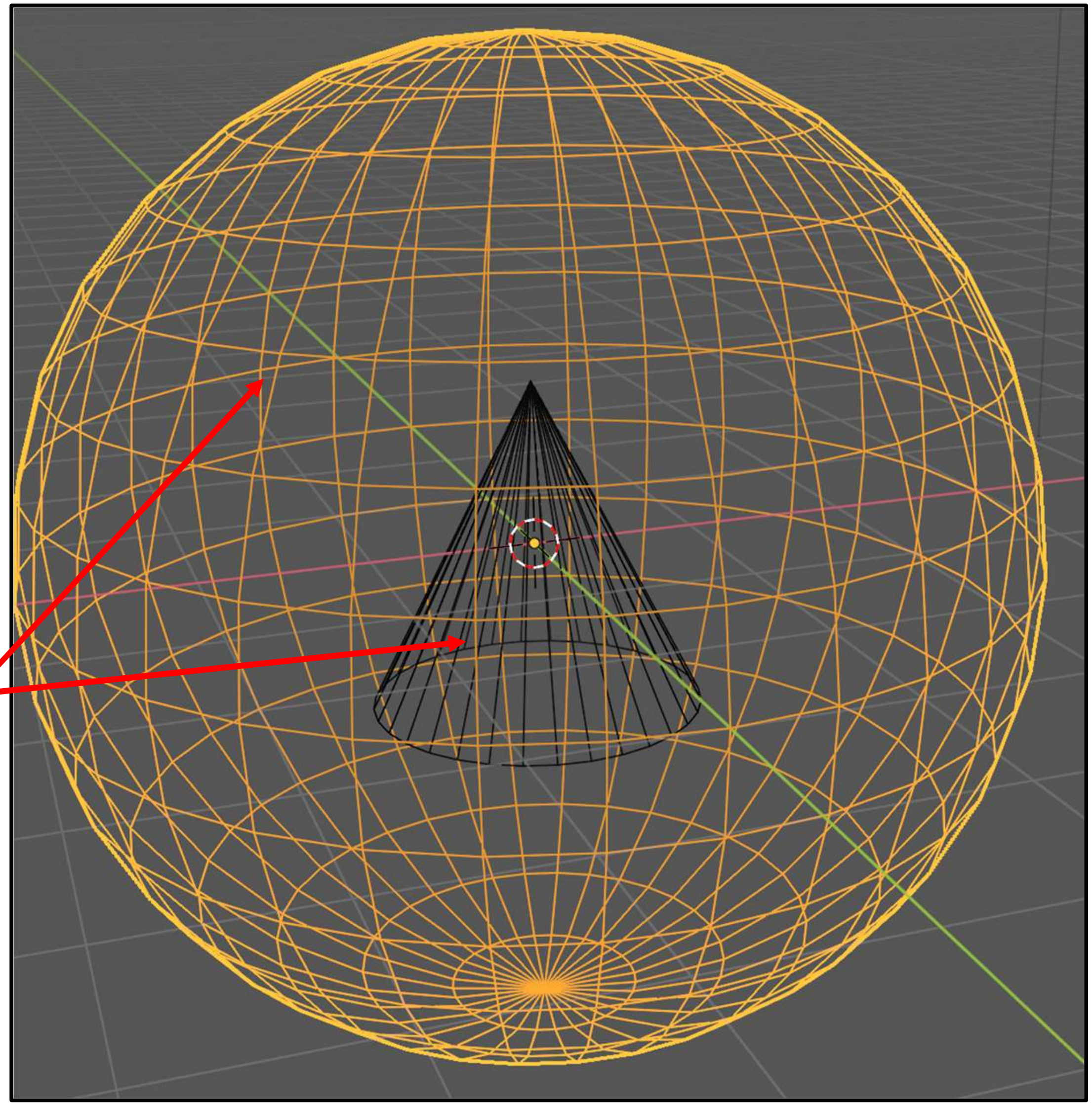
Wireframe, then Subdivision Surface



The Shrinkwrap Modifier

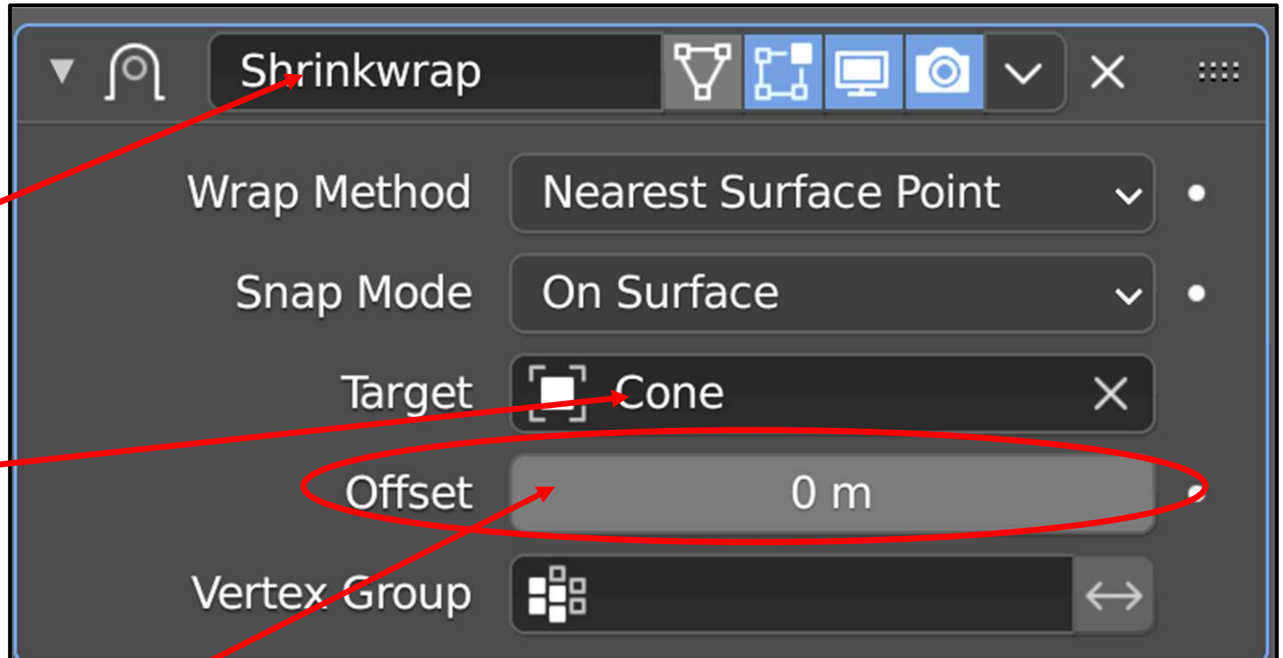


Turn on both **X-ray Mode** and **Wireframe Mode**



Add a UV Sphere and a Cone. Either scale the sphere up or scale the cone down so the cone is inside the sphere.

The Shrinkwrap Modifier

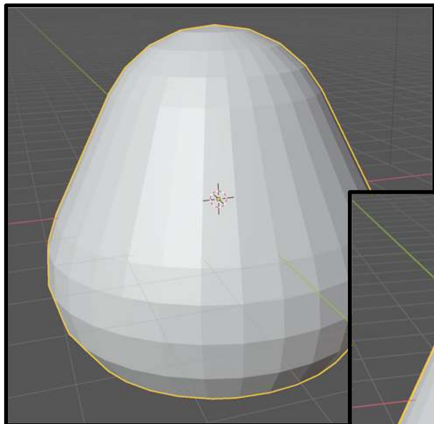


Click on the **sphere** and select the **Shrinkwrap Modifier**

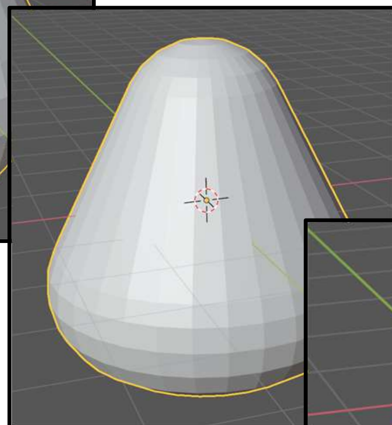
Select the cone as the **Target**

Adjust the **Offset** value. Positive values make most sense, but negative values are fun too!

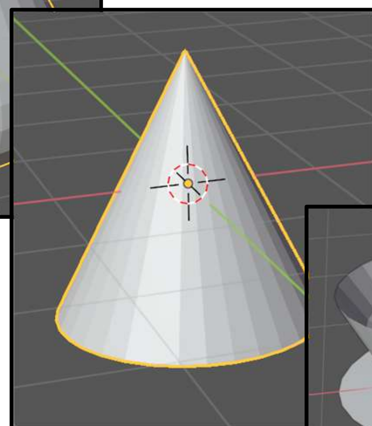
The Shrinkwrap Modifier



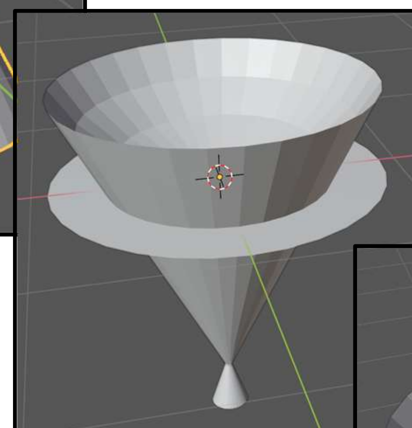
Offset = 2



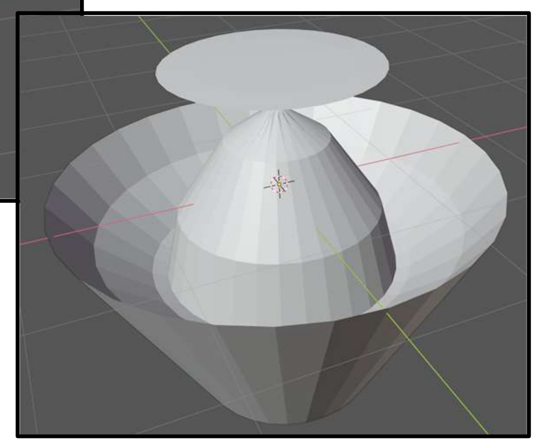
Offset = 1



Offset = 0



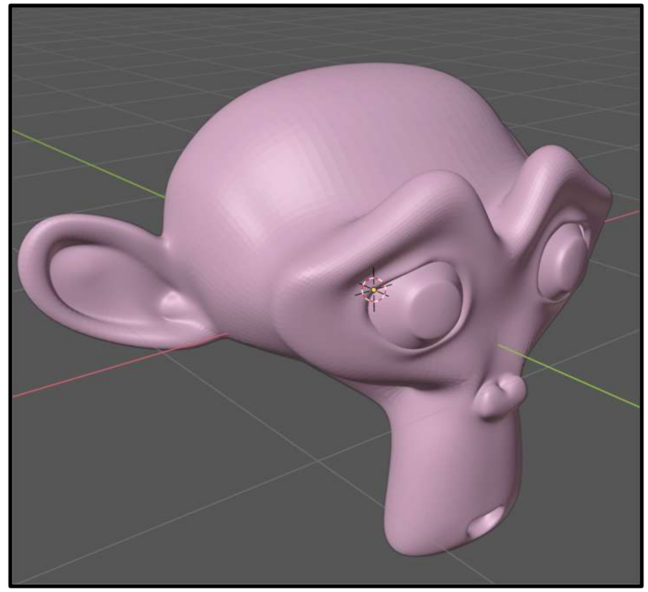
Offset = -1



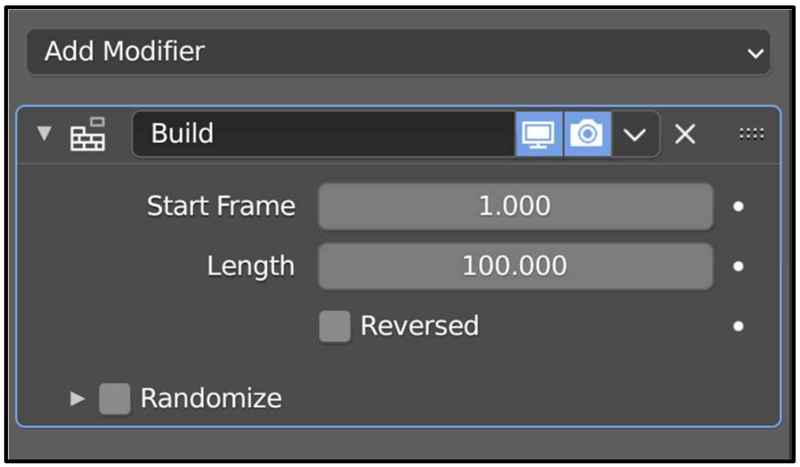
Offset = -2

The Build Modifier

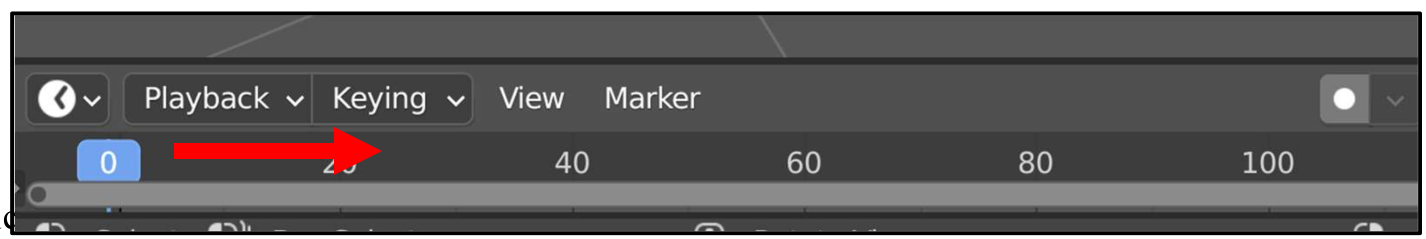
I suspect this is more applicable to engineering-ish objects, but it fun no matter what. Let’s use our old friend Suzanne the monkey.



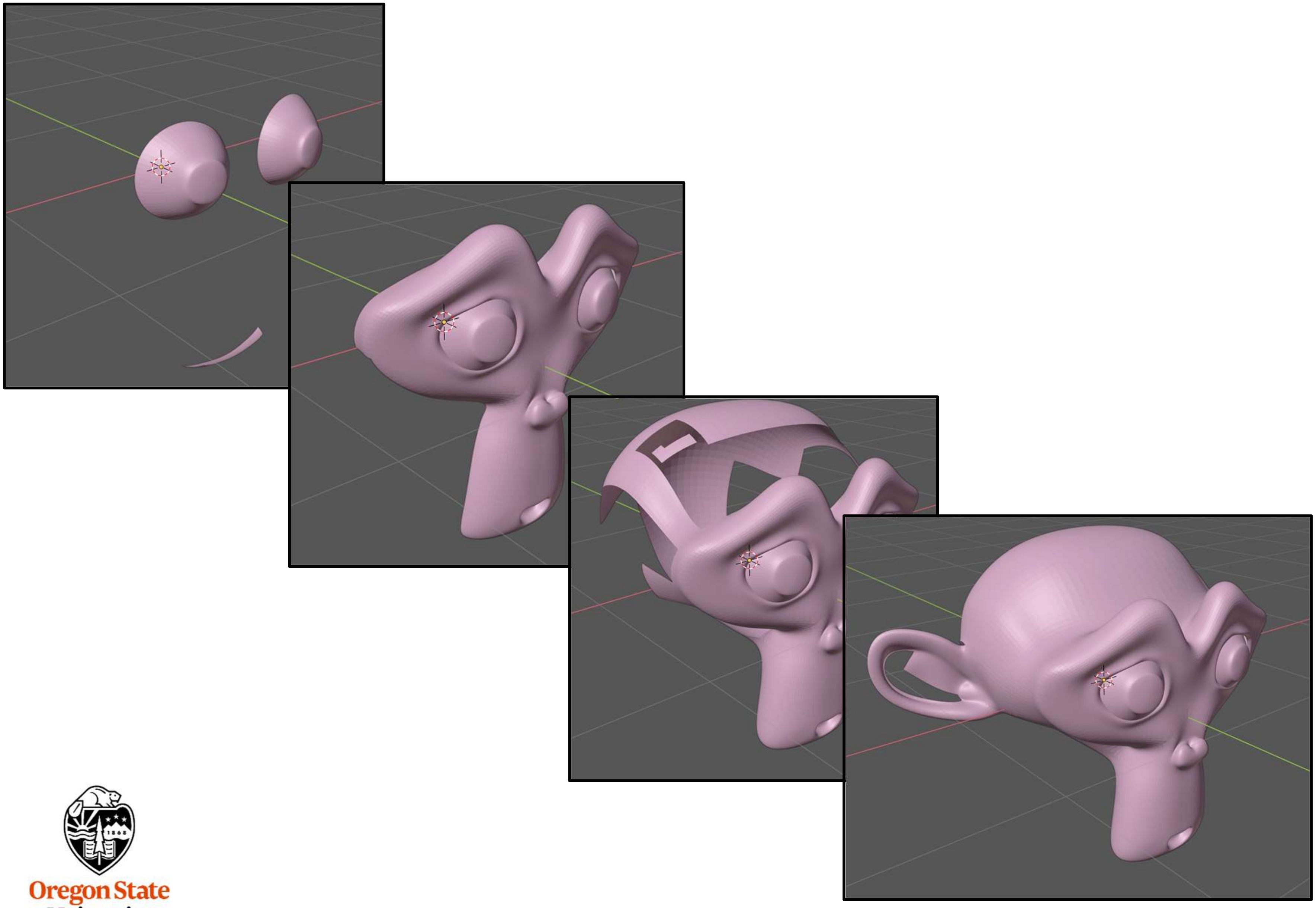
Go to **Modifers → Select Modifer → Build**
You get the following Modifer box. All the values are good defaults:



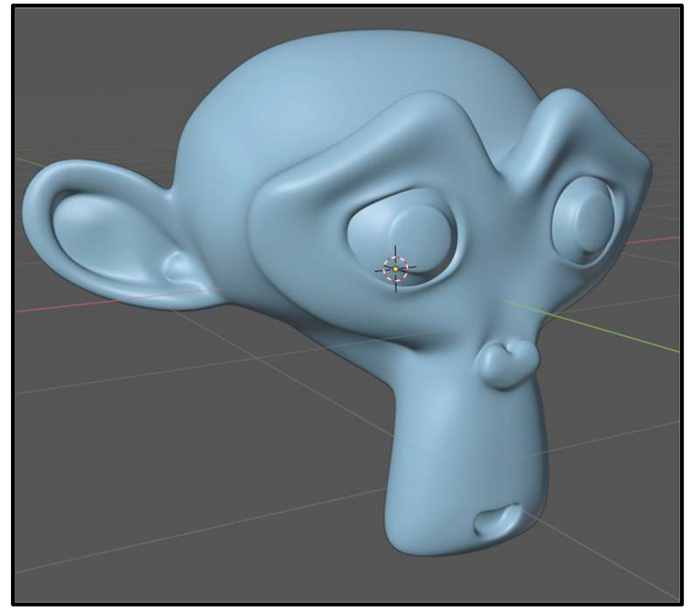
At this point, Suzanne has disappeared. What!? To bring her back, grab the blue animation time slider at the bottom of the screen and slowly move it to the right:



The Build Modifier

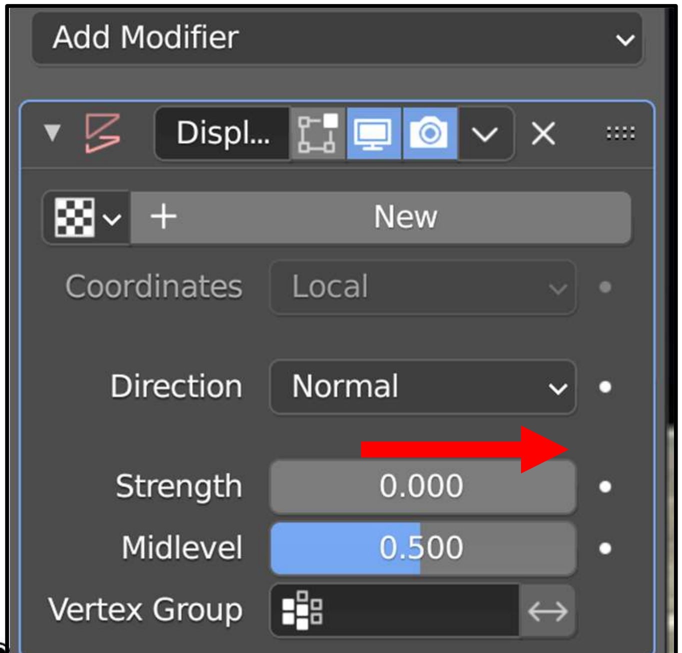


The Displace Modifier



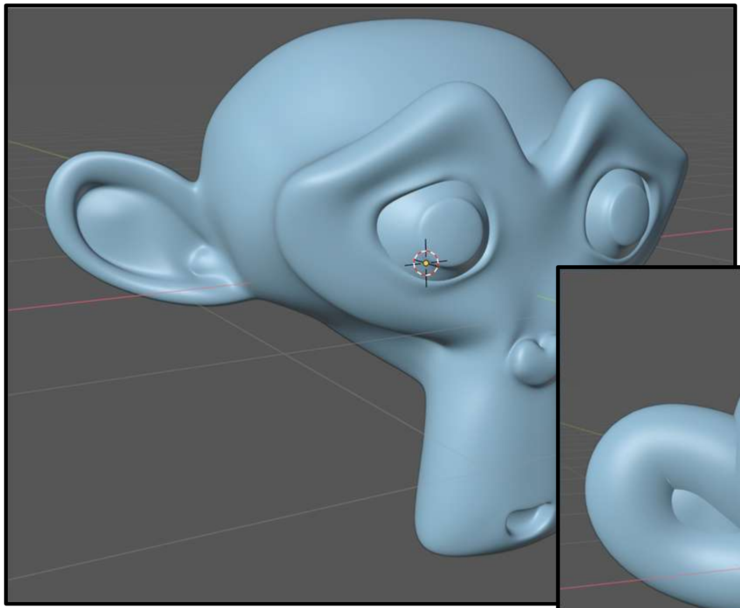
This Modifier pushes vertices out perpendicular to the surface. I would describe it as “puffing out the object”.

Go to **Modifers** → **Select Modifer** → **Displace**
You get the following Modifer box. If your object suddenly looks weird, don’t worry! Set this value to **0**:

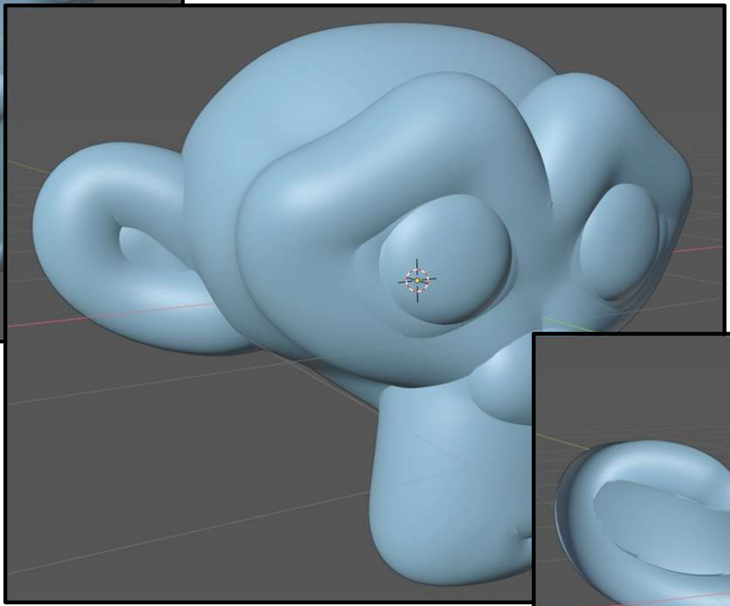


Now, slowly increase to Strength to be greater than 0. What happens? Is it possible to set it to a value less than 0? What happens?

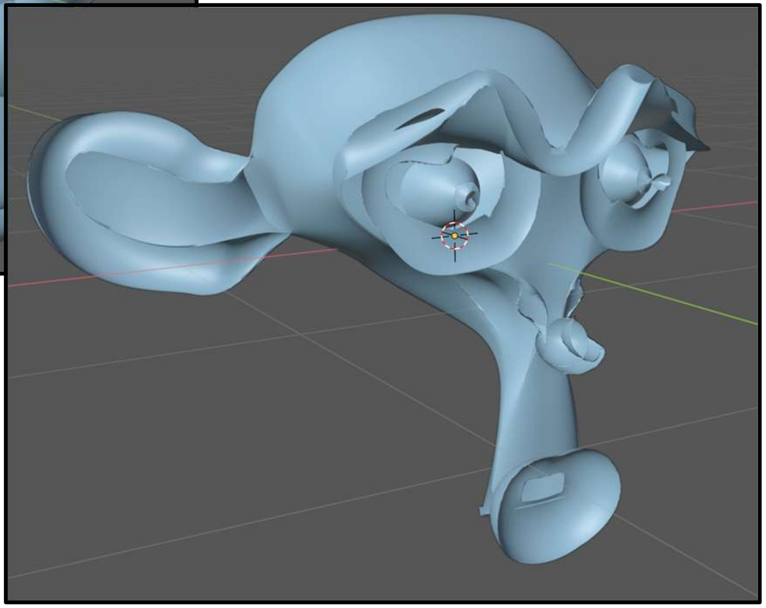
The Displace Modifier



Strength = 0.0



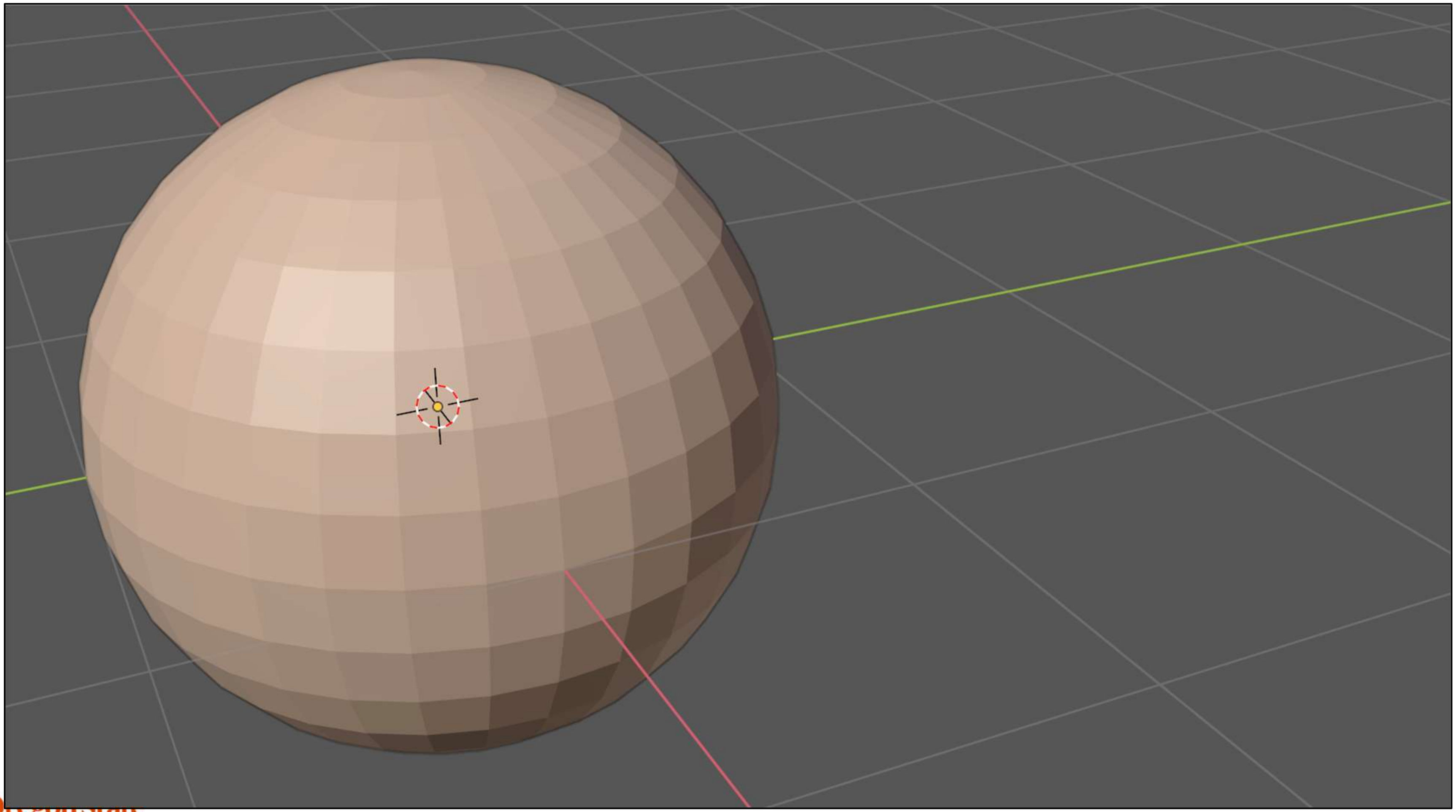
Strength = 0.3



Strength = -0.3

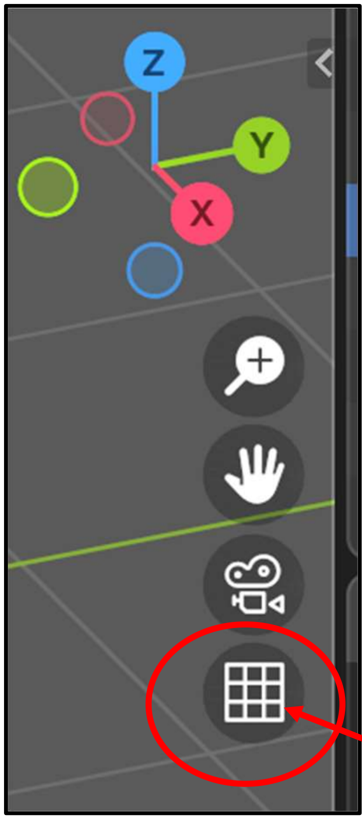
Vertex Groups

Add a **UV Sphere**



Vertex Groups

Select a group of sphere vertices to turn into a **Vertex Group.**

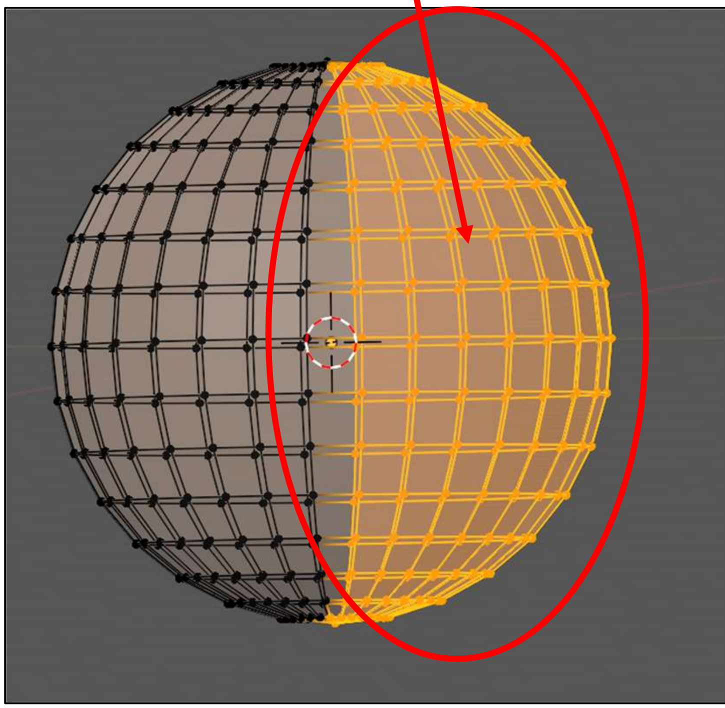


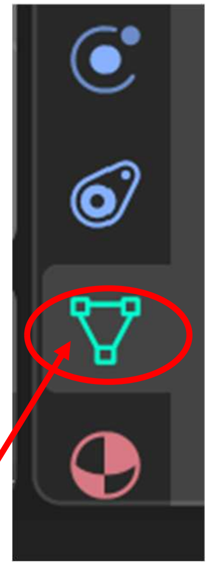
In **Object Mode**, turn on **X-ray**

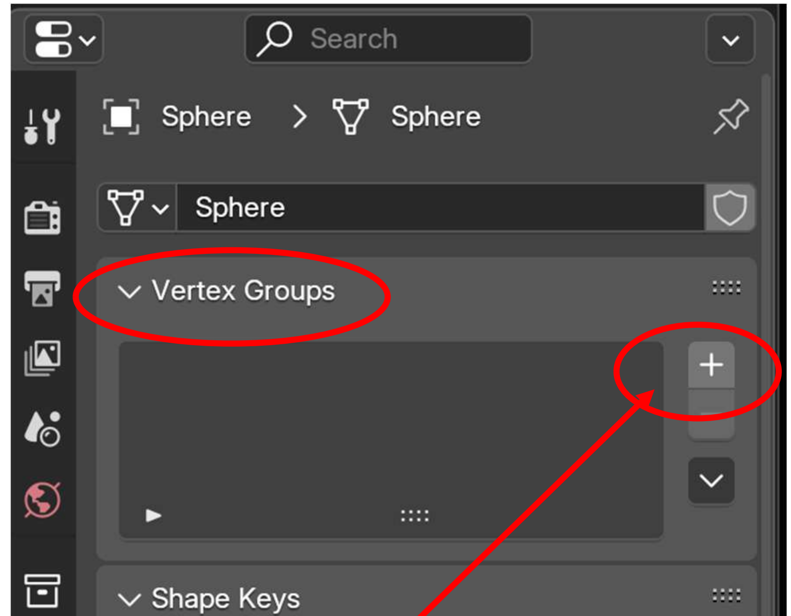
In **Object Mode**, turn on **Orthographic**

Vertex Groups

In **Edit Mode**, sweep over a group of sphere vertices





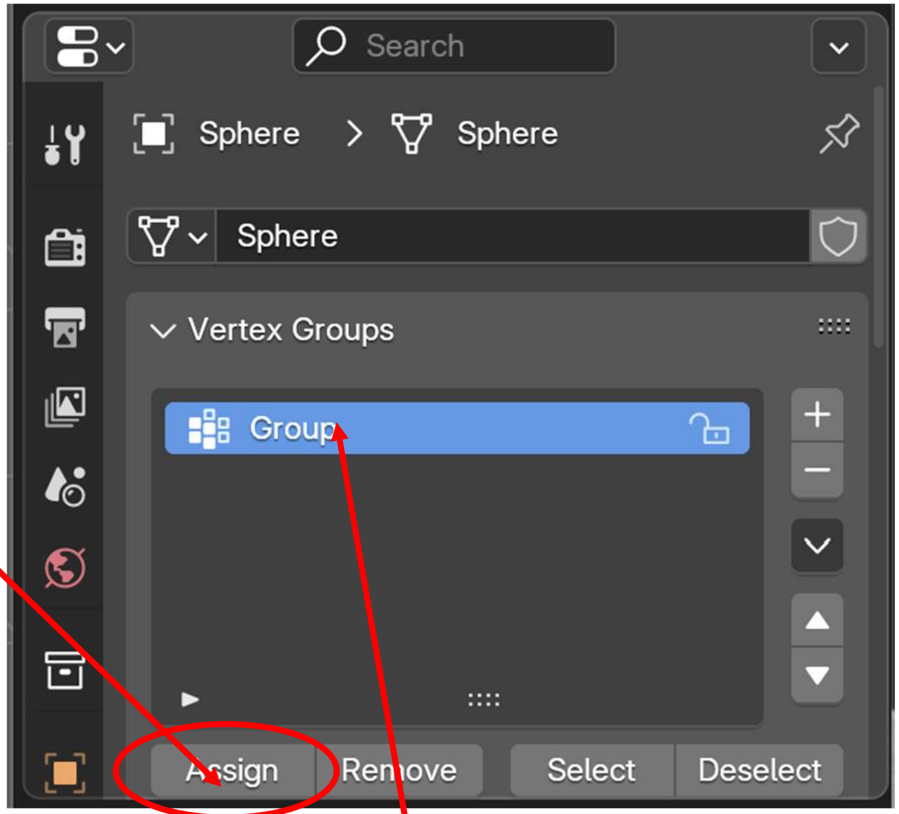


Click on the **Object Data Properties** icon

In **Vertex Groups**, click on the **+**
This creates a new Vertex Group

Vertex Groups

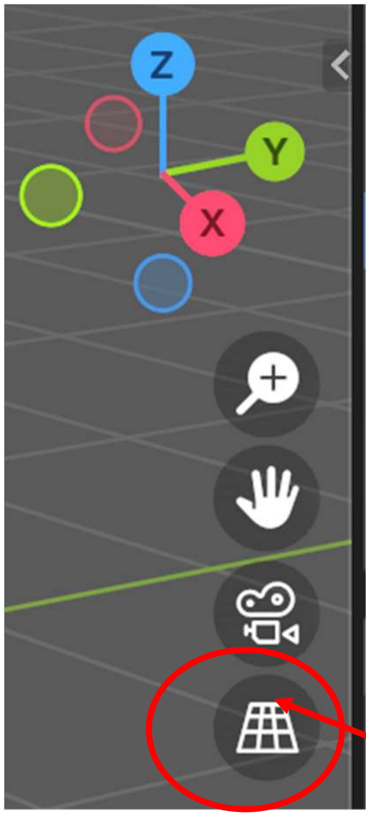
Now click on **Assign** to assign the vertices you picked to vertex group **Group**.



Double-click on **Group** and give that Vertex Group a more descriptive name

I named mine “Right” because these vertices are on the right side of the sphere.

Vertex Groups

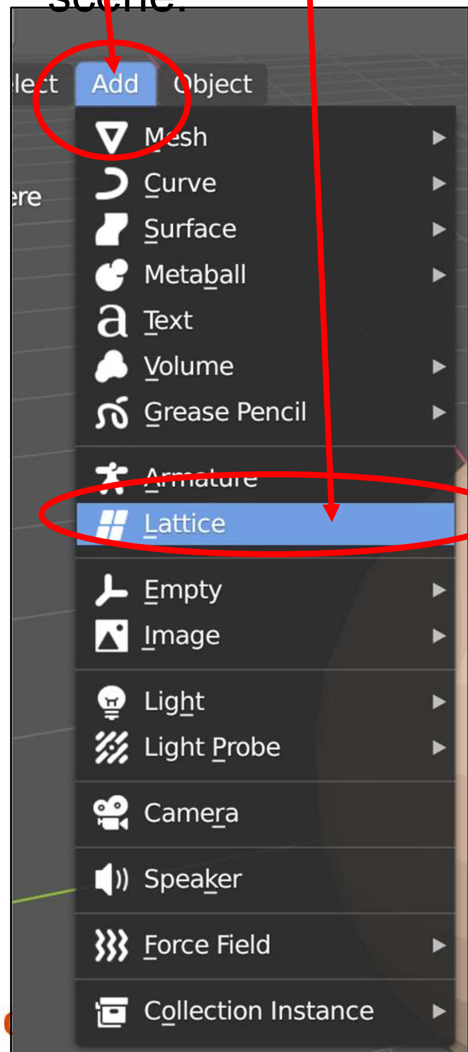


In **Object Mode**, turn off **X-ray**

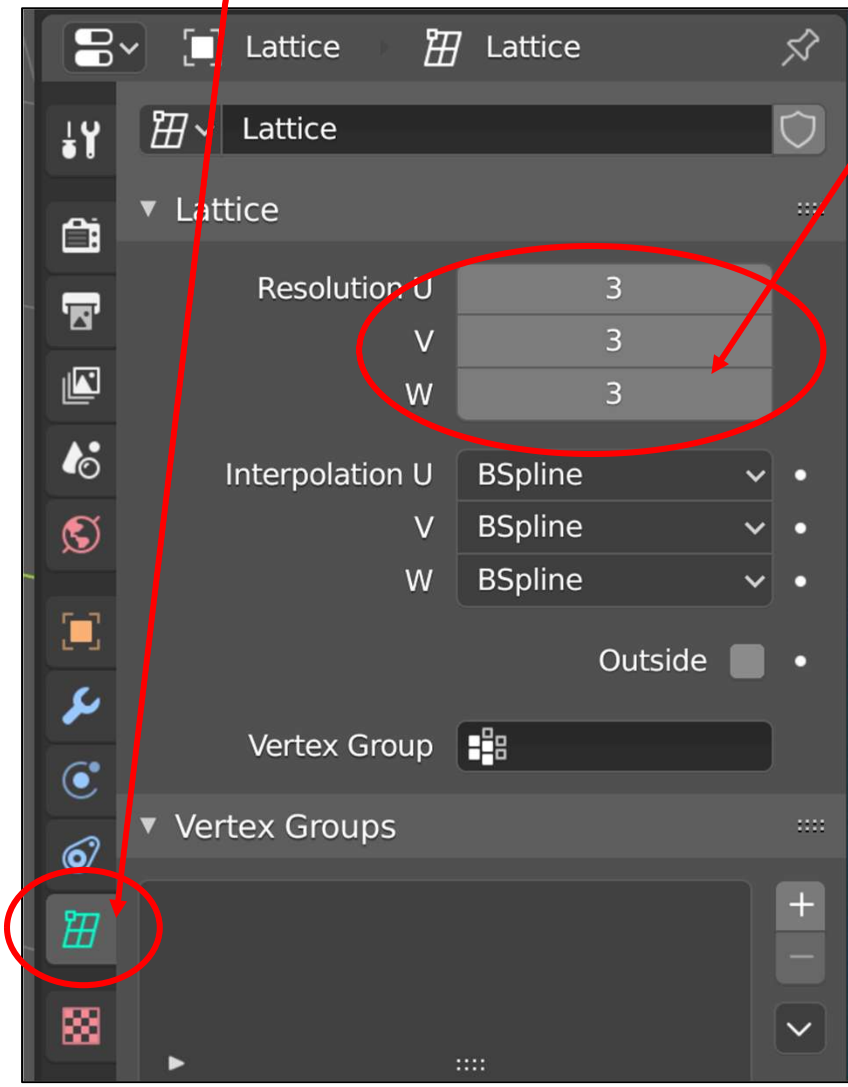
In **Object Mode**, turn on **Perspective**

The Lattice Modifier

Add a **Lattice** to the scene.

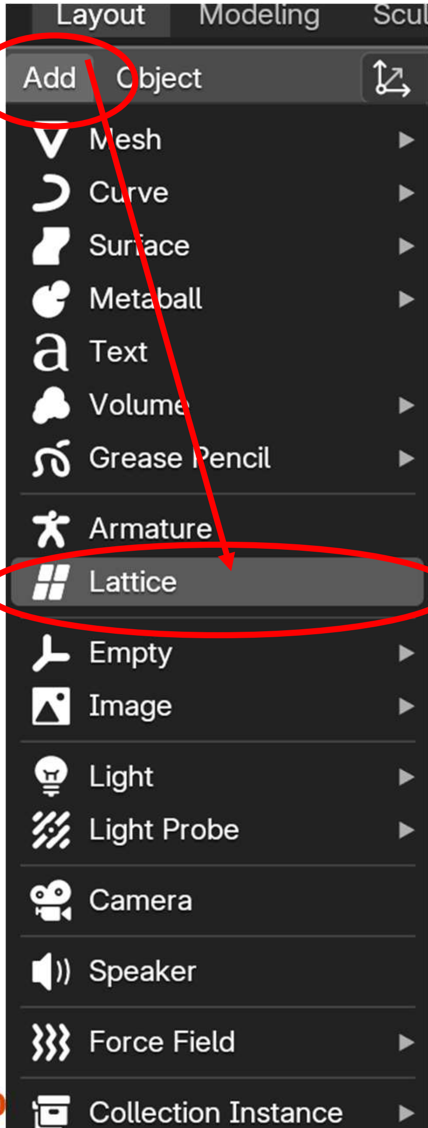


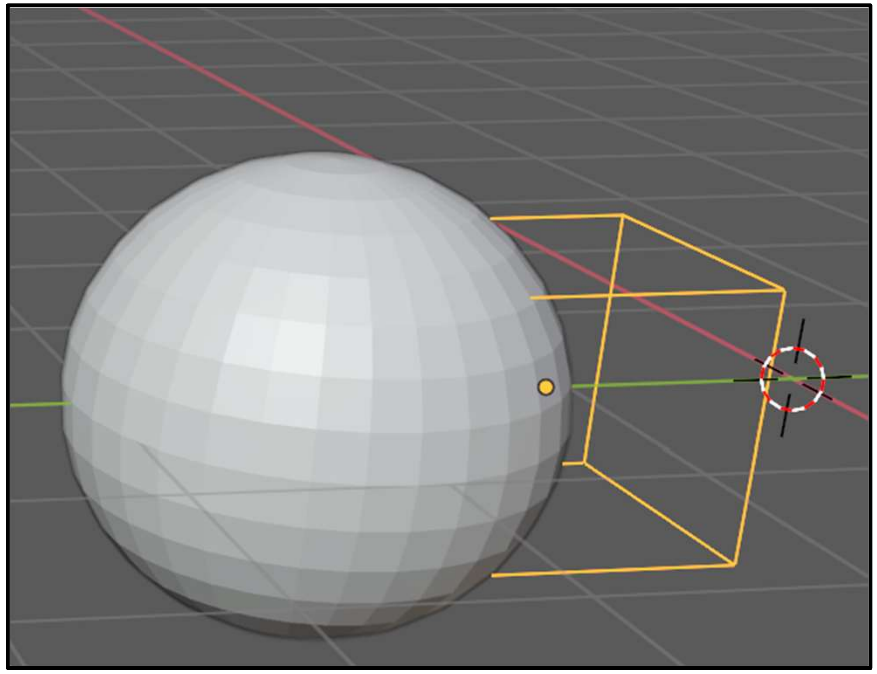
Click the **Lattice button** and (perhaps) add more lattice detail.



The Lattice Modifier

Select **Add** → **Lattice**



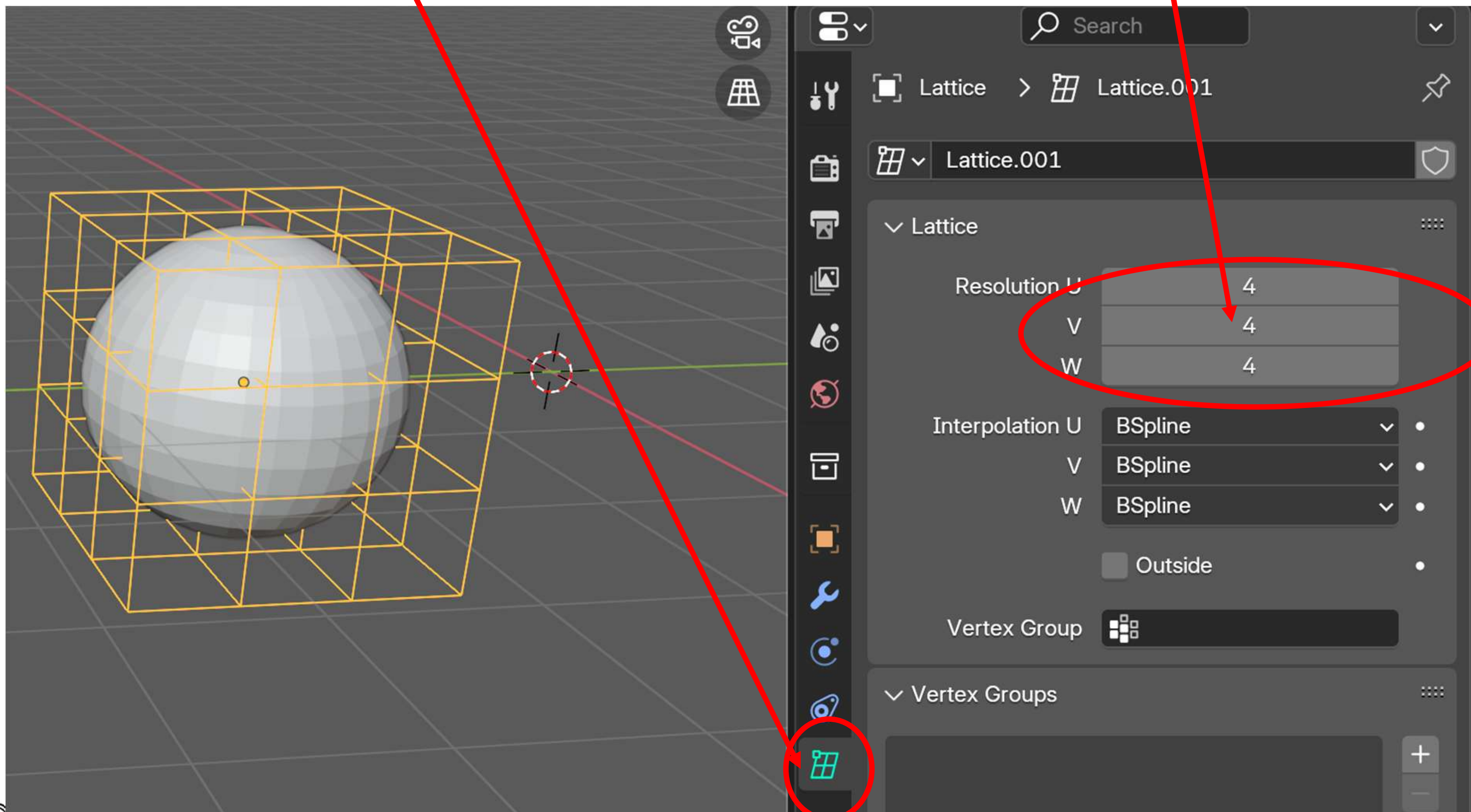


This adds a wireframe lattice to your scene.
(You might have to move your object out of the way to see it.)

The Lattice Modifier

Then click on the Lattice icon

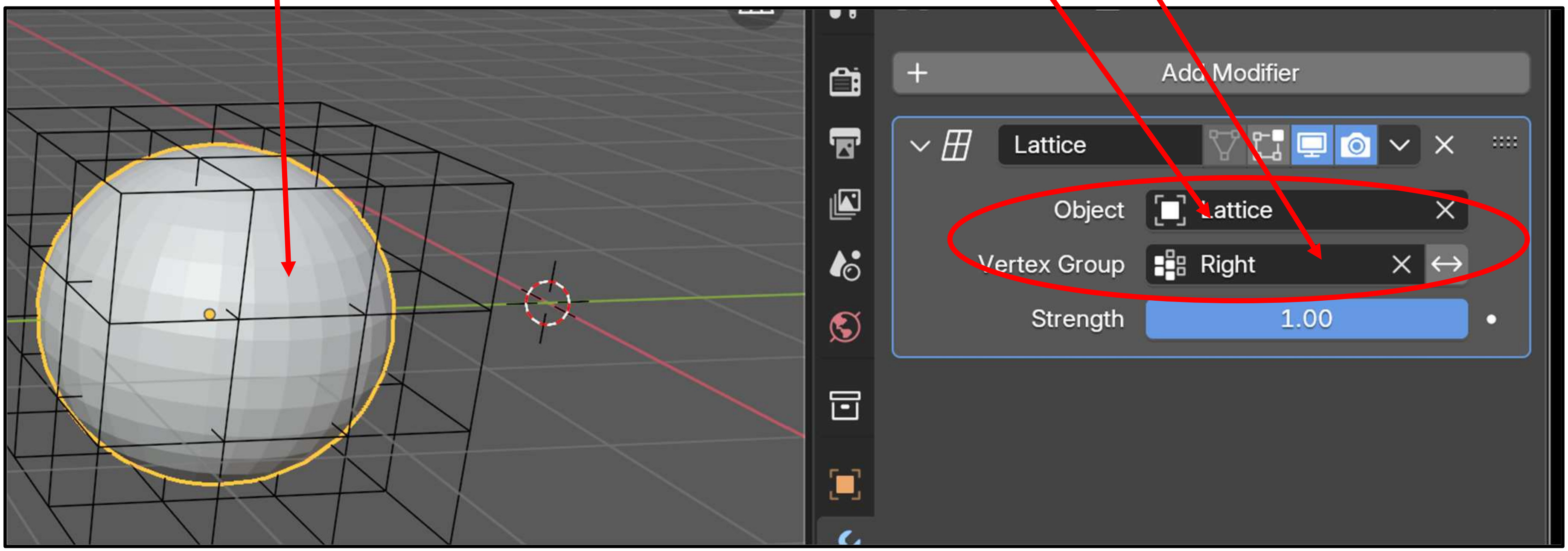
You can change these numbers to affect the number of sub-cubes in the Lattice



Scale and translate the lattice to surround your object, especially the vertices you put in the Vertex Group. Change the lattice's resolution as you see fit.

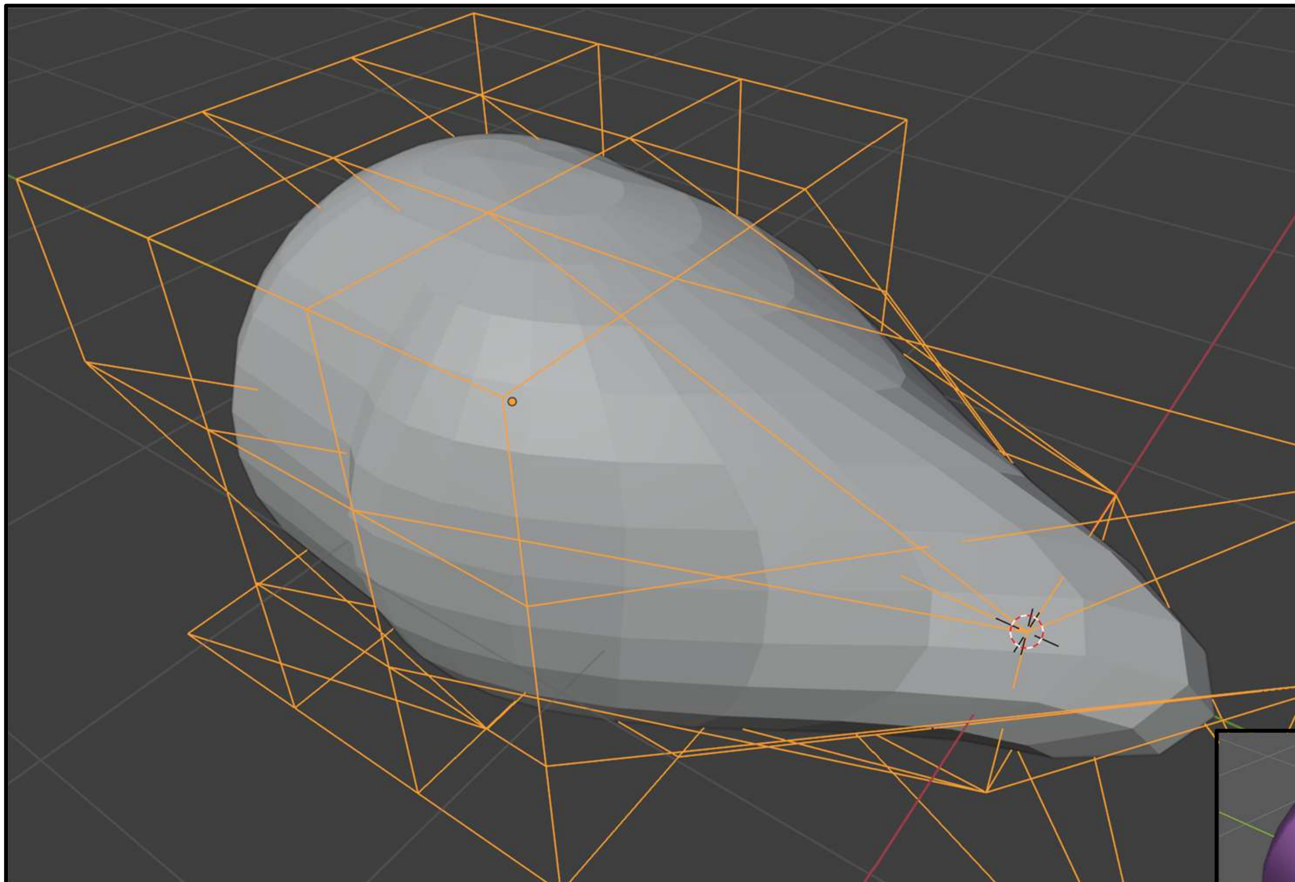
The Lattice Modifier

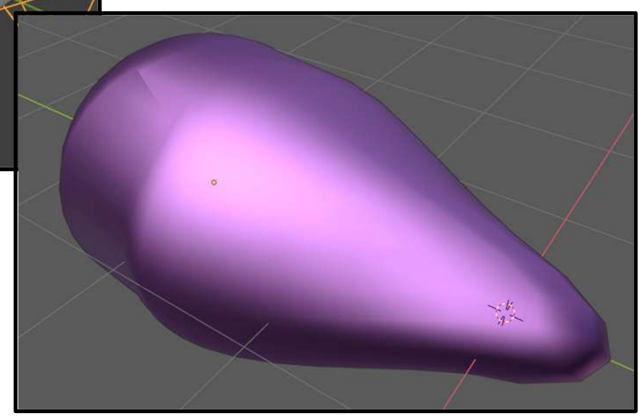
Select the Sphere and add a **Lattice Modifier** to it.
Tell it the name of the **Lattice** that you'll be editing.
Tell it the name of the **Vertex Group** that the edits will affect.



The Lattice Modifier

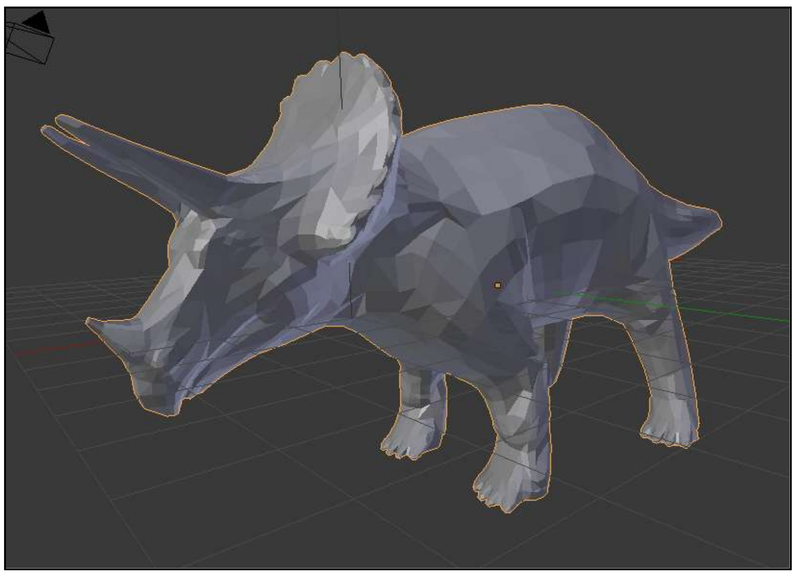
Select the **Lattice**, toggle to **Edit Mode**, select some of the vertices, and move, rotate, and scale them them:





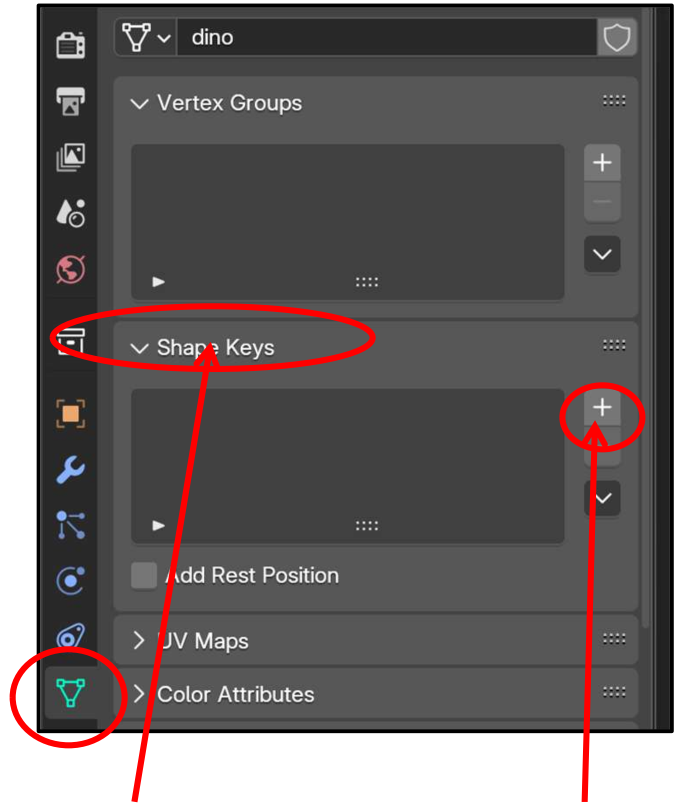
Shape Keys: A Modeling Aid

Shape keys are a way to do a variable morphing between two versions of the same object. The two (or more) instances must have the same number of vertices, but the vertices can (and should) be in different locations. Shape keys lets you interpolate vertex coordinates between those instances.



1. Select the object

2. Click on **Object Data**

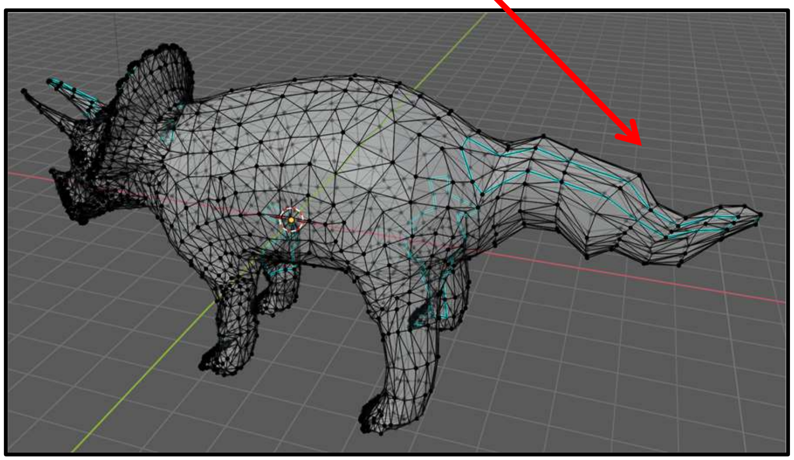


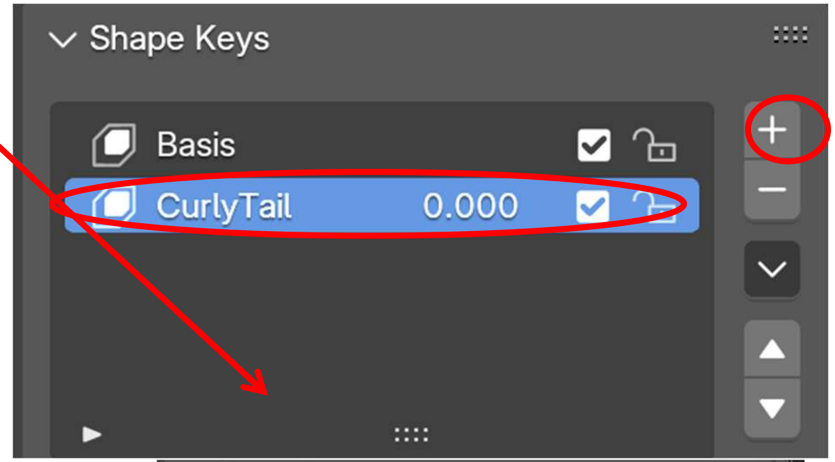
3. Under **Shape Keys**, click the plus sign **+**. This establishes the **Basis** shape.

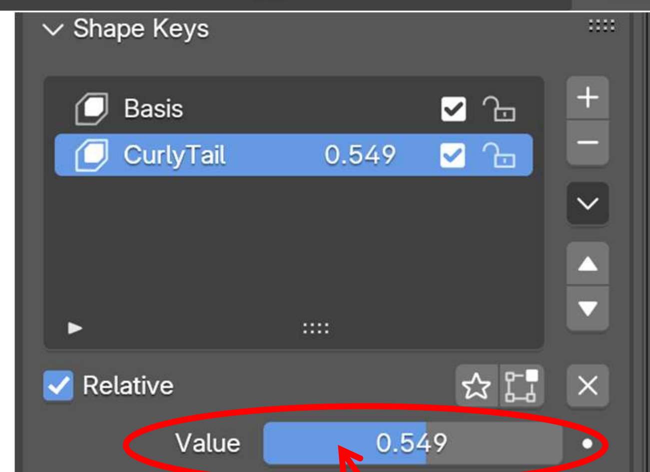
Shape Keys: A Modeling Aid

4. Under **Shape Keys**, click the plus sign **+** again. Give the new Shape key a more descriptive name

5. Now edit the original object by moving vertices, edges, or faces. Do this in **Edit Mode**.



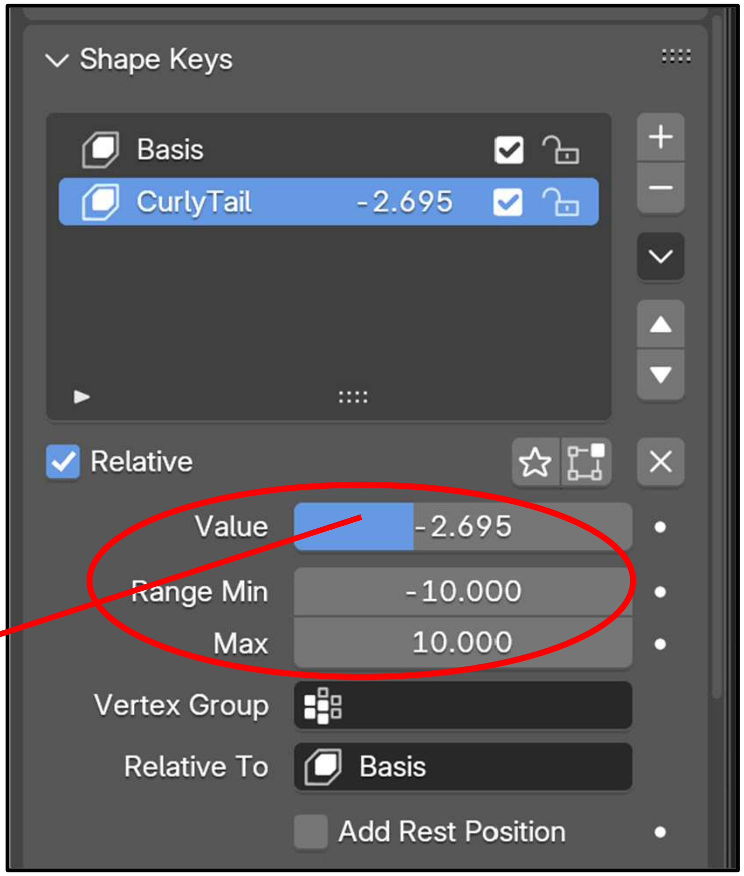


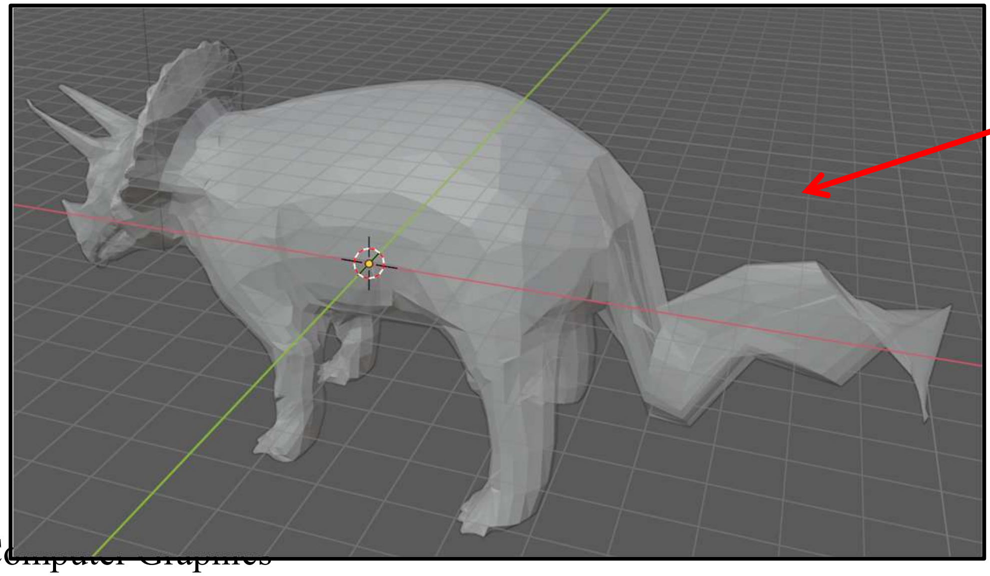


6. When you're done editing, go back to **Object Mode** and change the **Value** slider. A Value of 0. gives you the Basis object. A Value of 1. gives you the edited object. Experiment with values in-between.

Shape Keys: A Modeling Aid

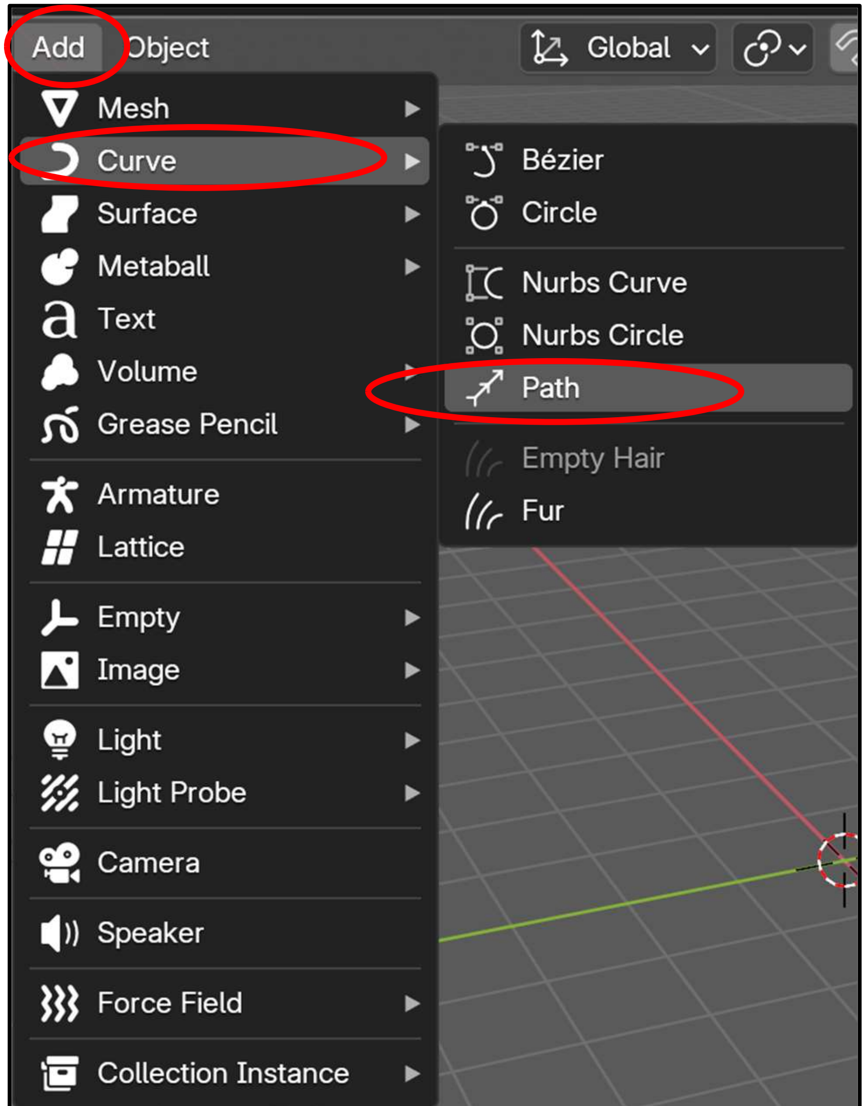
Normally, the Value slider should go between 0. and 1., but it doesn't have to. By changing Value's **Min** and **Max** value beyond that range, you can do object **extrapolation** as well as **interpolation**.



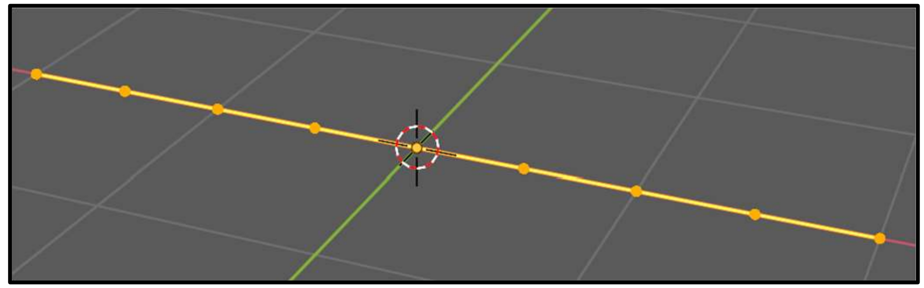


Deforming Along a Curve

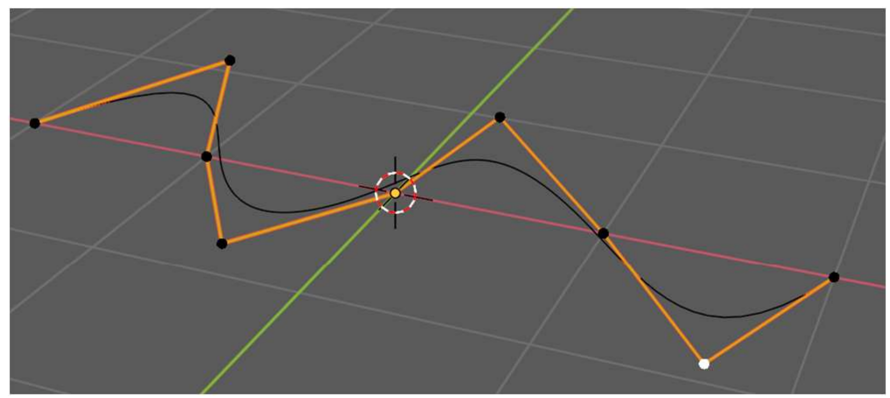
In **Object Mode**, select **Add → Curve → Path**



Tab to **Edit Mode** then **RMB → Subdivide** so it looks like this:



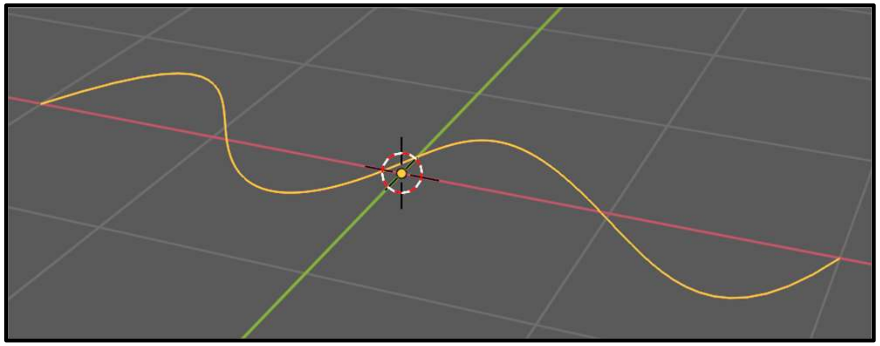
Still in **Edit Mode,** grab some of the red control points and move them in Y or Z:



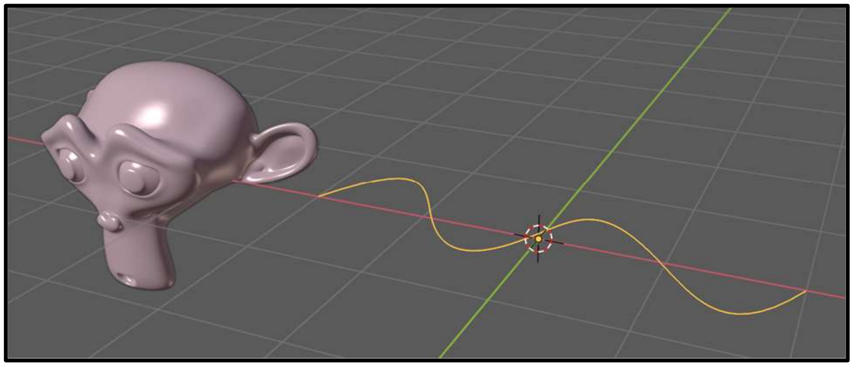
Now **Tab** back to **Object Mode**

Deforming Along a Curve

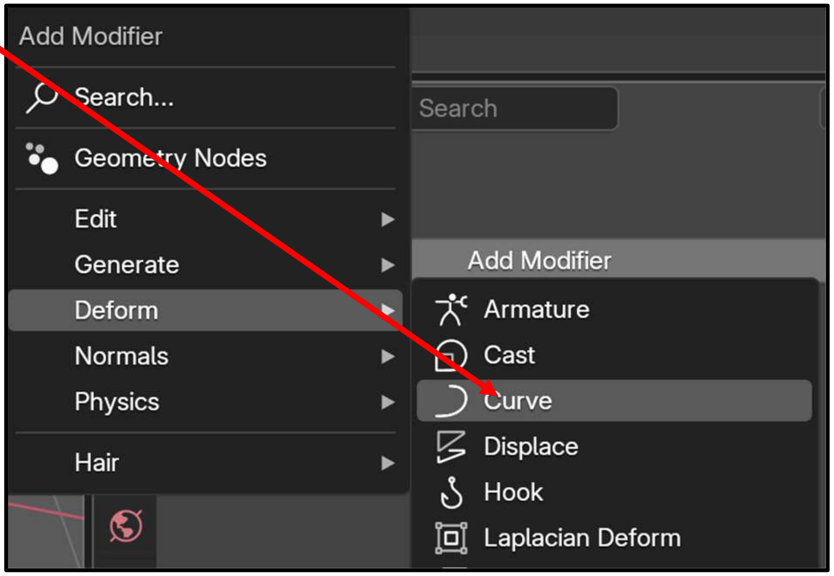
In **Object Mode**, the curve looks smooth:



Now create a 3D mesh object and place it at the left end of the Path:

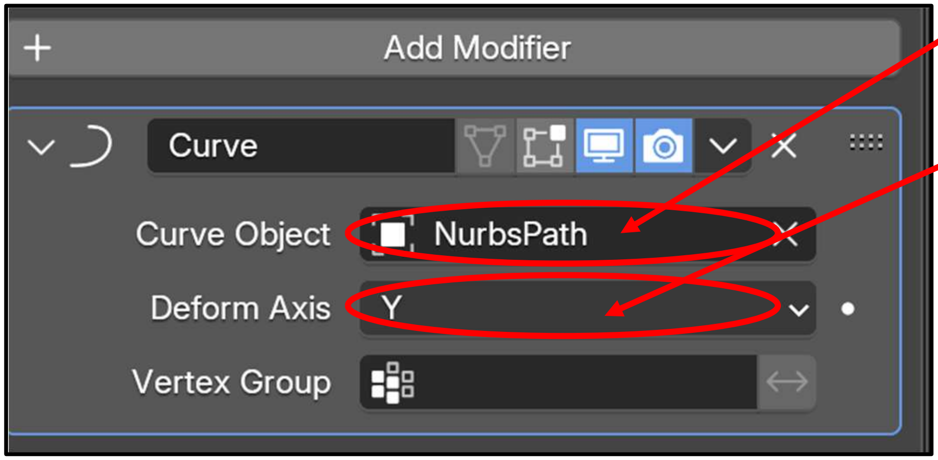


To the non-Path object (monkey in this case), add a **Modifier → Deform → Curve**



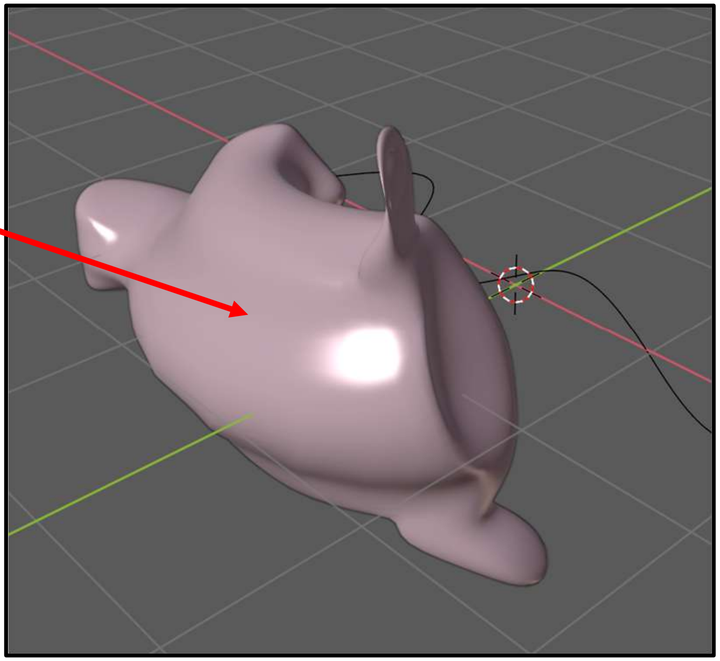
Deforming Along a Curve

Select the **Path** object here



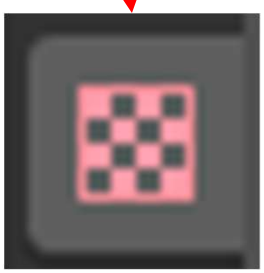
Select a **Deform Axis** direction

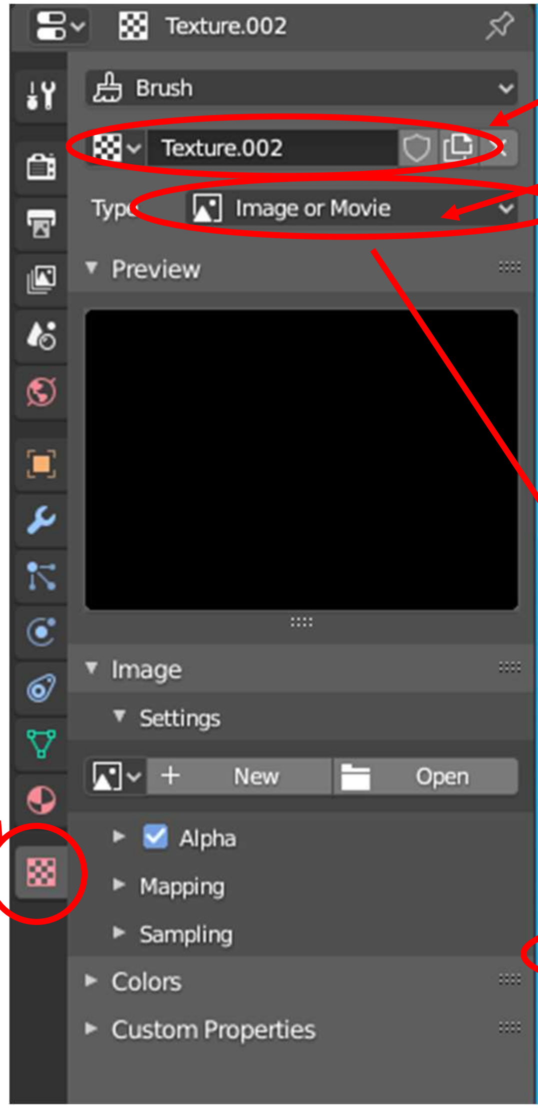
Move the Monkey along the Y axis. This deforms the object along the curve.



Texture Pattern Displacements

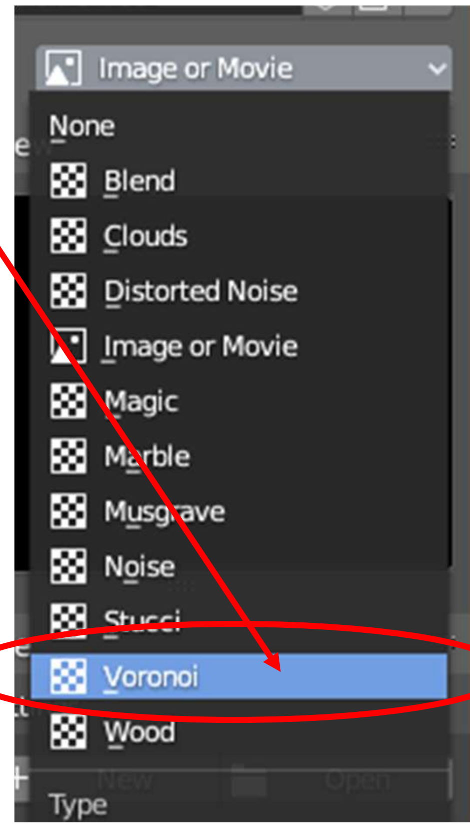
Click on the **Texture Property button**

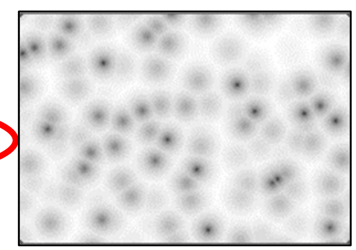




Remember the texture “name” (**Texture.002**) – you will need it later.

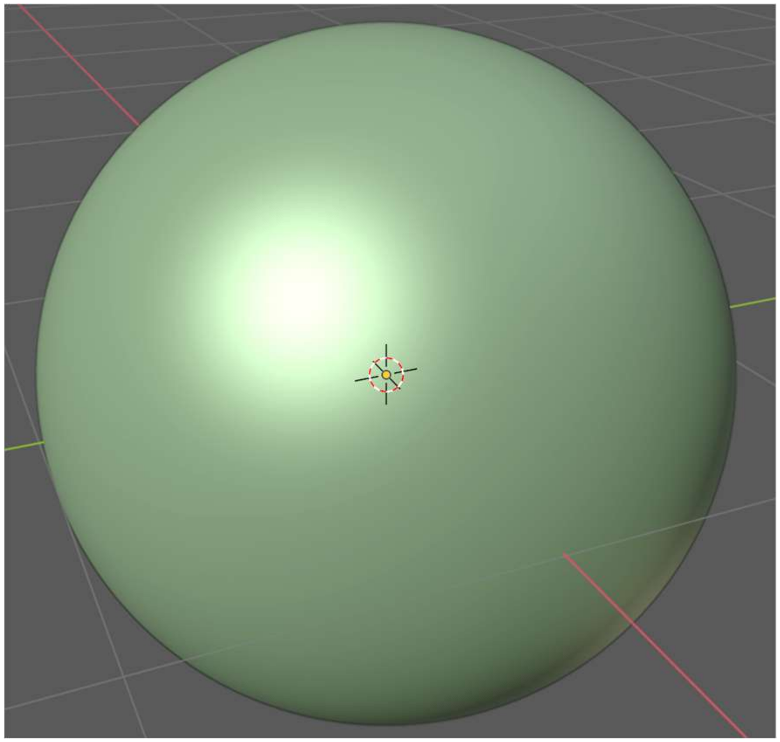
Select which texture you want for the displacement pattern.
I like **Voronoi** because of the cells

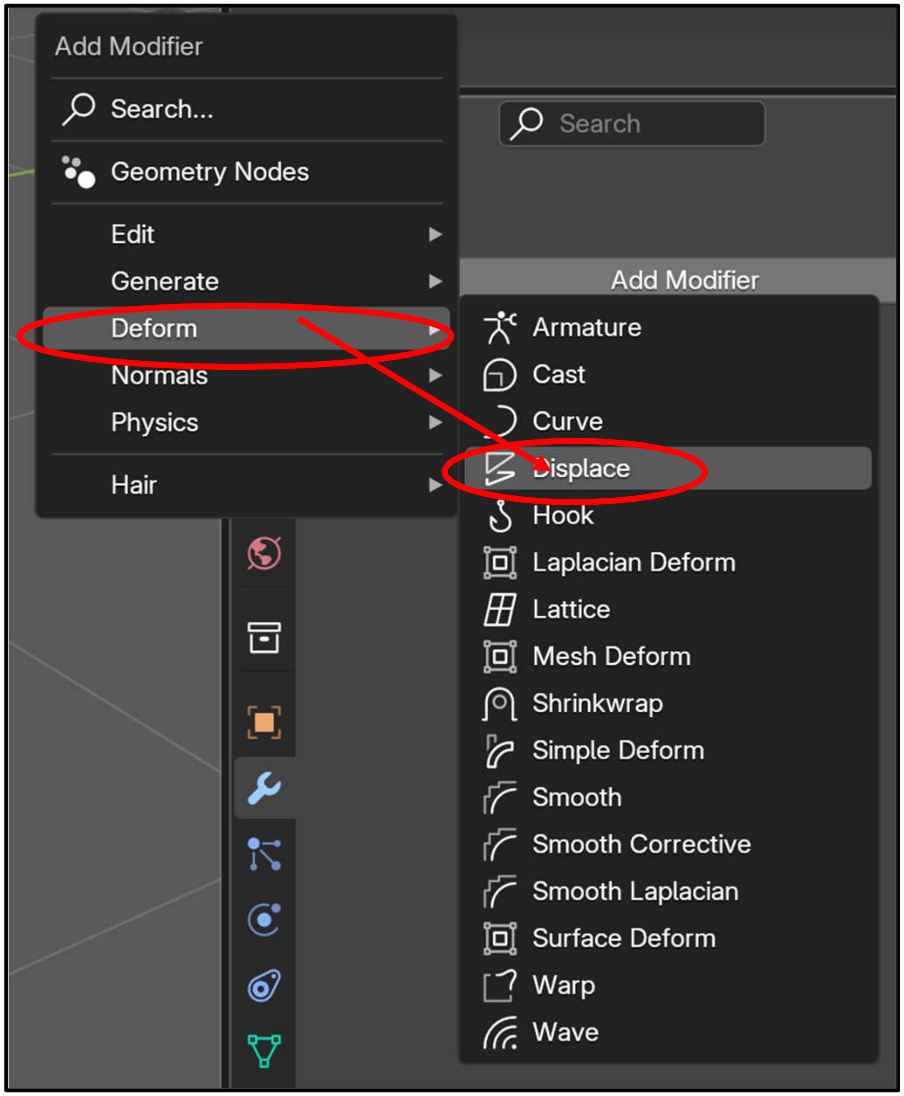




Texture Pattern Displacements

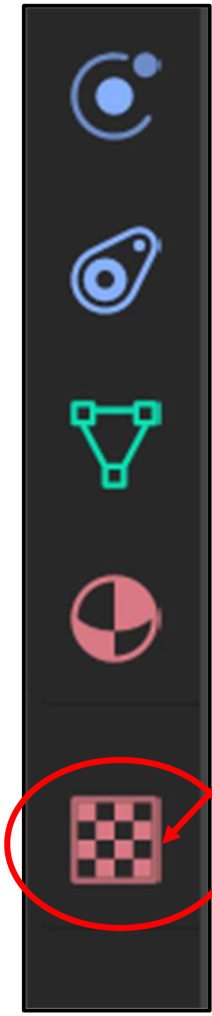
Create an object, add a couple of levels of **Subdivision Surface Modifier**, then add a **Displace Modifier.**

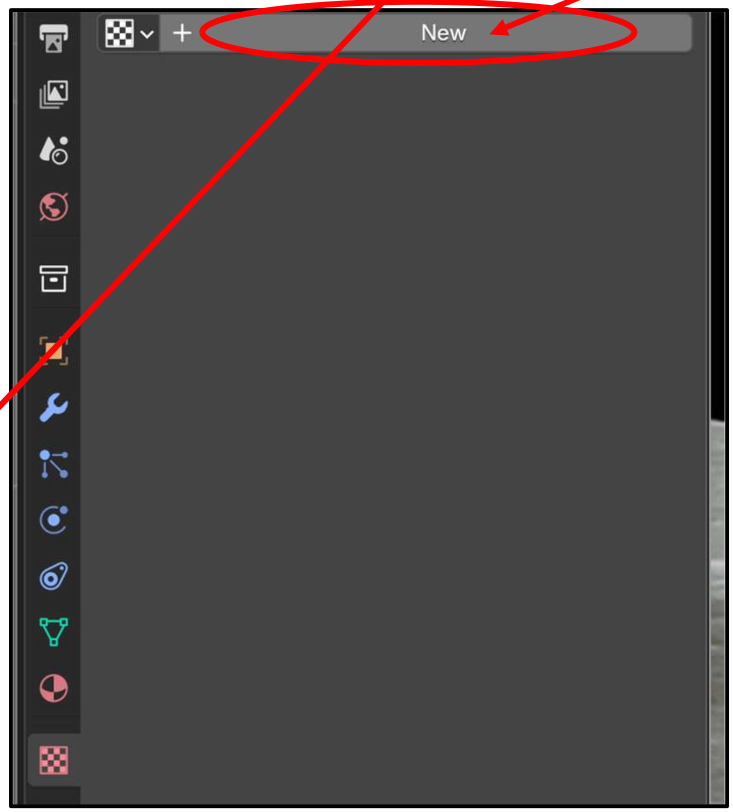


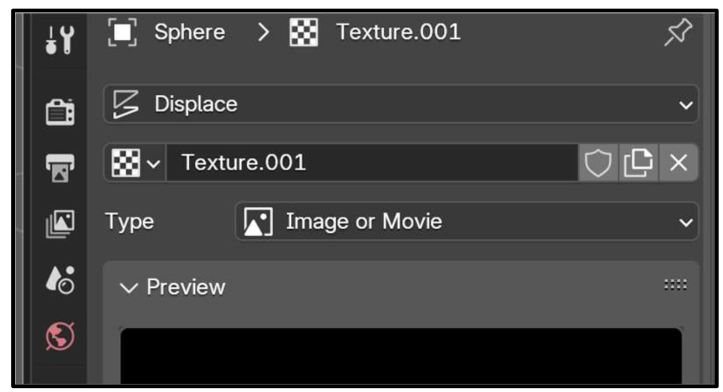


Texture Pattern Displacements

When you select the Displace Modifier, a texture icon will appear here. Click it. Then select **New**.

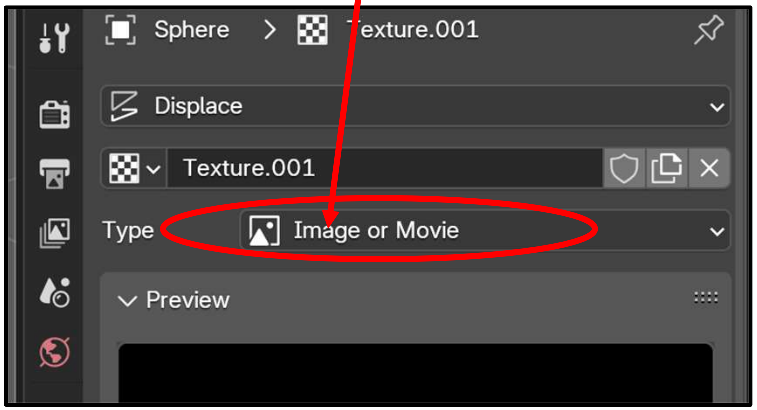


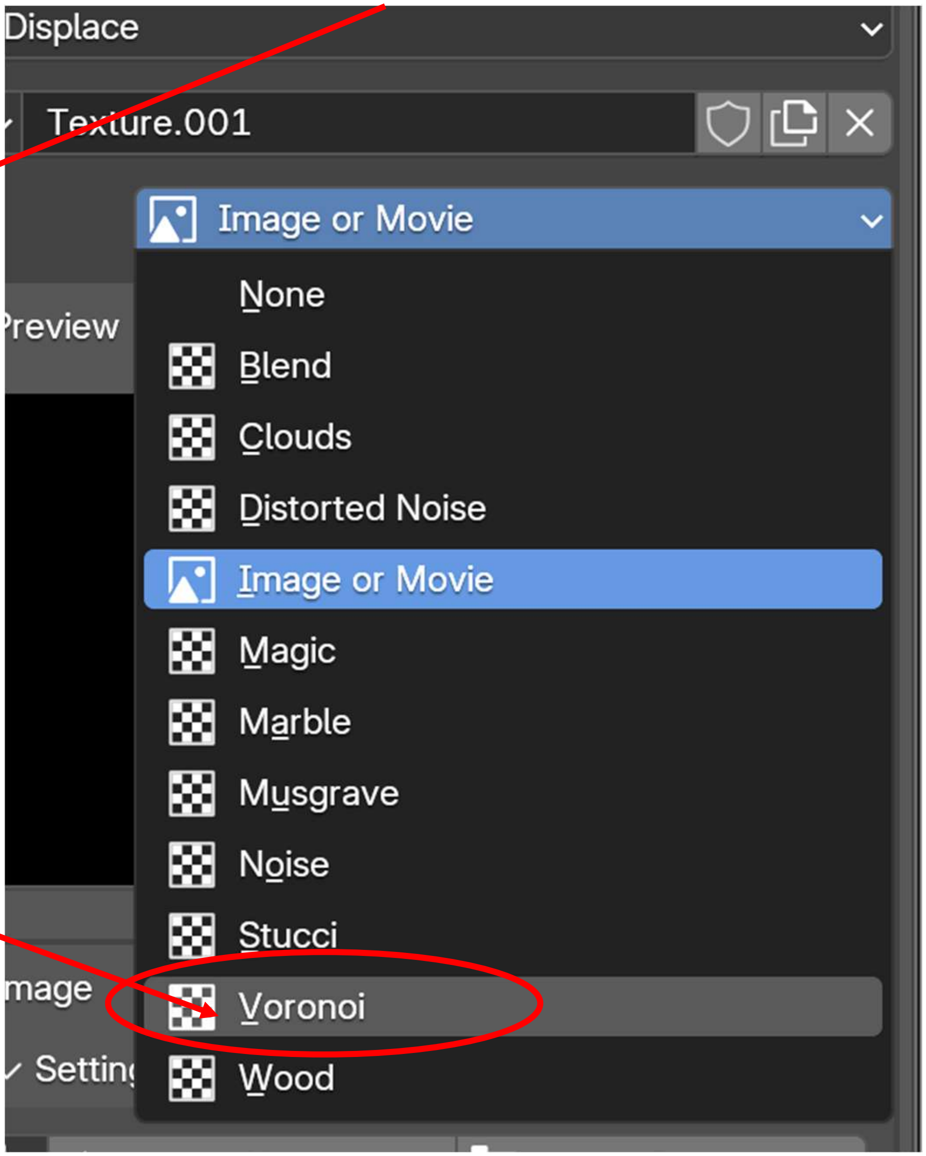




Texture Pattern Displacements

Select **Image or Movie**.

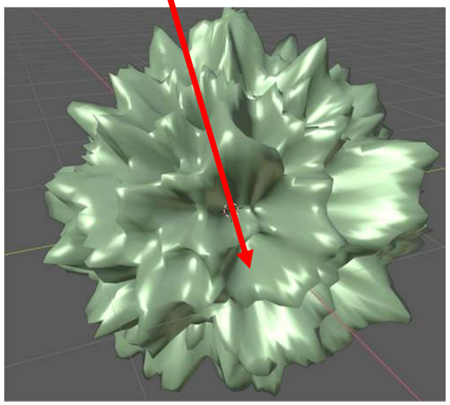


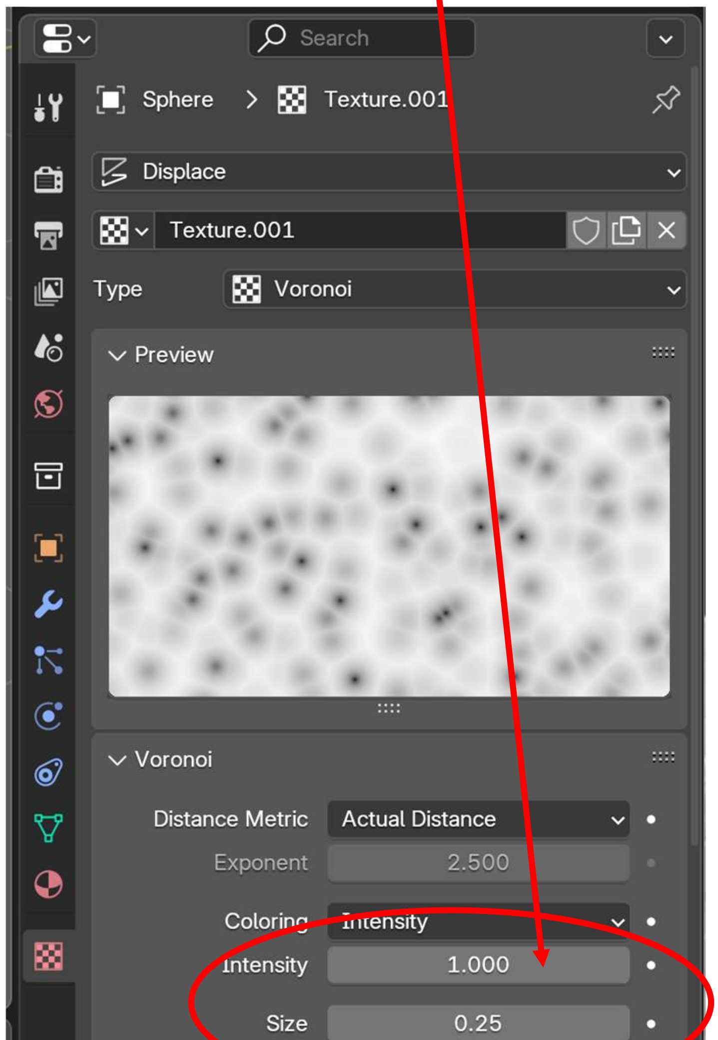


You can select anything in this list that you want. I am partial to **Voronoi**!

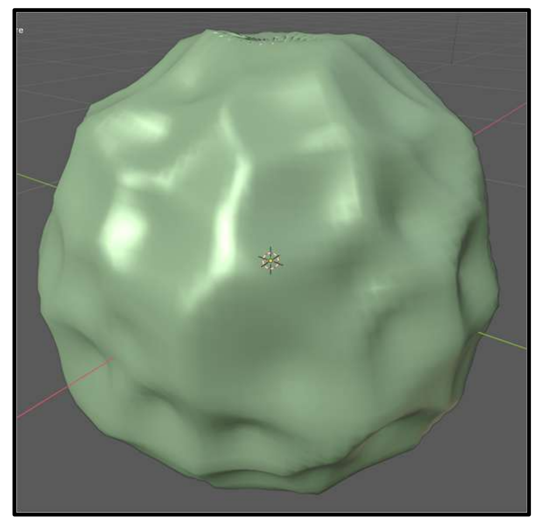
Texture Pattern Displacements

At this point, your object might have gone wild. If you like it this way, then leave it alone. If you want to change it, adjust these numbers:



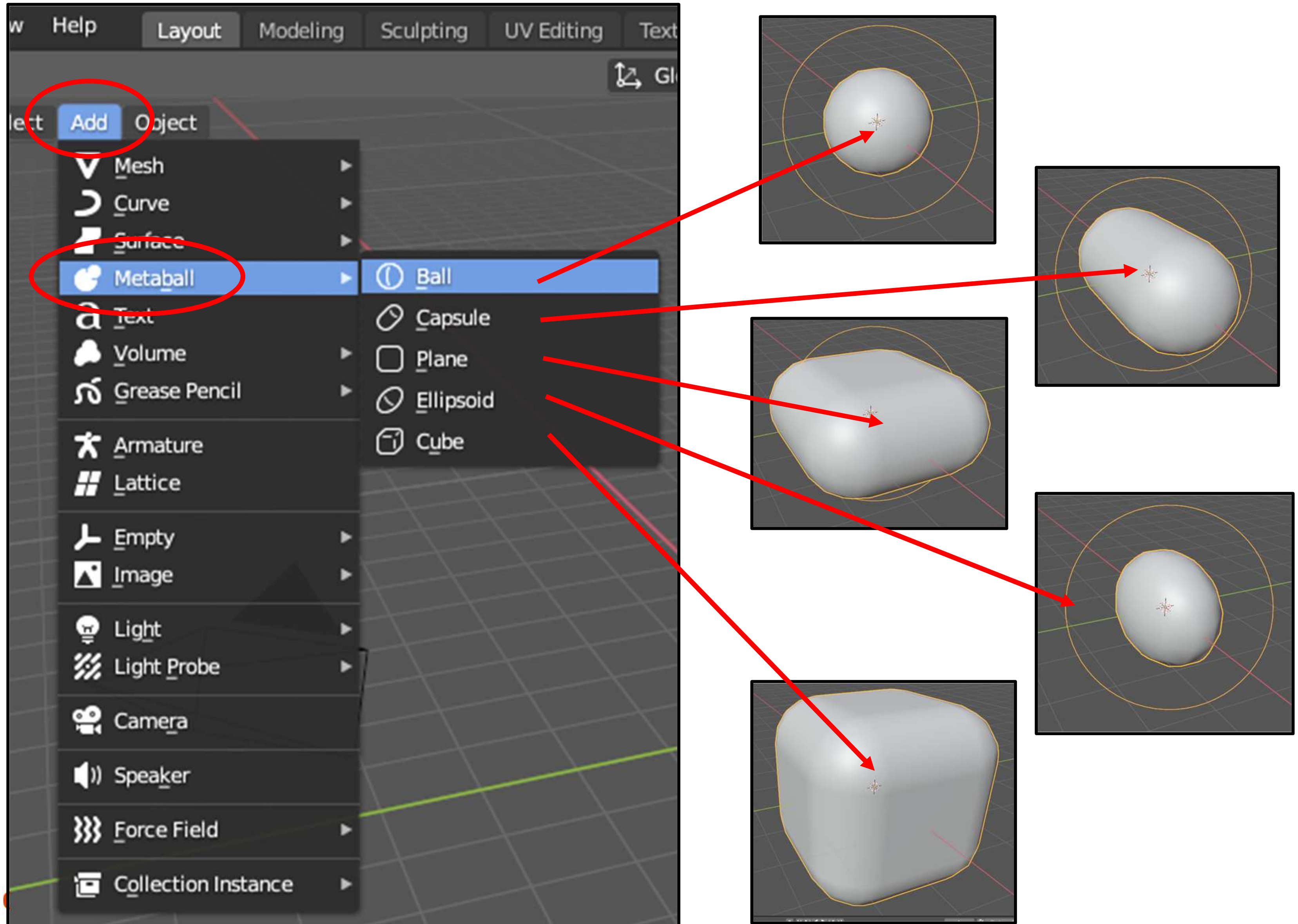


I wanted this to look more like a rock than an exploding star:



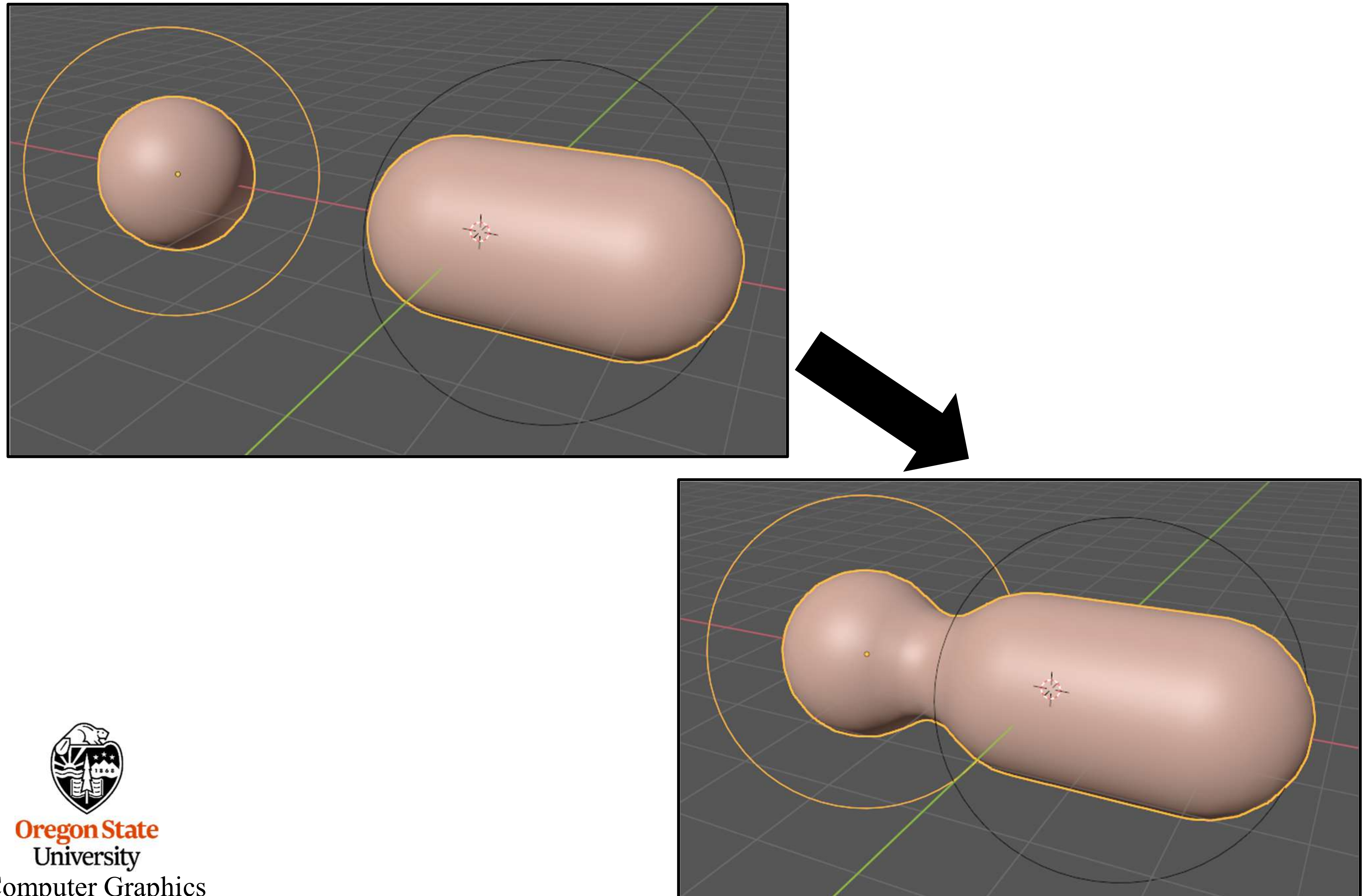
Metaball Objects

Metaball Objects are another way to 3D model:



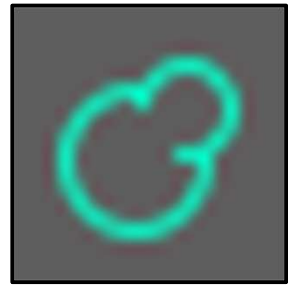
Metaball Objects

The cool thing is that, if you move (**g**) them close enough, they will "glom" into a single object

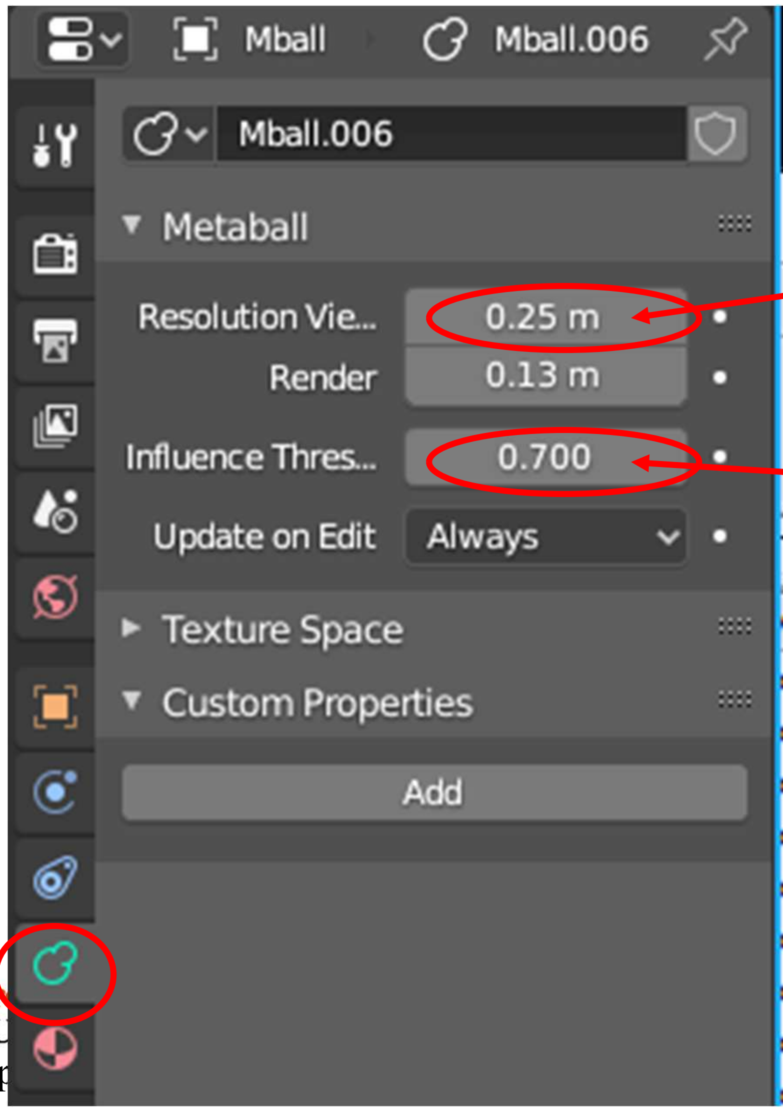


Oregon State University
Computer Graphics

Metaball Objects



There is a special Metaball properties menu to control their characteristics:

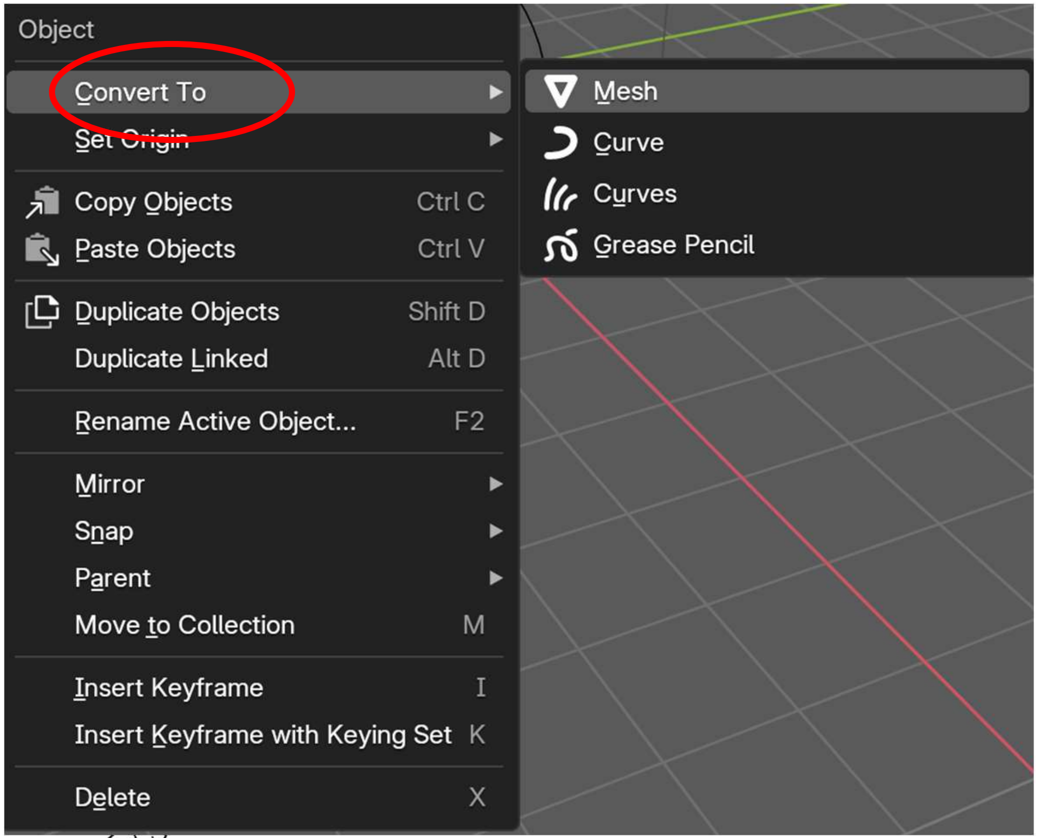


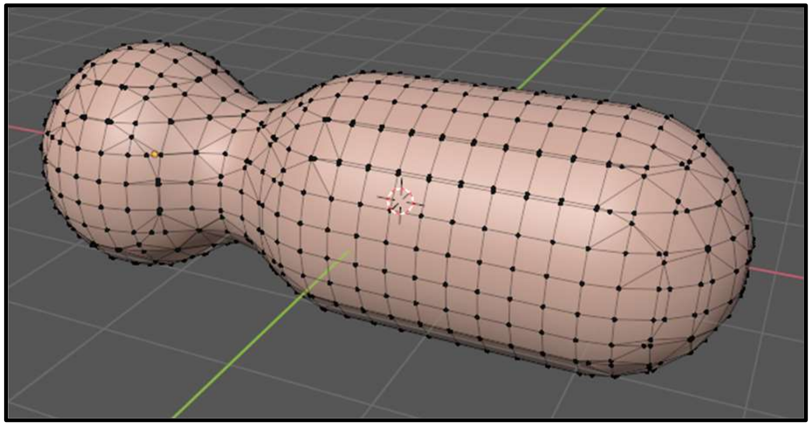
A smaller number here gives a better surface quality.

How close 2 meatball objects need to be to “glom”

Metaball Objects

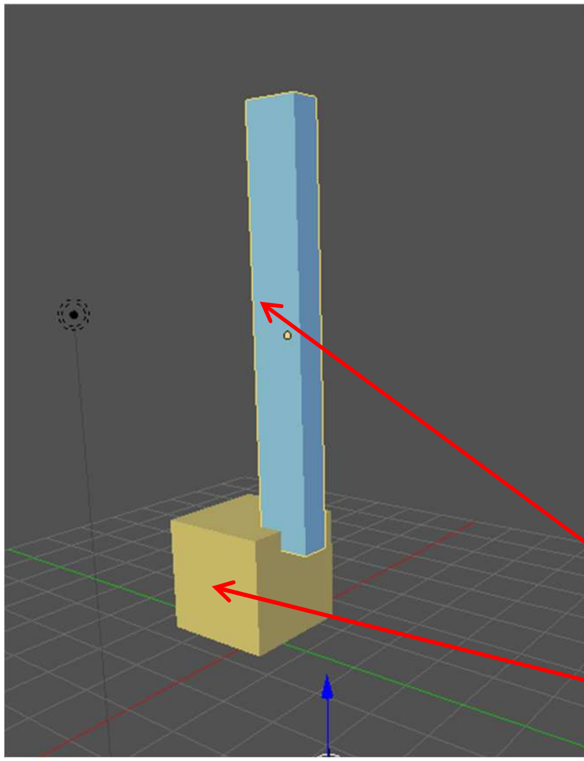
But, Metaball objects *are not meshes*, so you cannot do a lot of the cool editing that you can with meshes. But, you can turn a Metaball object into a mesh by selecting **RMB → Convert To → Mesh**





After tabbing into Edit Mode

Parent-Child Relationships in Modeling



Child

Parent

Many times, one object is connected to another object. In modeling, this is called a **Parent-Child relationship**. (It is also sometimes called a Hierarchical Relationship.)

When the Parent moves, the Child moves with them.

When the Child moves, the Parent is unaffected.

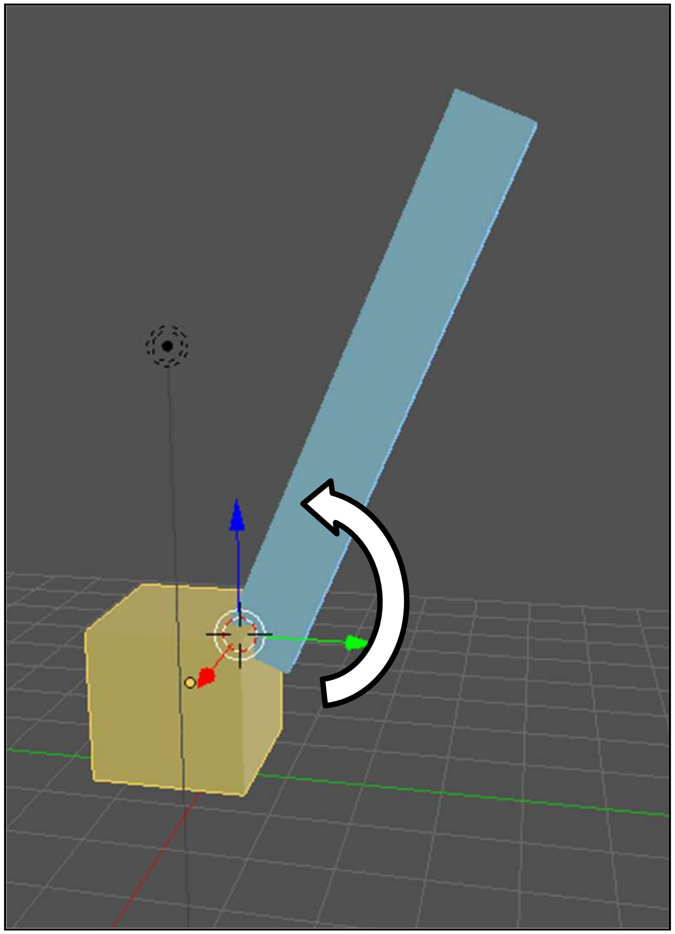
This is *really* useful !

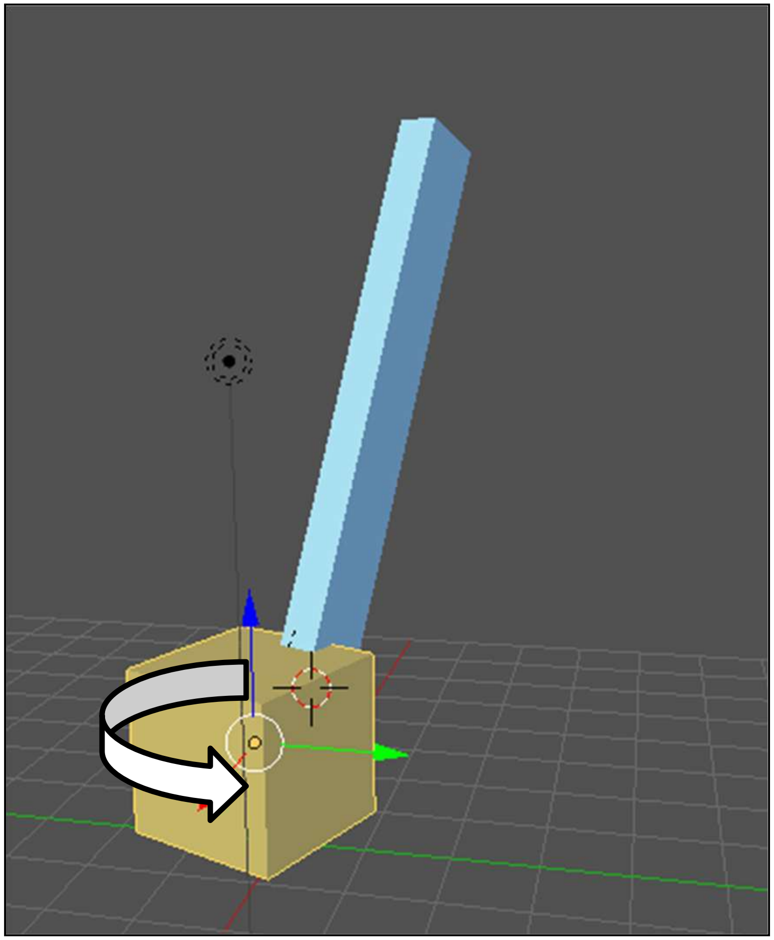
You can create as many levels of Parent-Child relationships as you want: As the song goes:

"The foot bone's connected to the ankle bone, the ankle bone's connected to the leg bone, the leg bone's connected to the thigh bone, …"

1. Move the Child's pivot-point to where you want it connected to the Parent. A convenient way to do this is to Tab into Edit Mode and translate ('g') the object, moving it until the pivot-point is where you want it to be. Then Tab back to Object mode and translate the object and pivot-point back where they belong.
2. Select the Child piece
3. Shift-select the Parent piece
4. Hit **Control-'p'** on the keyboard

Parent-Child Relationships in Modeling

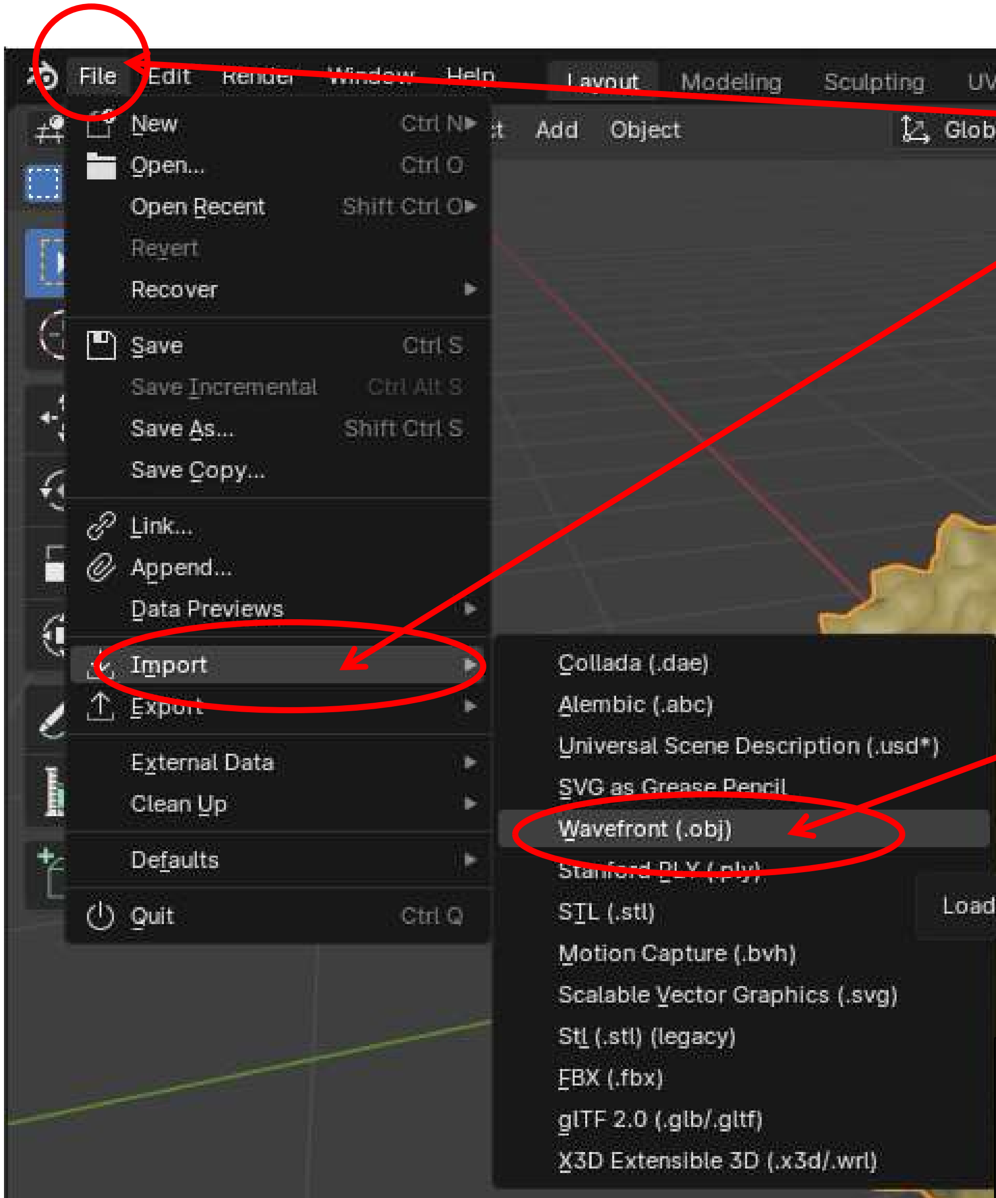




If you rotate the blue (child) piece ('ryy'), then just it will move

If you rotate the yellow (parent) piece ('rz'), then both it and the child piece will move

Importing Objects from Other Places



Select **File → Import**

Collada = export format from game modeling systems

Stl = 3D printer format

3ds = format from Autodesk 3D Studio

Obj = Probably world's most common export format There are a *ton* of .obj models for free on the Internet! Google the phrase:

free obj files

.obj files are also pretty straightforward to create. So, if you have a shape in mind and can write a computer program to generate it, you can write your own .obj file and Import it into Blender.

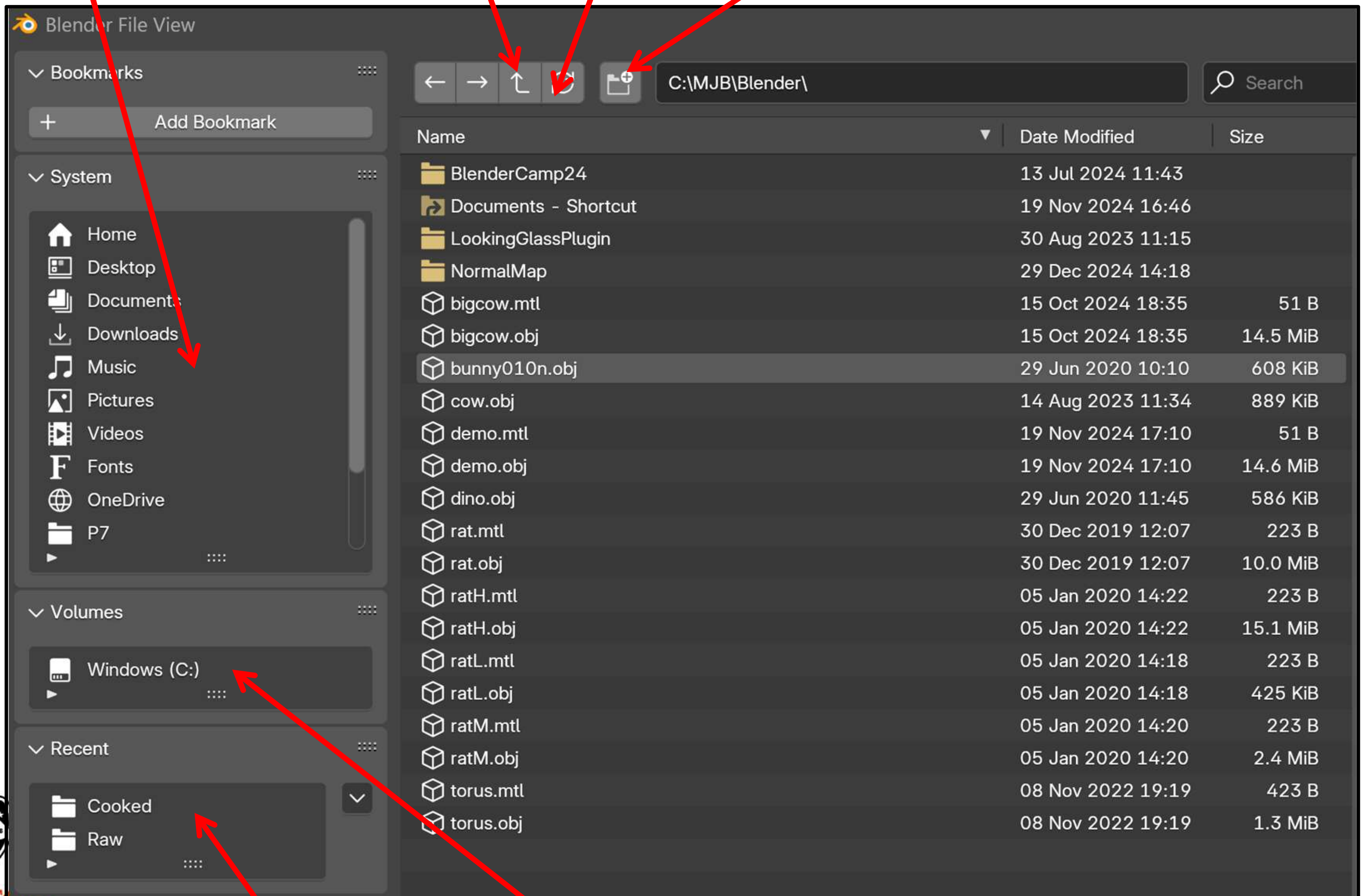
The Blender File Navigator

System locations

Go up one folder

Refresh the file list

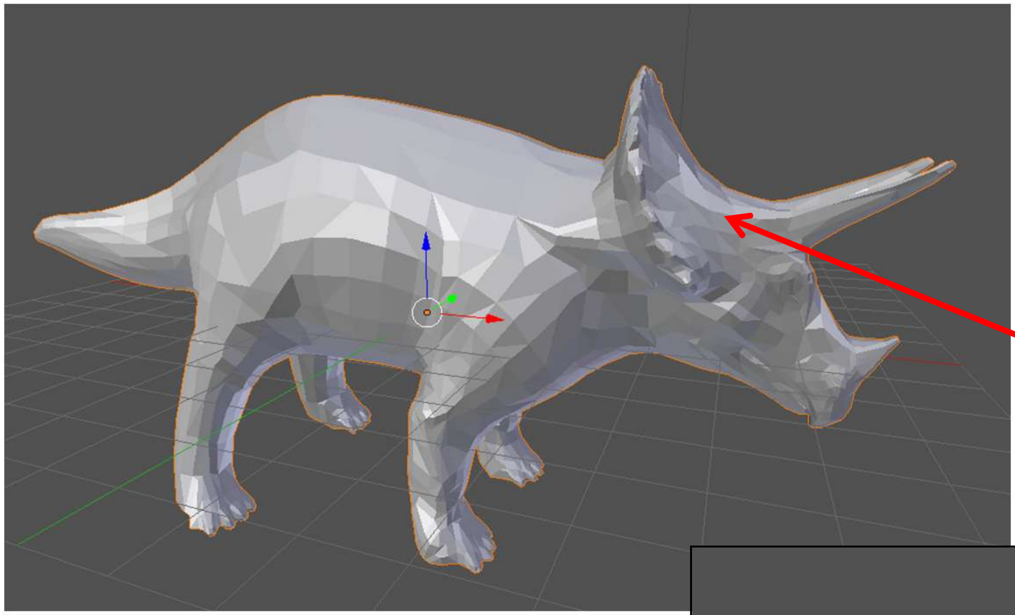
Create a new folder



Recent folders accessed

Disc volumes

Importing Objects from Other Places

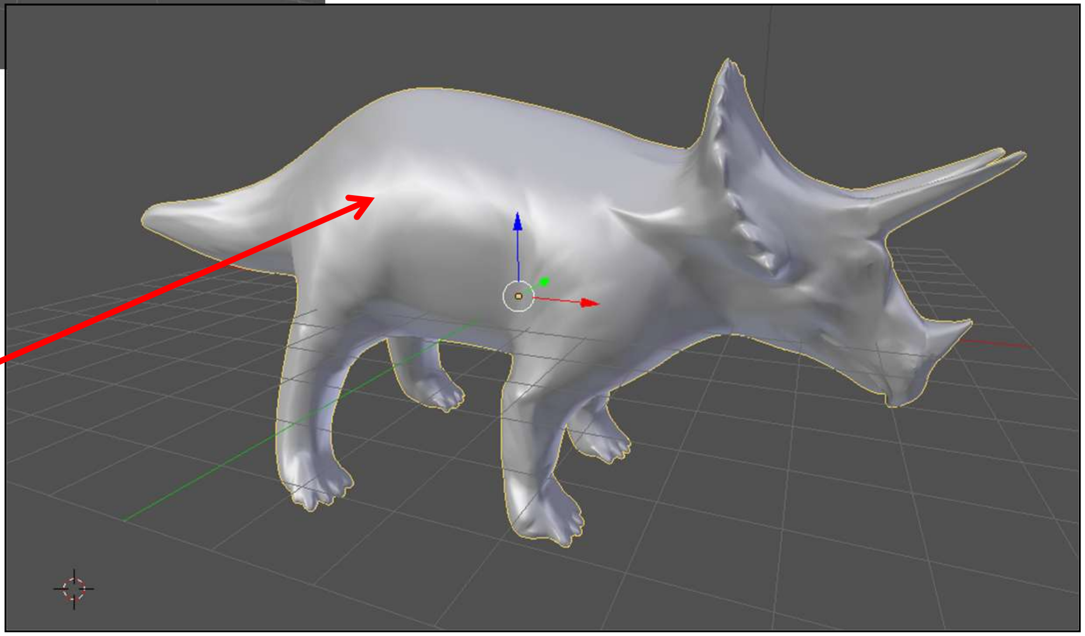


File = **dino.obj**

You can get this file from the web page:
http://cs.oregonstate.edu/~mjb/blender

As-is, flat shaded

Subdivision surfaced
+
Smooth shaded



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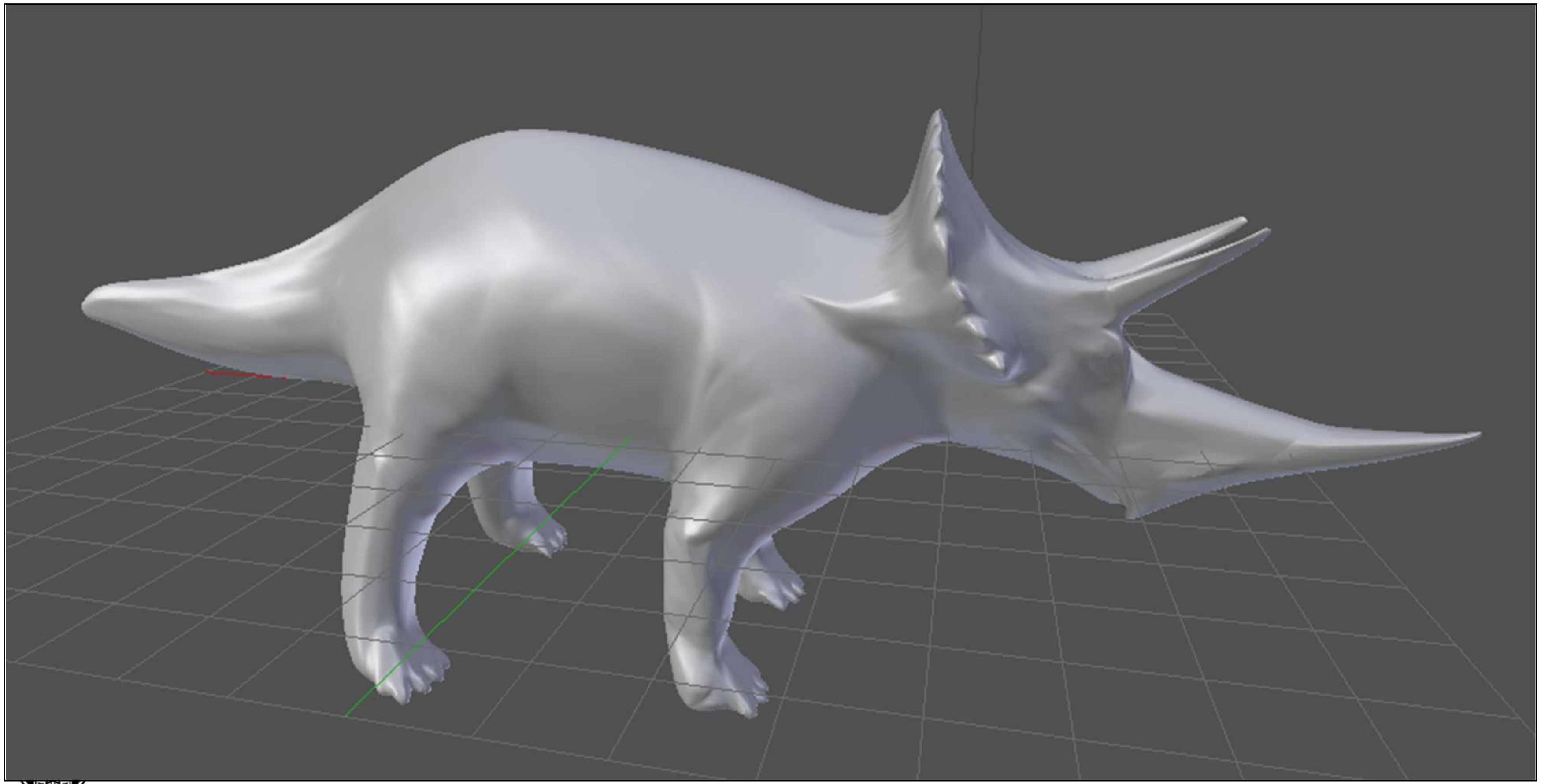
Importing Objects from Other Places

Abusively edited using a Lattice



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Importing Objects from Other Places

Here are some places to find OBJ files to use yourself:

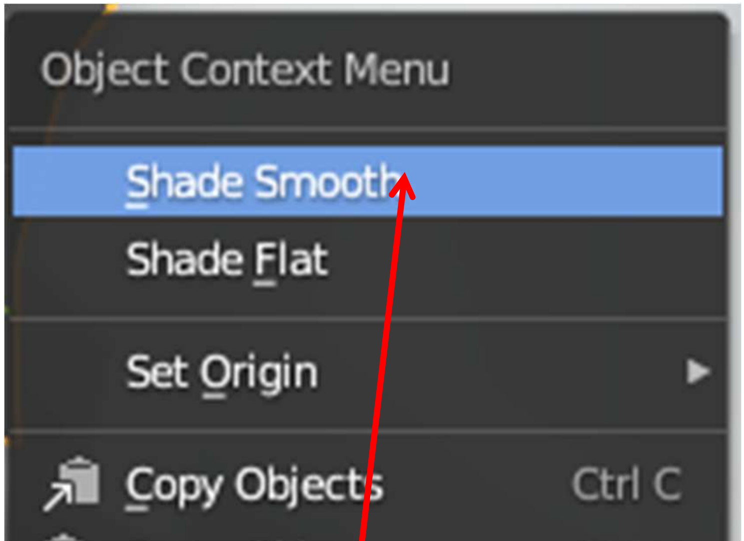
- https://www.blenderkit.com/asset-gallery?query=category_subtree:model%20order:-created
- https://polyhaven.com/
- http://thefree3dmodels.com
- https://free3d.com/3d-models/star-wars
- http://lodbook.com/models
- http://people.sc.fsu.edu/~jburkardt/data/data.html
- https://sketchfab.com/features/free-3d-models
- http://www.turbosquid.com/Search/3D-Models/free/obj

Links checked: July 12, 2024

Or Google the phrase: **"free obj files"**

The ***blenderkit*** link also provides a Blender plugin. If you install it into Blender, then you can search for OBJ files without ever leaving Blender.

Exporting Objects to Other Places

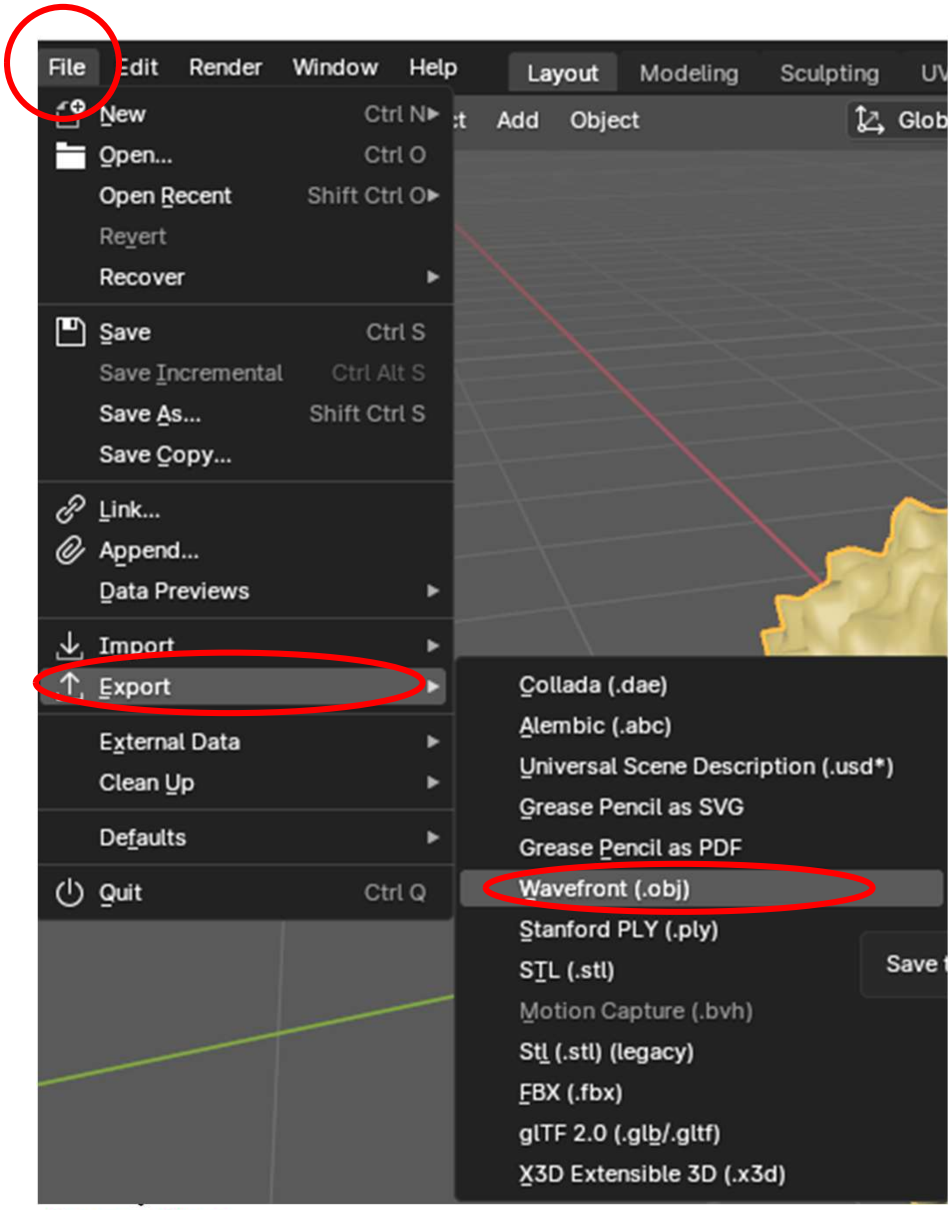


Blender has a number of file formats it knows how to export to. If you are looking for a nice, general one to experiment with, try the **.obj** format.

Just be sure to use the RMB menu to select **Shade Smooth** first

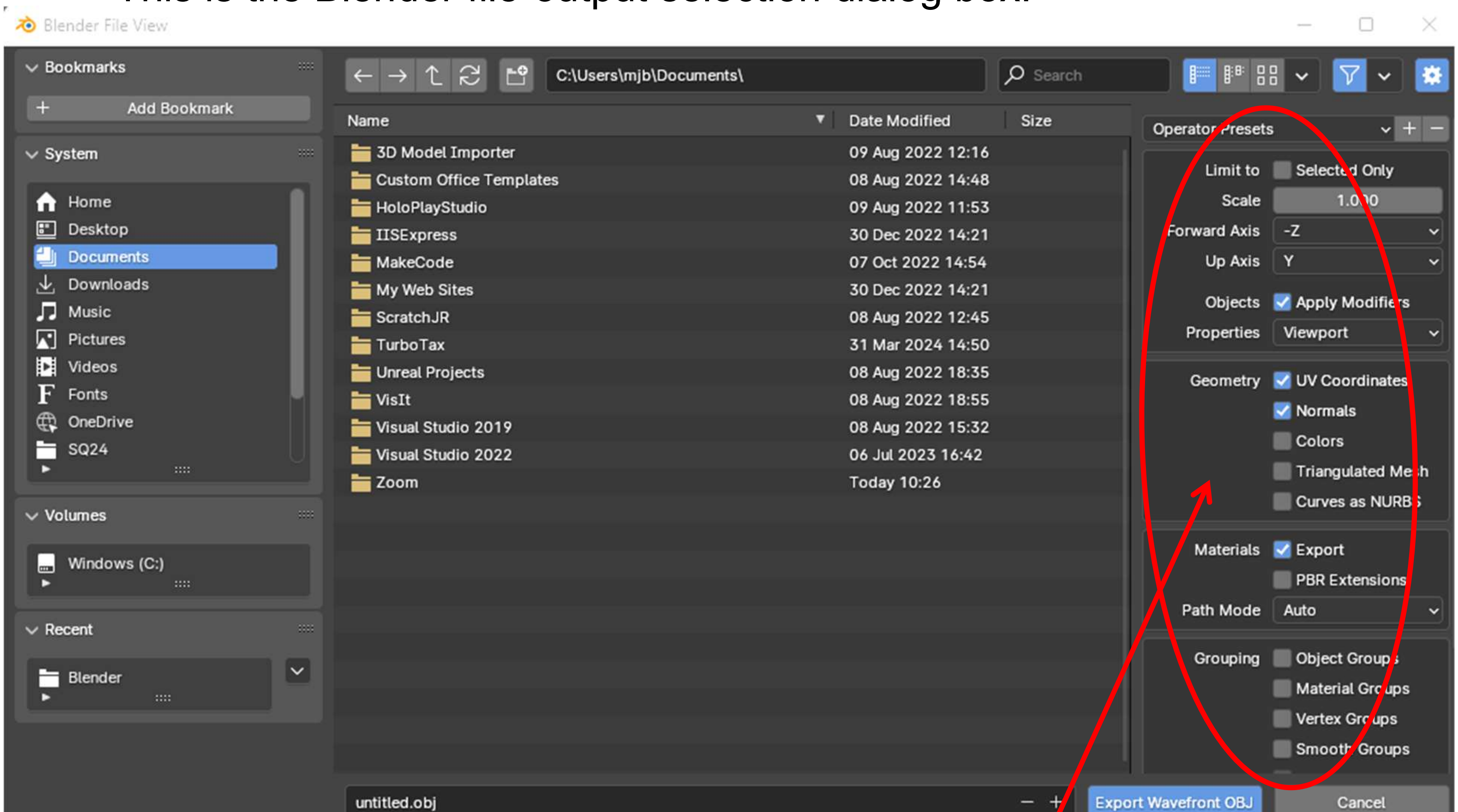
Select **File → Export → Wavefront (.obj)**

Exporting to an OBJ File



Exporting to an OBJ File

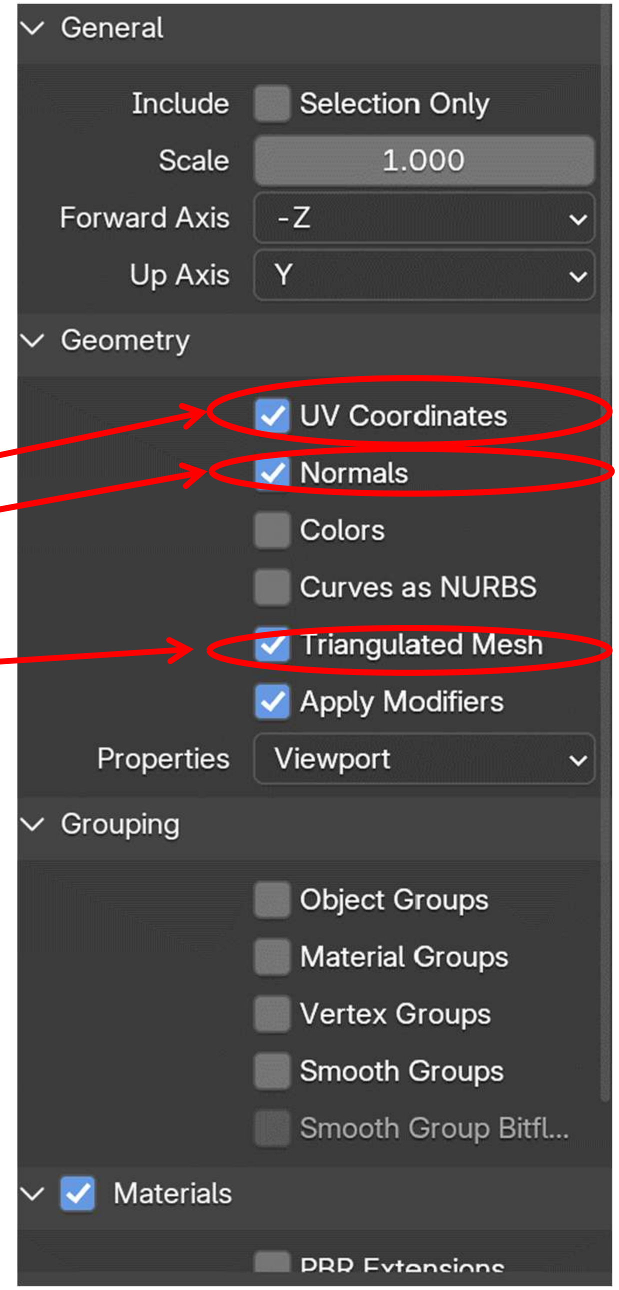
This is the Blender file-output selection dialog box:



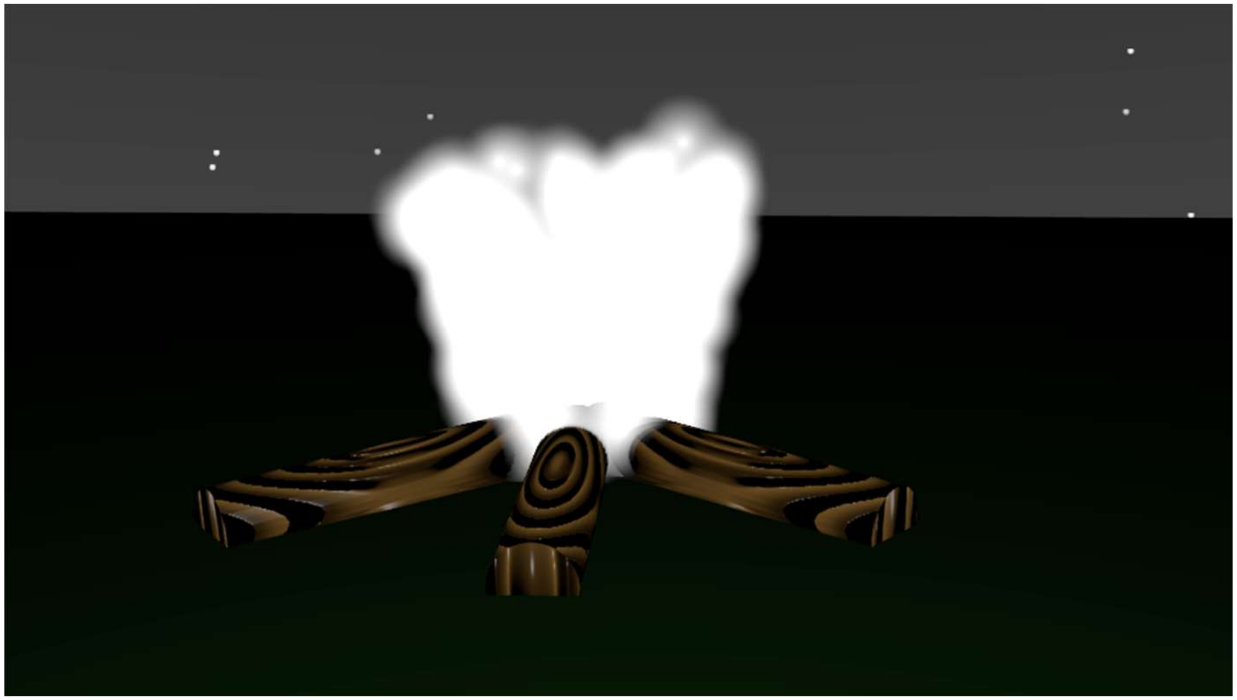
OBJ-specific settings
(see next slide)

OBJ-Specific File Settings

In the export dialog, be sure to click on
- **UV Coordinates**
- **Normals**
- **Triangulated Mesh**



7. Rendering



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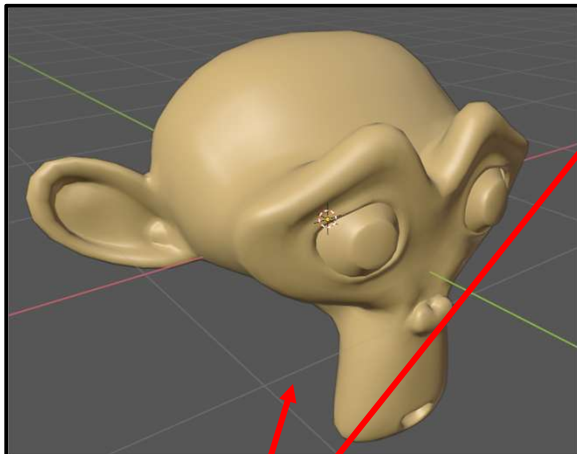
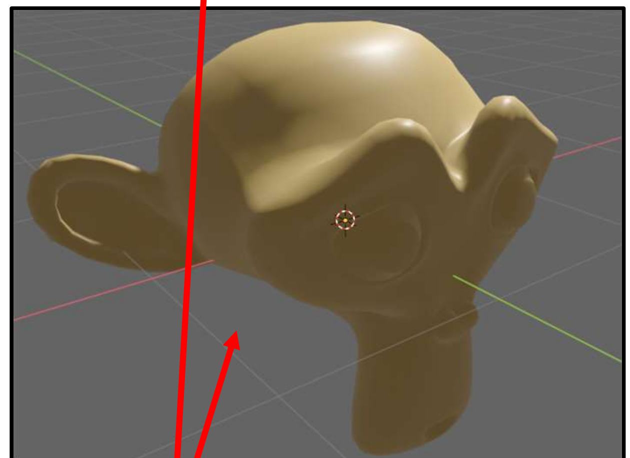
Computer Graphics

On-screen Rendering Mode



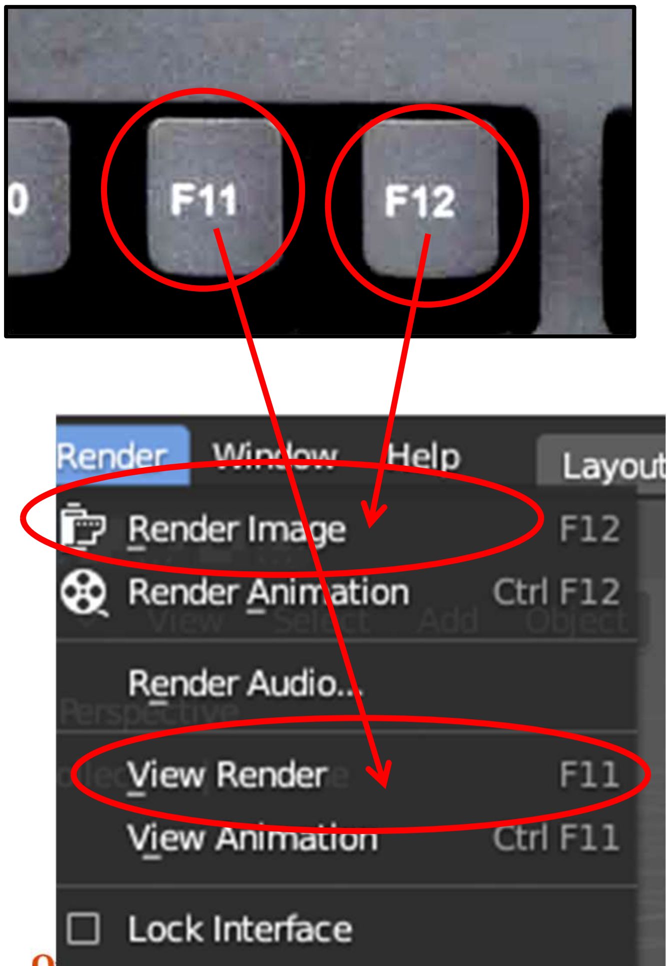


We have been using this one. This one gave you good generic lighting so you could model without worrying about light sources.

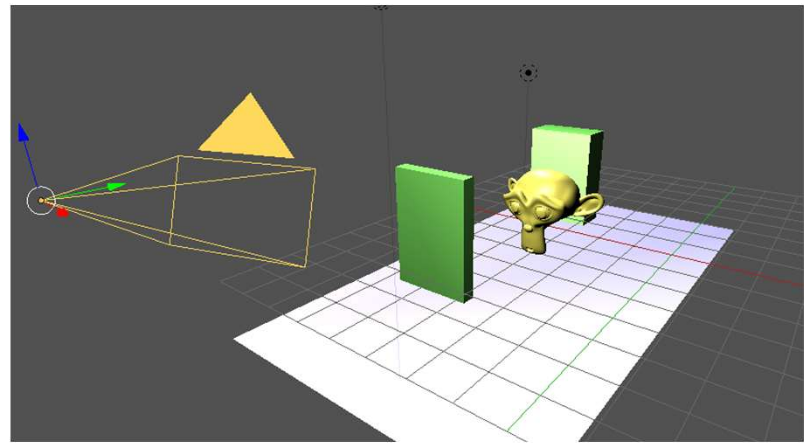
Now switch to this one.
This one will give you a pretty-good preview of what happens when you actually render the scene. But, we now have to deal with Rendering specifics.

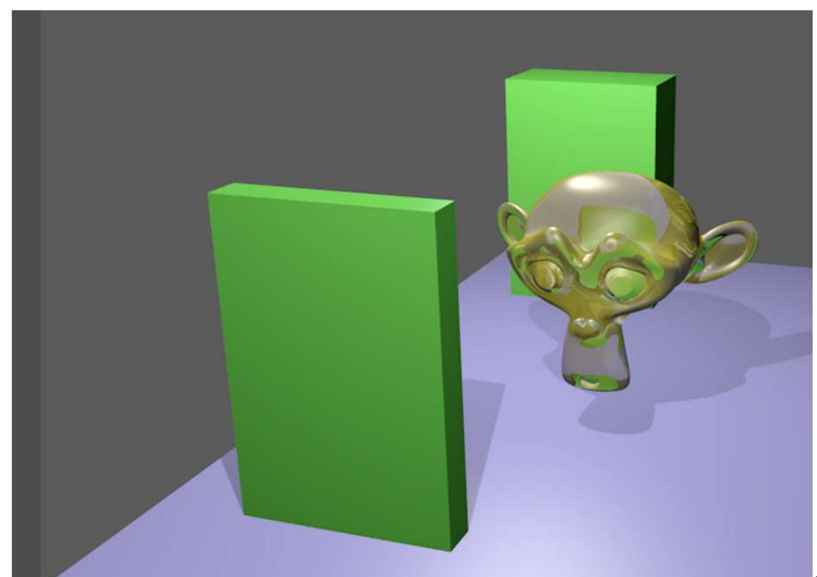
Rendering

"Rendering" is Blender's process for creating *really* high-quality images. Click on **Render** → **Render Image** or hit the **F12** key (you might have to hit the **fn** key at the same time). The rendering operation can often take some time, depending on how complex your scene is.



scene.blend



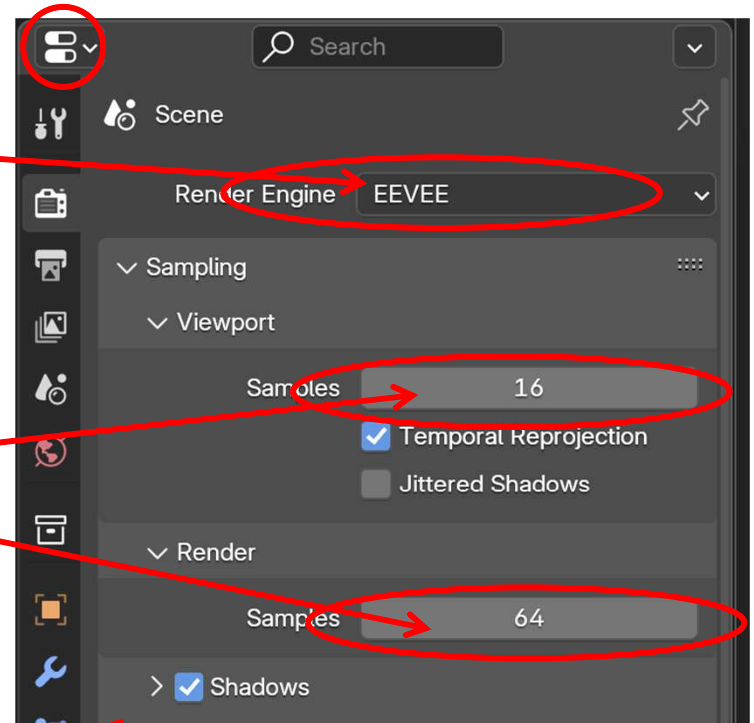


Rendering Properties

Clicking on the **Rendering Properties** button will allow you to set various rendering parameters.

For now, be sure the Render Engine is set to **EEVEE**.

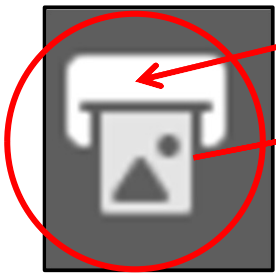
You want at least some **Anti-Aliasing,** which is done by making more than one sample per pixel. 16 and 64 are good values.

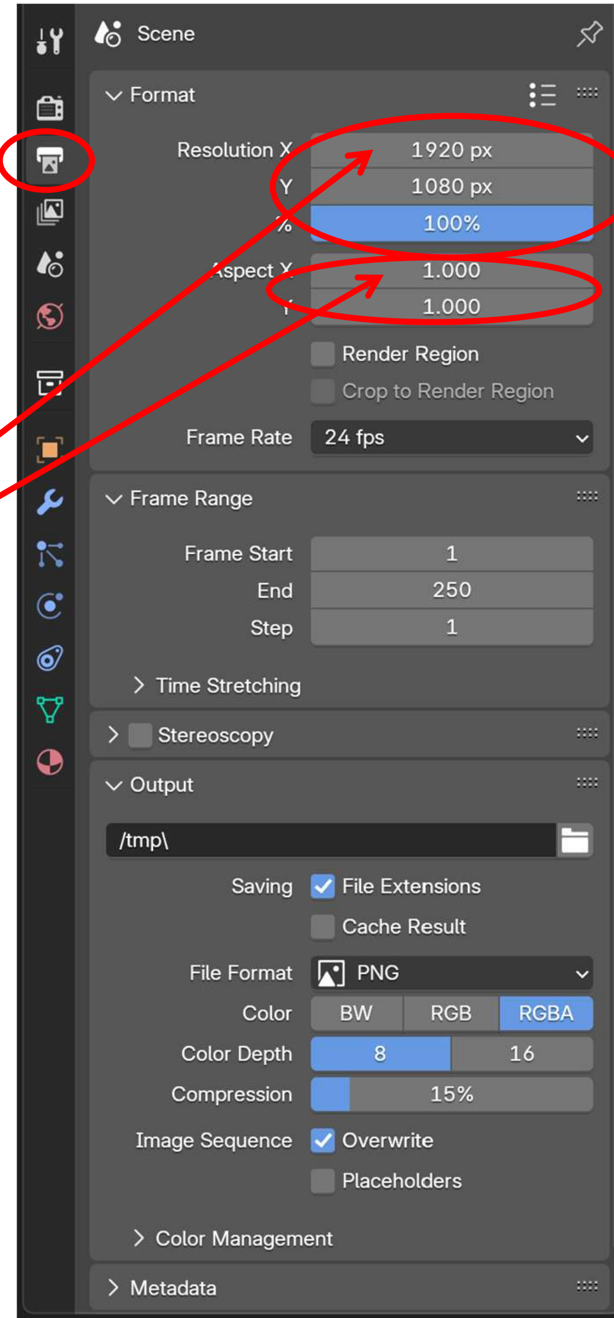


The rest of these are interesting, but are not needed right now.

Output Properties

Clicking on the **Output Properties** button will allow you to set various rendering parameters. The one you care about the most is pixel resolution.



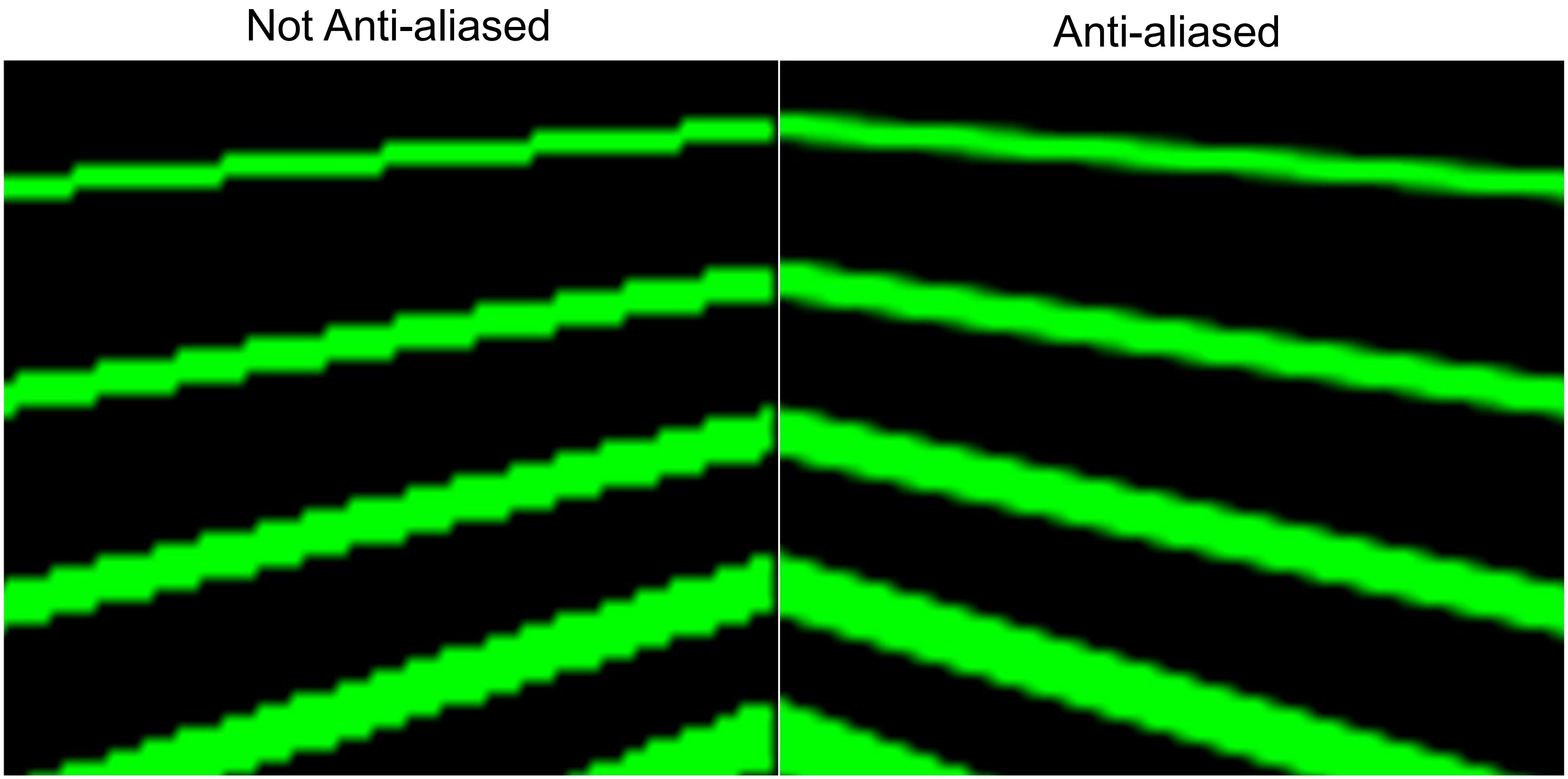


These are OK values, but you can improve your rendering speed by making them smaller. Don't make them smaller by changing the 1920x1080, make them smaller by changing the **100%**.

Notice that the image aspect ratio being used here is 16:9 (=1920:1080). This is the most common aspect ratio today for TVs and computer monitors.

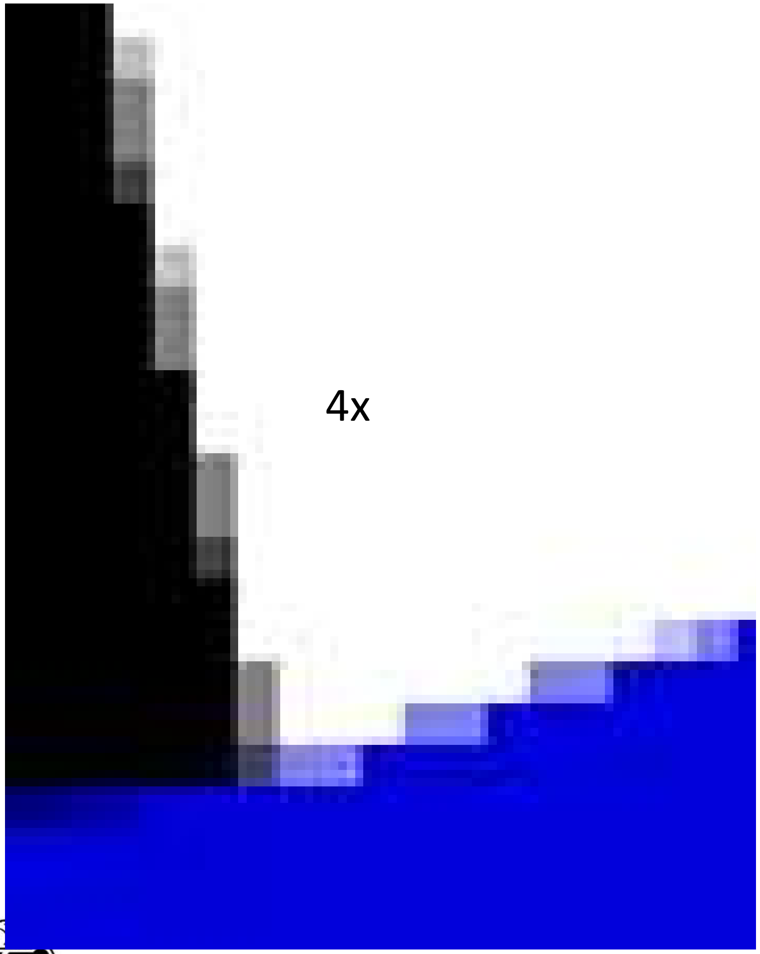
The rest of these are interesting, but not needed right now.

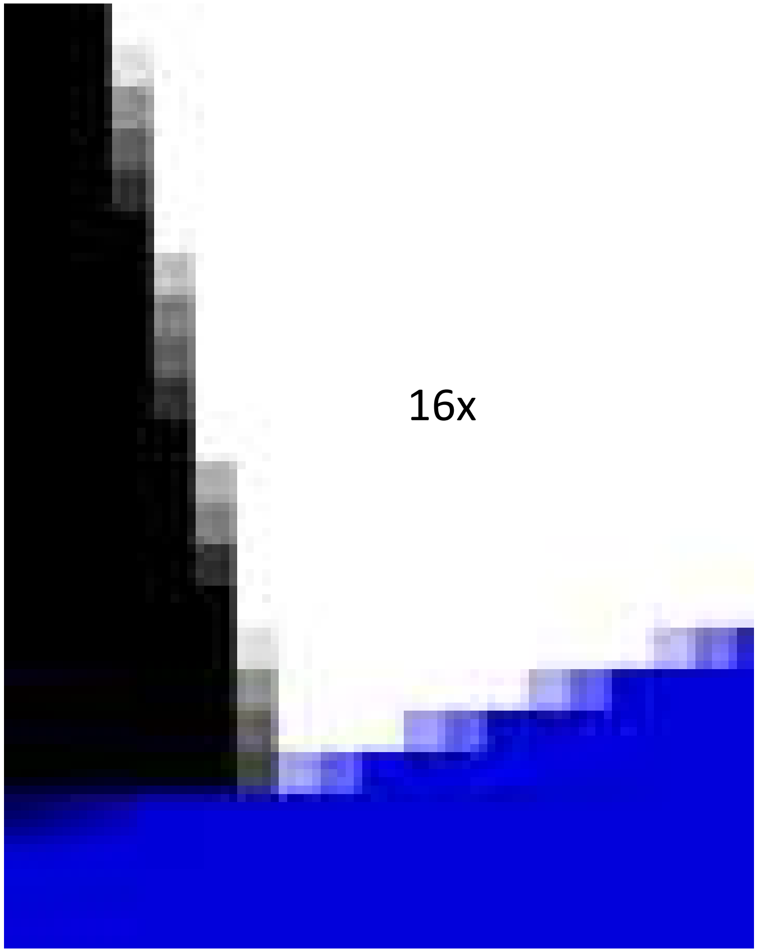
What is Anti-aliasing?



Anti-aliasing is a good-news bad-news joke.
Good news: the scene looks much smoother
Bad news: the scene takes longer to generate
Good news: you probably want to do it anyway

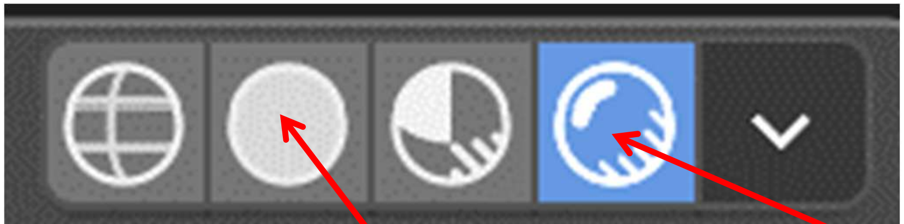
Anti-aliasing is Implemented by Oversampling within Each Pixel





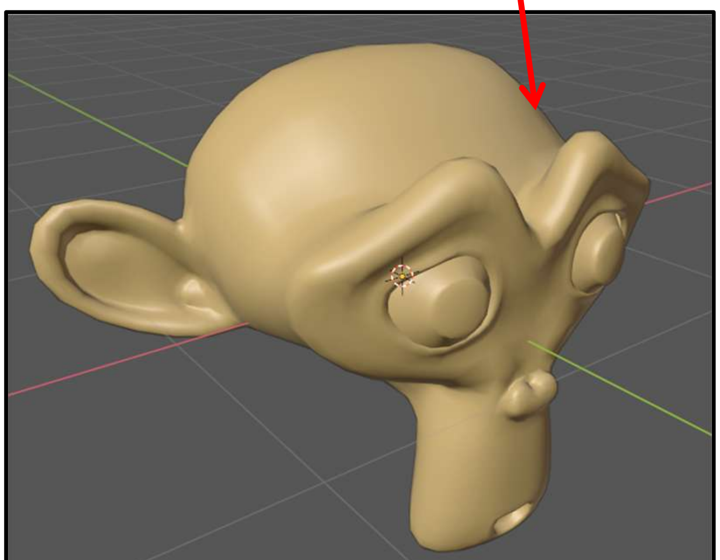
NVIDIA

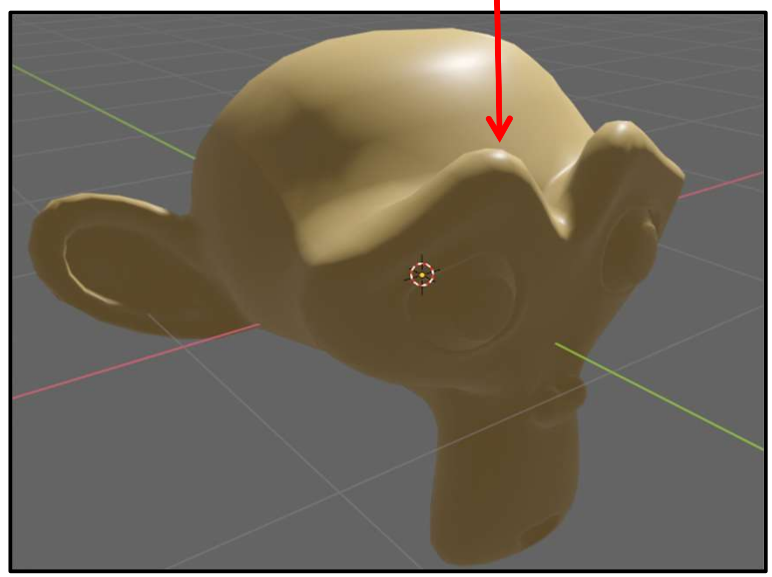
Lighting



Let's say that you are in **Viewport Shading Mode** and your scene situation looks like this

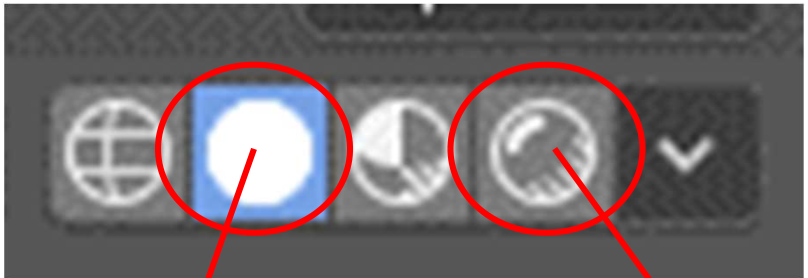
You now change to **Render Mode** and get this:



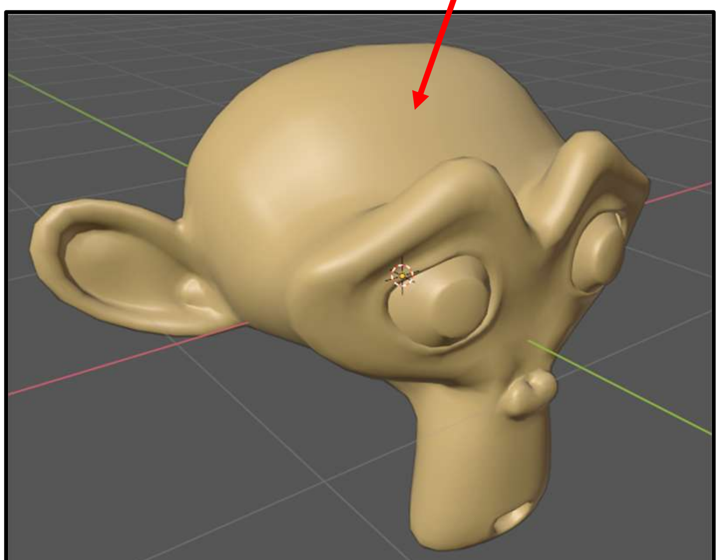


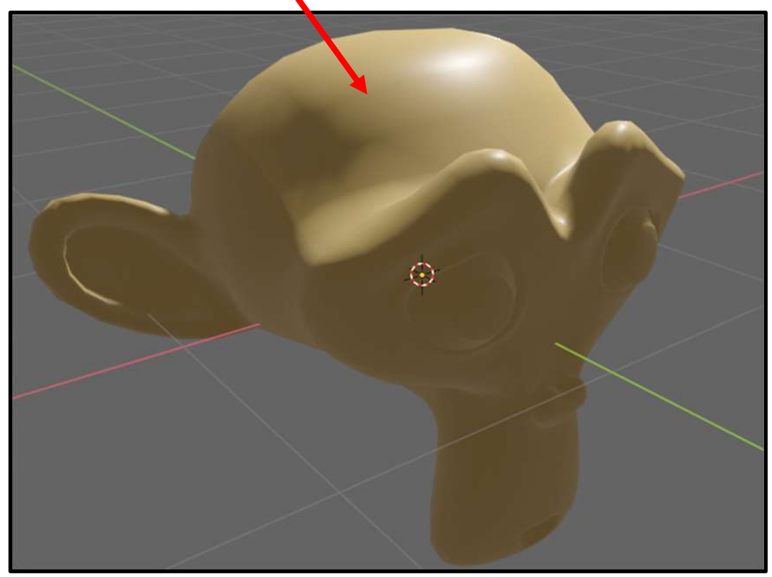
Blech! Why is the bottom part of my scene so dark?

Lighting

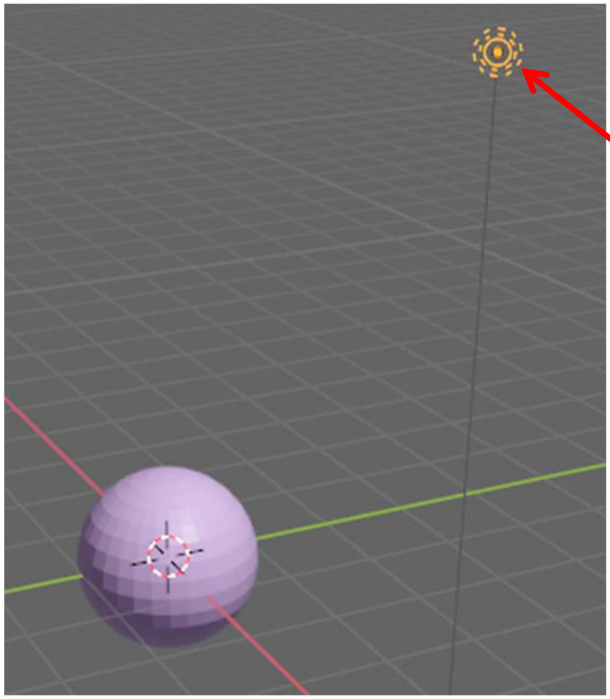


The answer is that **Solid Shading Mode** doesn't require your scene to be lit but **Render Mode** does.





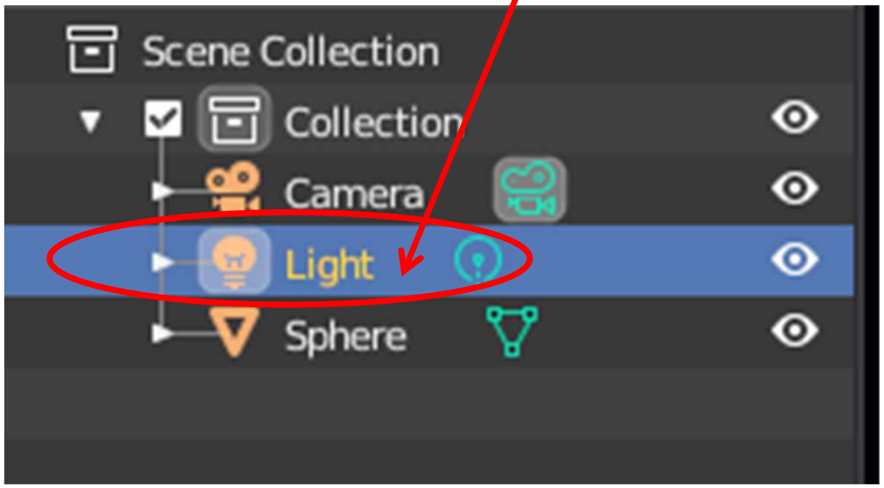
Lighting



By default, your scene has a single light in it.
It looks like this.

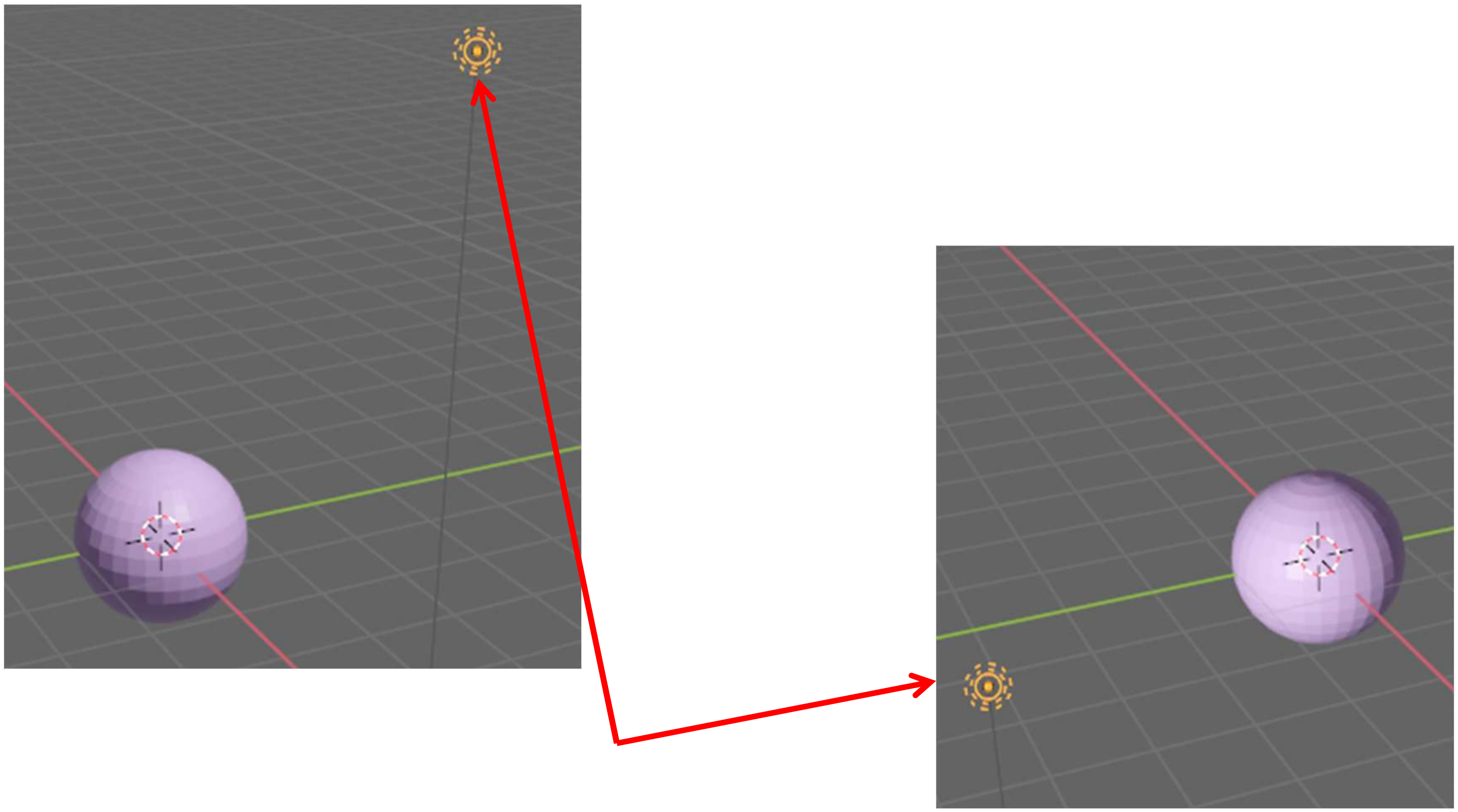
If you can't find it, try zooming out.

If you still can't find it, select it in the **Outliner**.



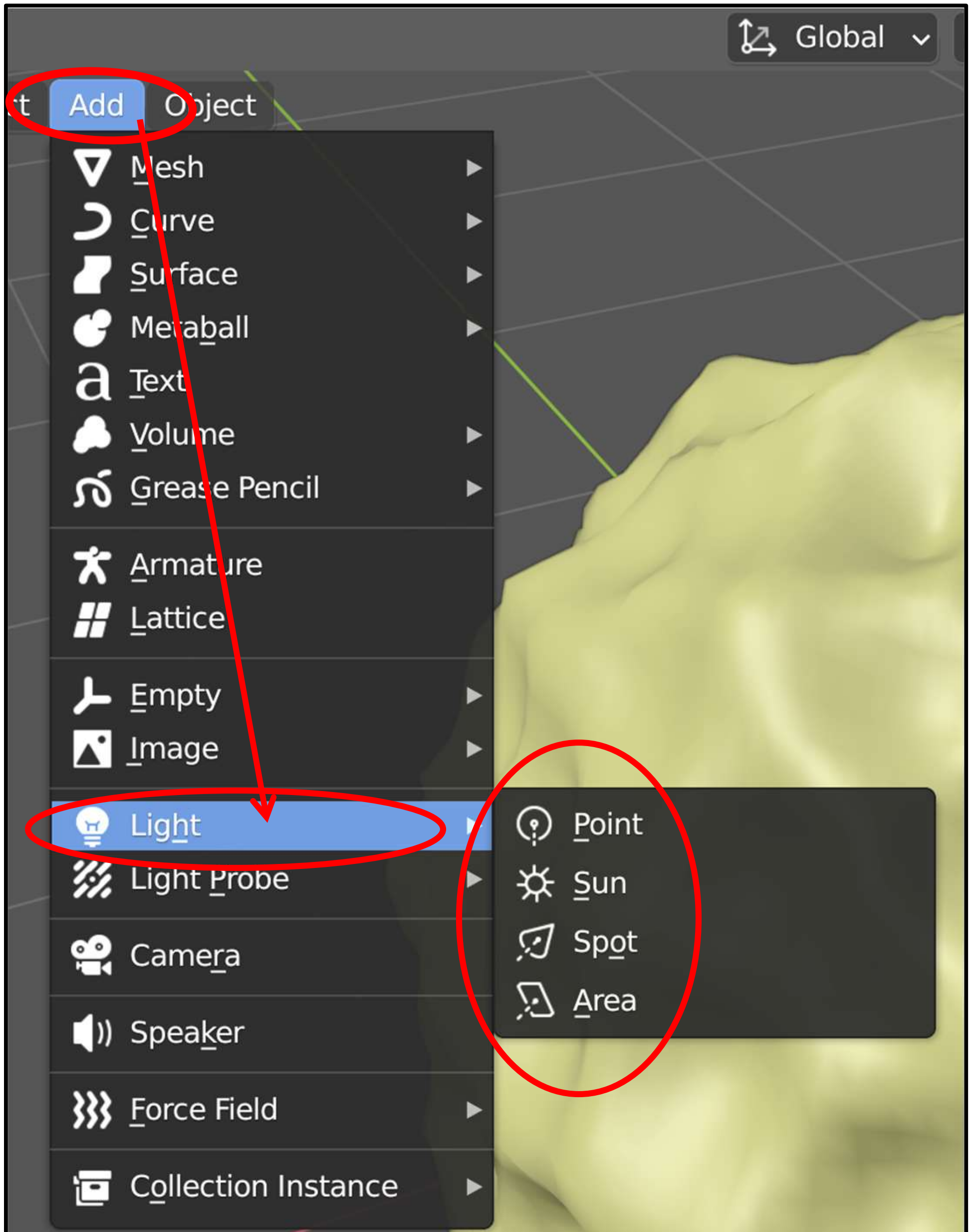
This is like any other object.

Lighting



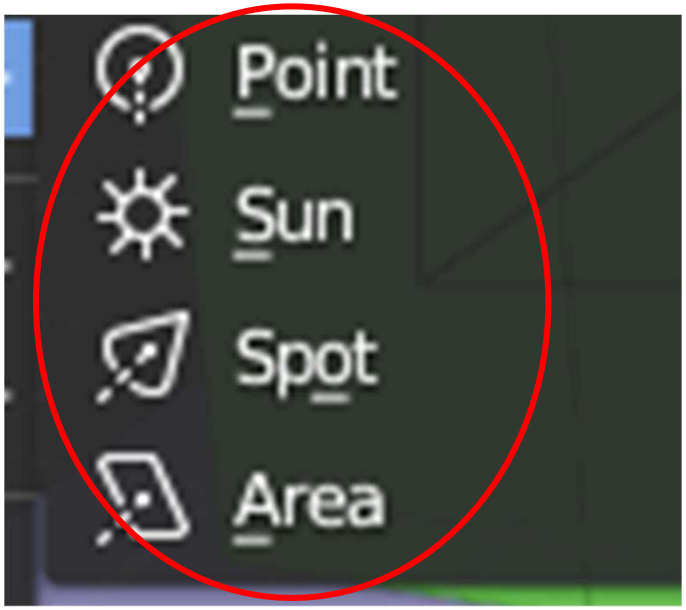
A light is like any other object. It can be LMB clicked on (or selected in the **Outliner**). It can be grabbed (**g**) and moved around. Moving it around will change how the lighting looks.

Lighting



But, to make this work better, you probably want to add more lights.

Lighting



There are four types of **Lights** that you can **Add**

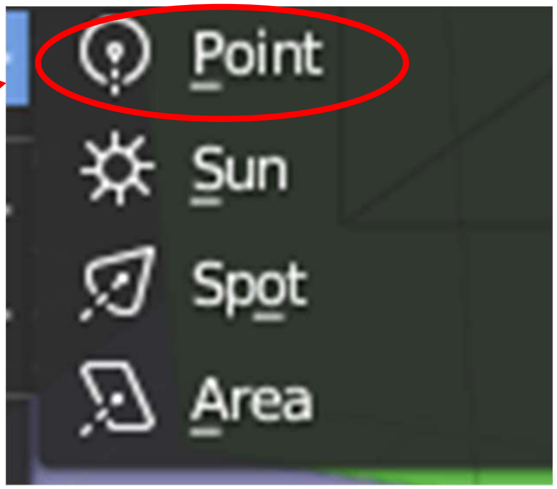
1. A **Point** Lamp shines light in all directions. The light is local to the scene. This is usually the best type of light to start out with.

2. A **Sun** Lamp appears to come from a single direction and its rays are parallel. This acts as if the light is very far away.

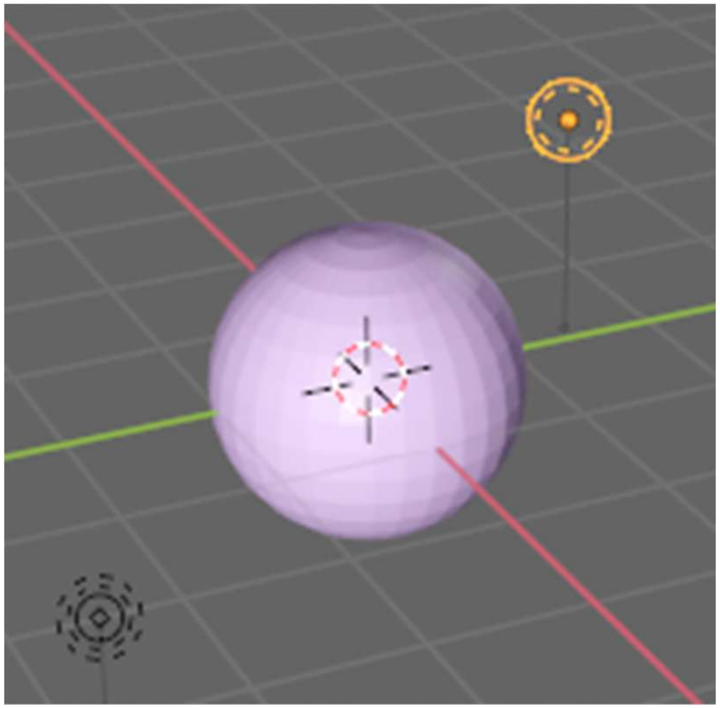
3. A **Spot** Lamp is like a Point Lamp, but only shines in one particular direction.

4. An **Area** Lamp is light coming from a finite surface, like most lights really are.

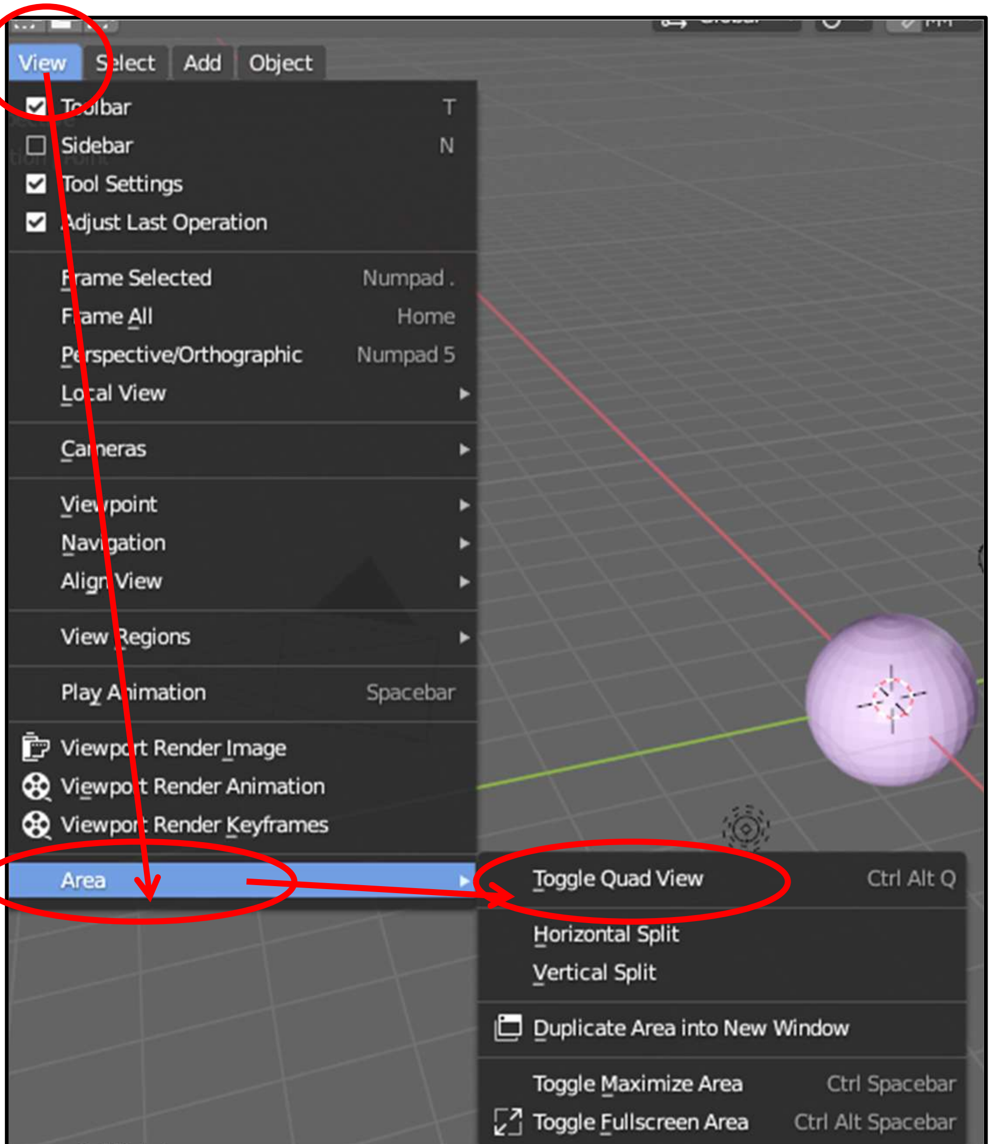
Lighting – try this

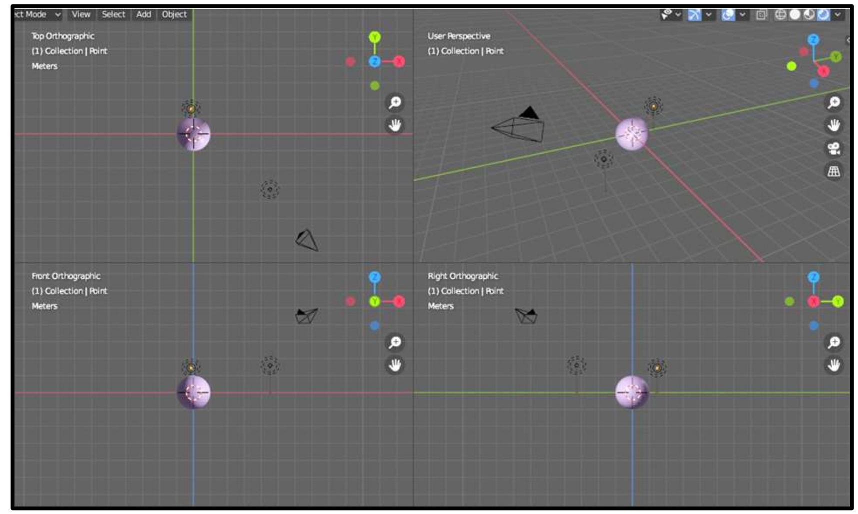


1. Add another Point Light
2. Position the Light (‘g’).
3. The Point Light has no obvious local coordinate system, so it just uses the global coordinate system.
4. As you move the Light, you will see the lighting of the scene change
5. You will probably have to rotate the scene (MMB) to get the light position where you think it should be. Or, you can also toggle the **Quad View** mode (Control-Alt-q).

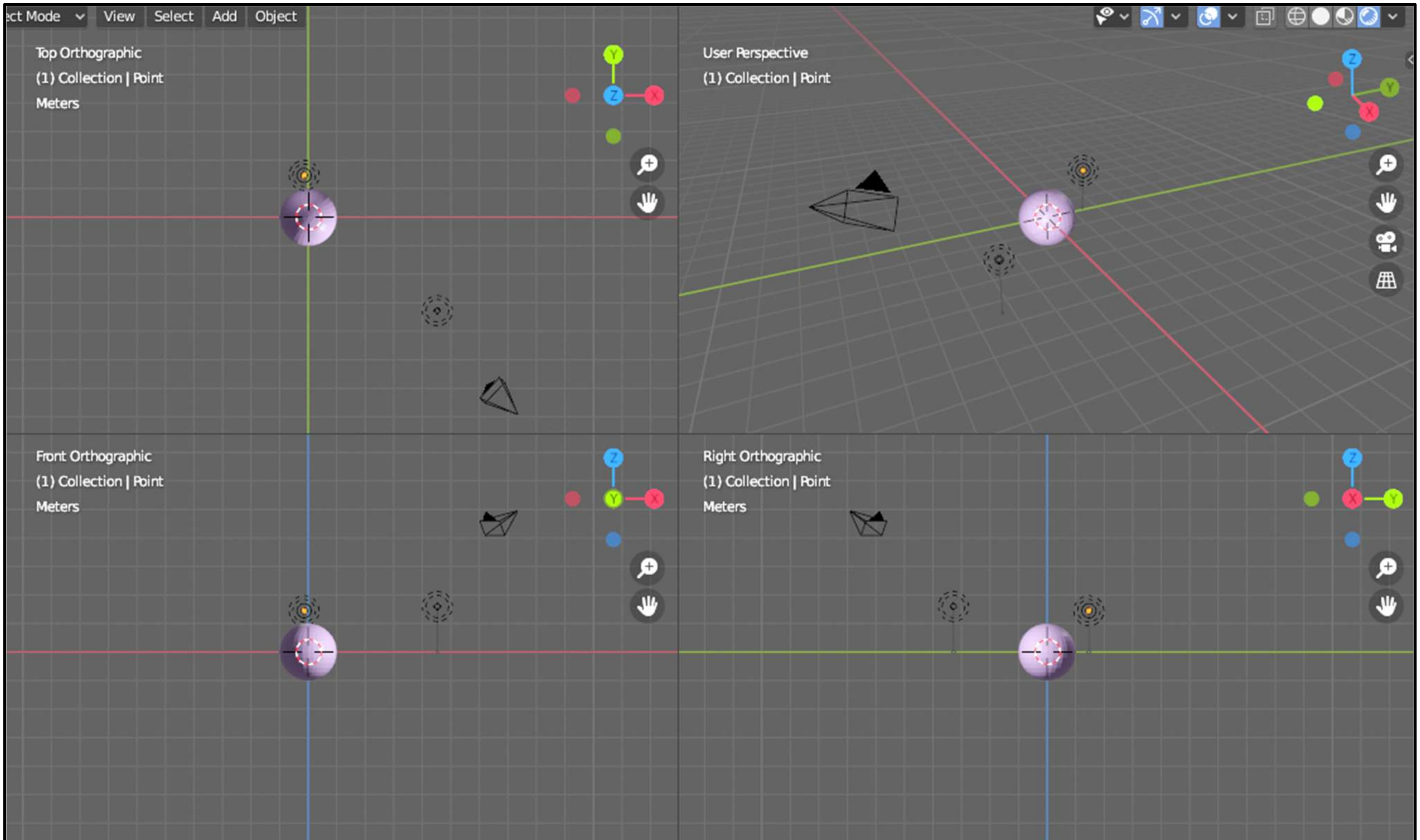


Lighting – Quad View

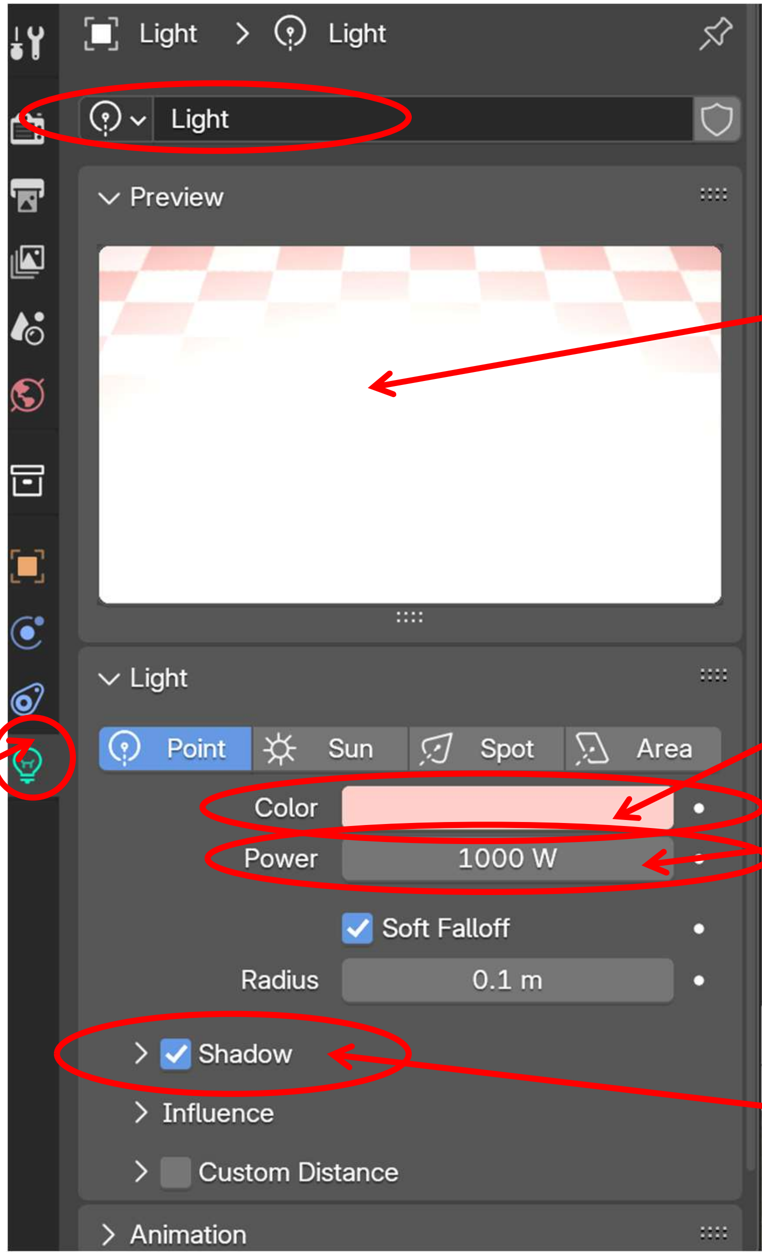




Lighting – Quad View



Lighting – Properties



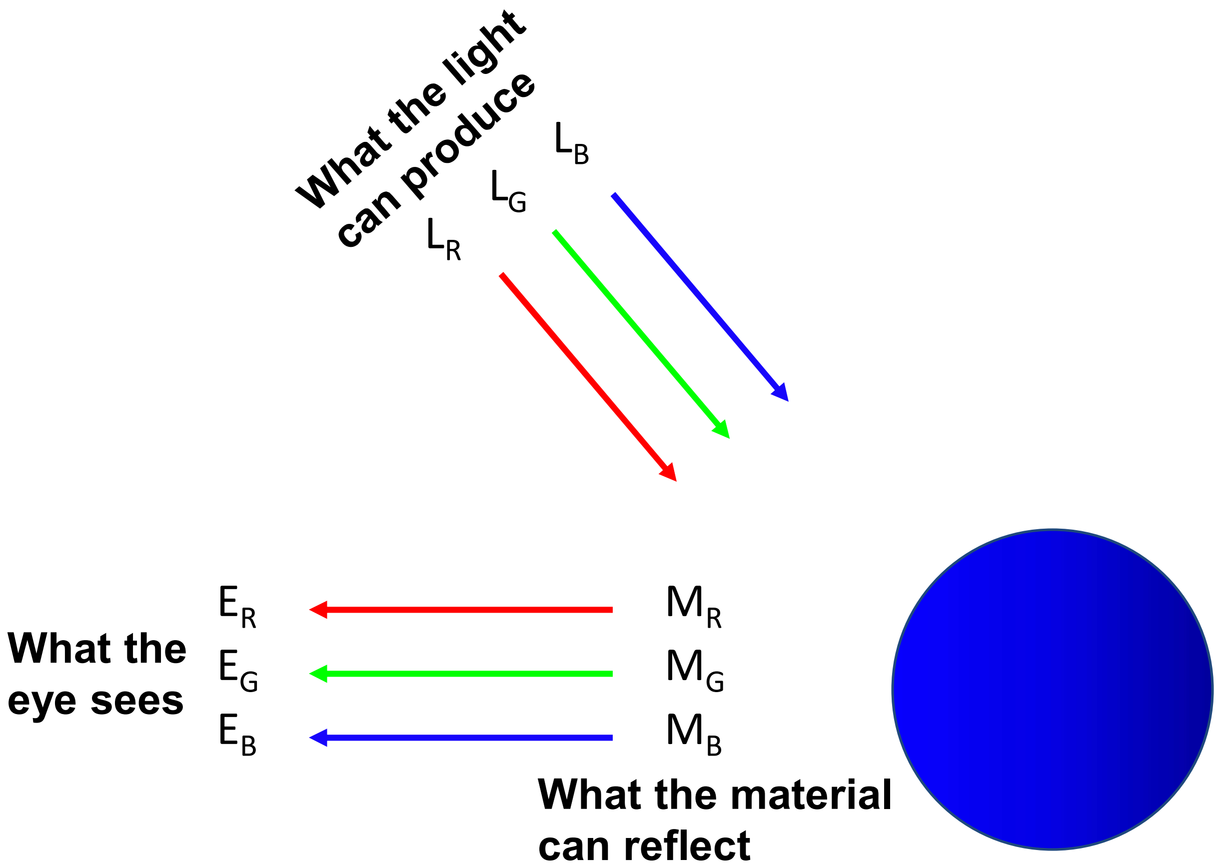
This preview shows how the Light spreads out

What color to make the Light

How bright to make the Light shine.

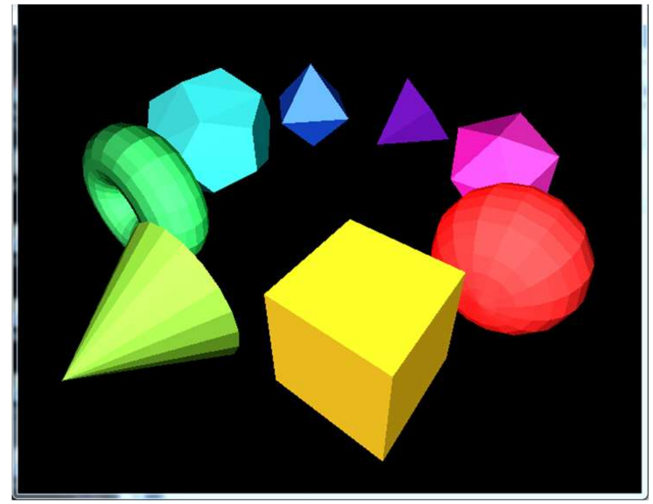
Be sure this is clicked on in order to get this light to cast shadows

Lighting – What does it Mean to Have a Colored Light?

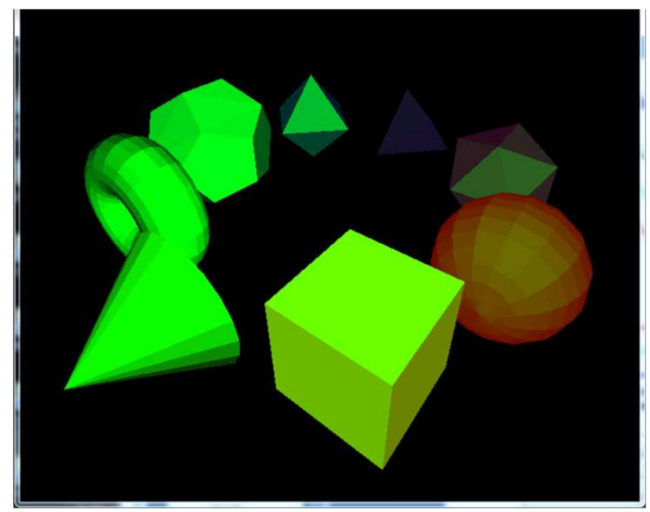


$$
\begin{aligned}
E_R &= L_R * M_R \\
E_G &= L_G * M_G \\
E_B &= L_B * M_B
\end{aligned}
$$

White Light



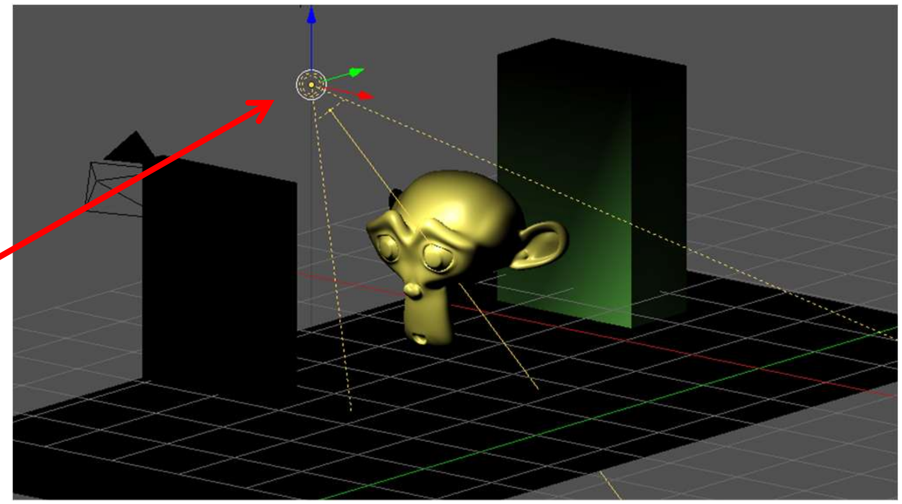
Green Light



Lighting – Principles

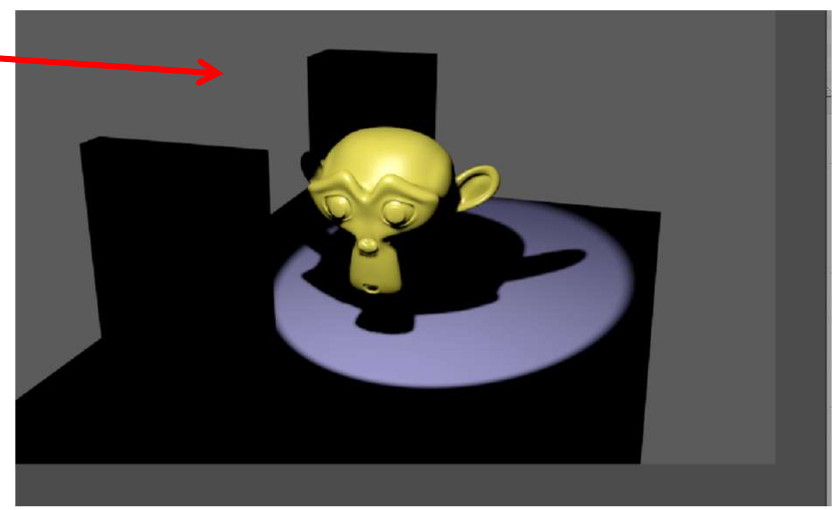
In modeling, rendering, and animation, there are two major roles that lights play:

1. Key
2. Fill



Let's say we want to put a spotlight on the Monkey (and who doesn't?). We add a Spot Light. We position it over the Monkey and angle it down, like this. This is our "Key Light". It does what we most want to do.

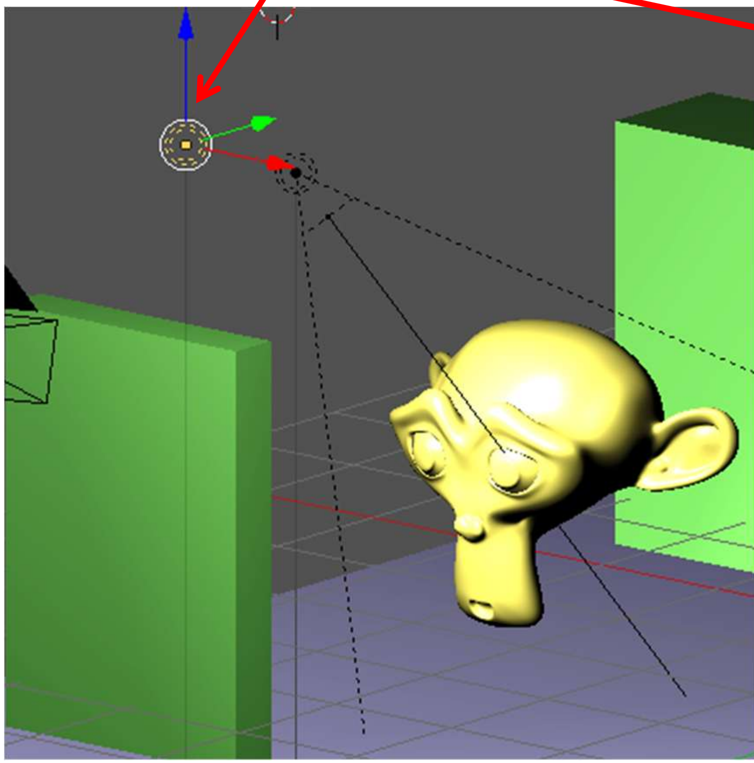
We render and get this.

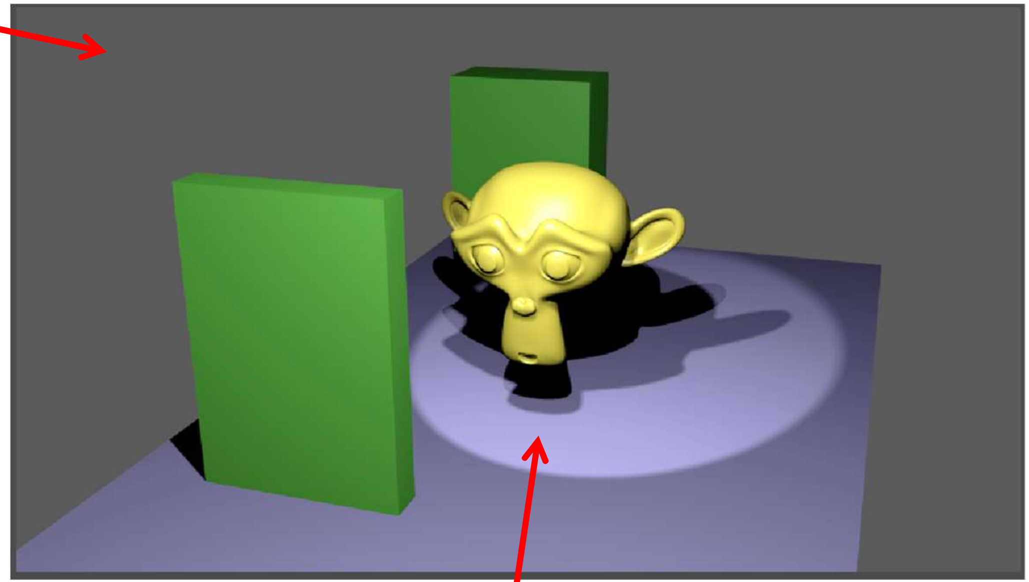


The Key Light is working really well, but the rest of the scene is too dark. We now need to use one or more Fill Lights.

Lighting – Principles

We Add a Point Light and position it over the scene. Because we are in Render Mode, we can interactively see when we have it positioned well.

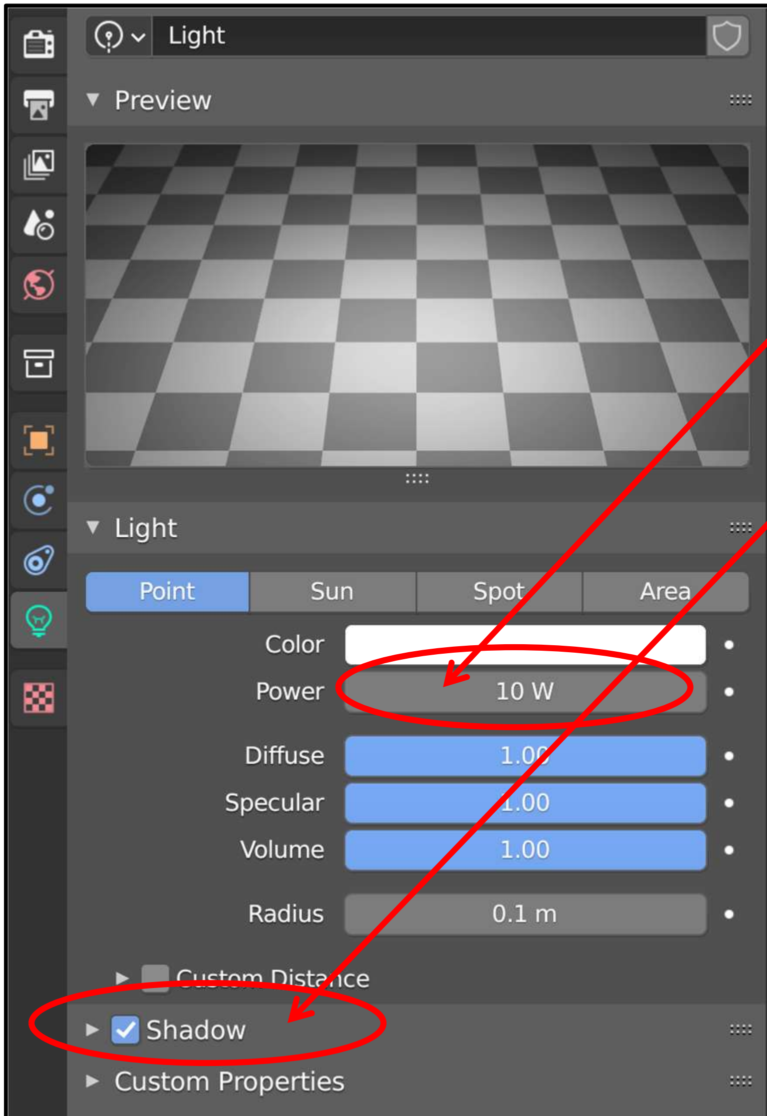




The scene looks much better. But, there are still two problems.

1. The rest of the scene is now bright enough that our "star" is no longer highlighted.
2. The Fill Light is casting another shadow which is distracting.

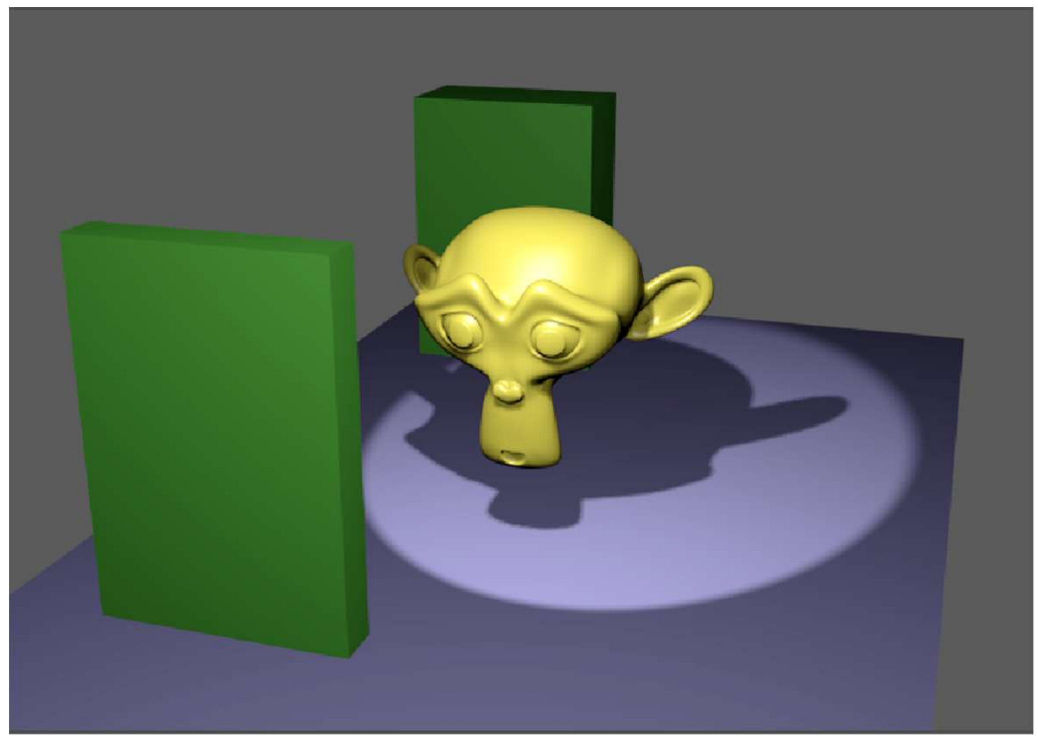
Lighting – Principles



So, we make two adjustments to our Fill Light:

We lower its brightness.

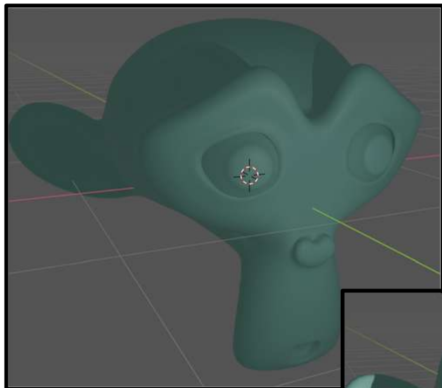
We un-click here to force it to not cast shadows.



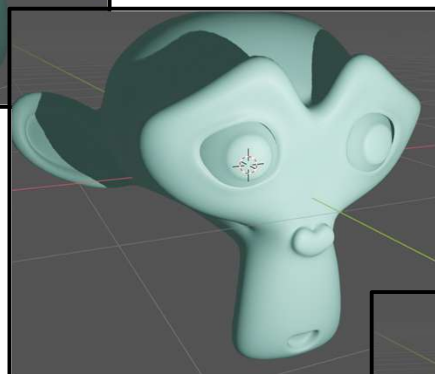
Lighting – Blender Wattages

These are not absolute specifications however. Your perception of brightness will depend on how far the light is from the object and what color the light and object are.

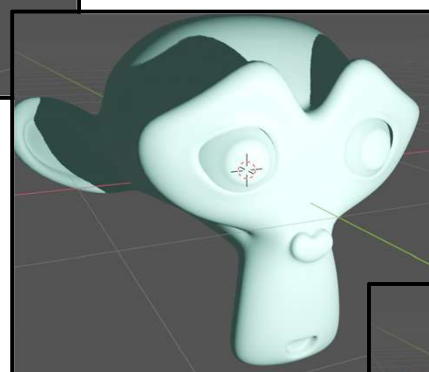
10 W



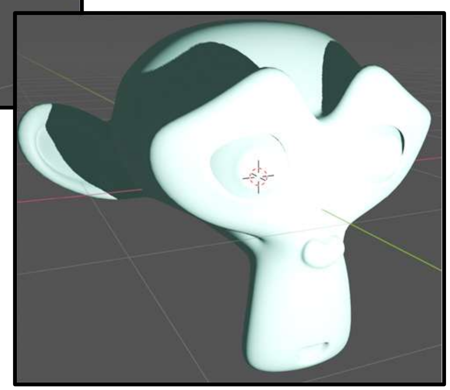
100 W



250 W

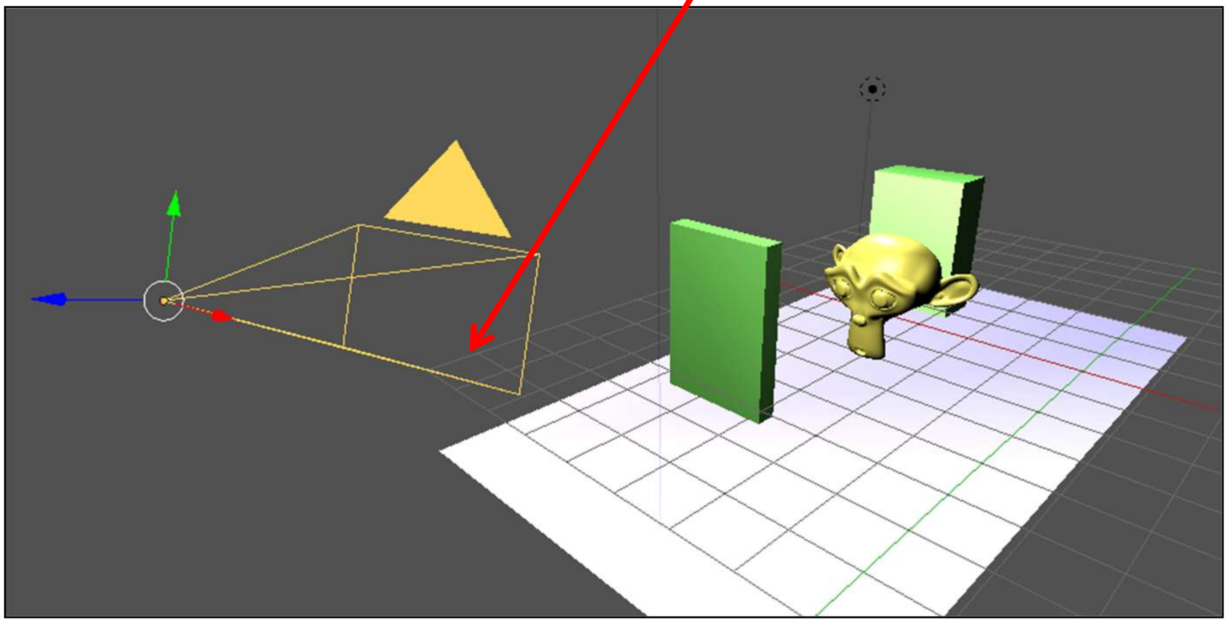


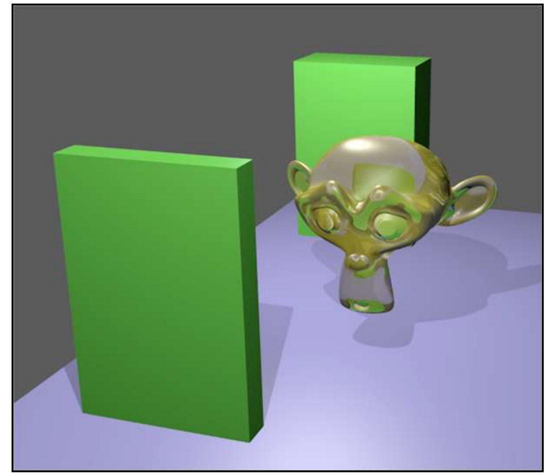
500 W



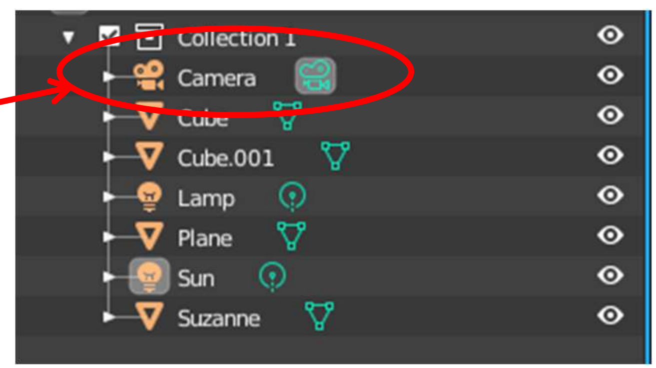
Rendering

The view that is rendered is not the same orientation that you see on the screen. It is from the ***Camera position***, which needs to be set separately.

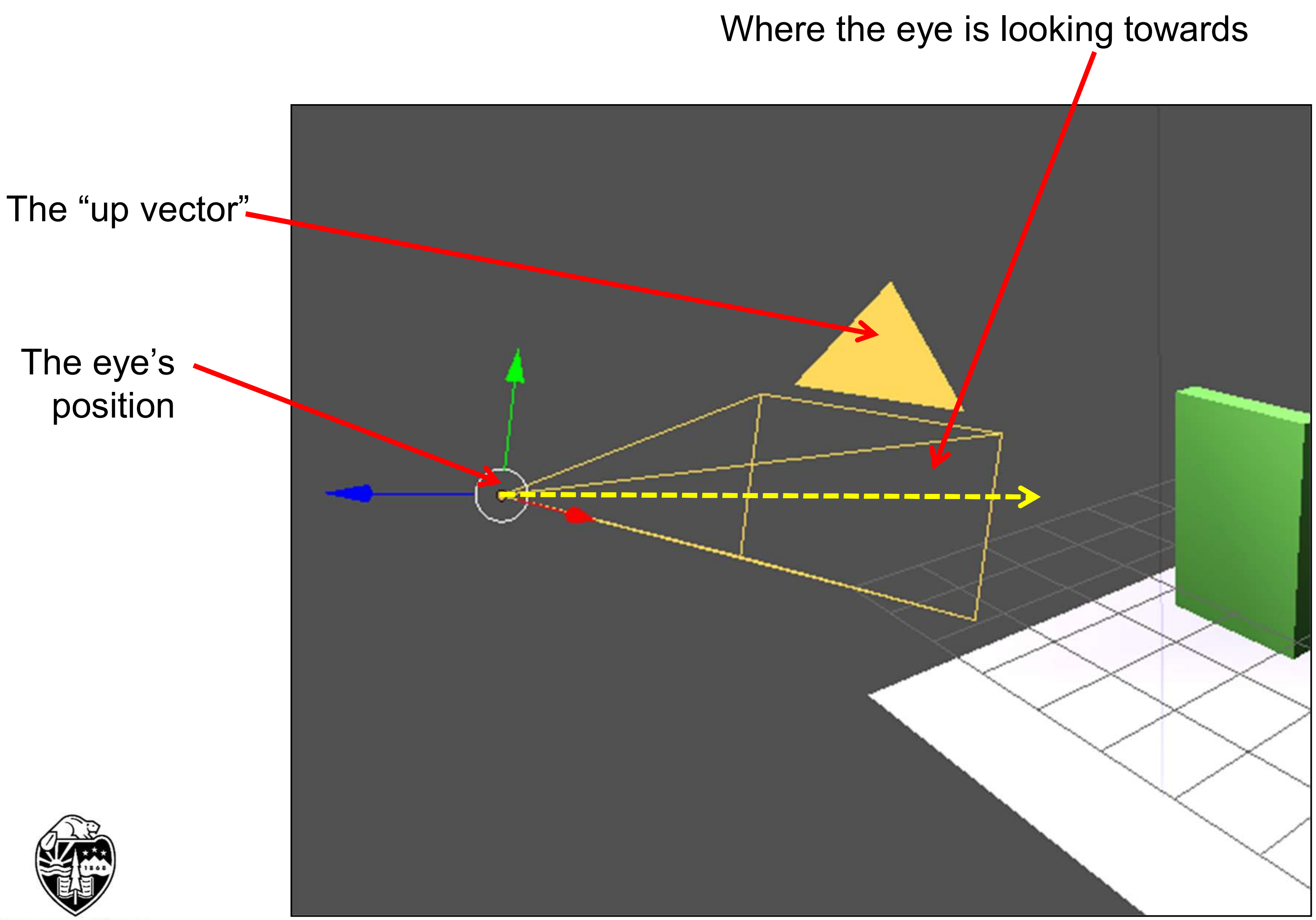




If you the Camera icon, LMB click on it. If you don't see it, zoom out some. If you still don't see it, click on the Camera in the Outliner.



The Camera


Where the eye is looking towards
The "up vector"
The eye's position

The Camera

The camera is just like any other object in the scene.

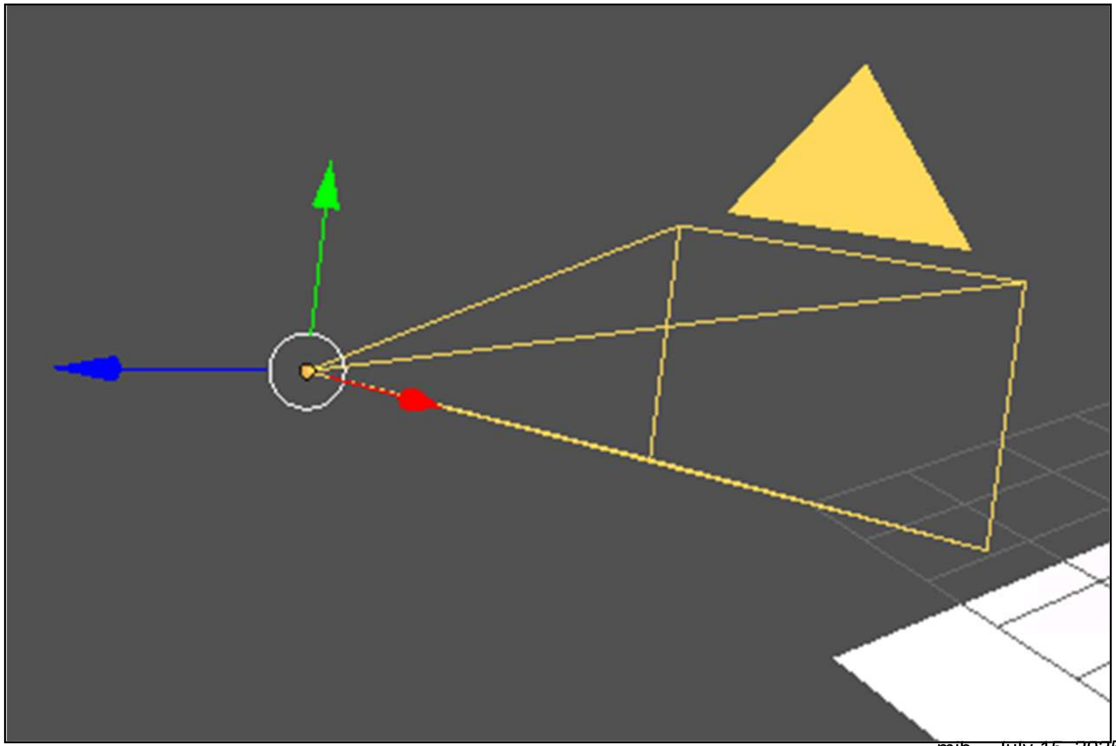
1. It can be selected with a LMB click
2. It has its own local coordinate system attached to it.

Note the local coordinate system for the camera:

- X is to the right of where the eye is looking
- Y is the up-vector
- Z is opposite of where the eye is looking

This is useful to know. For example, to dolly the camera in or out, select it and then move it in its local coordinates:

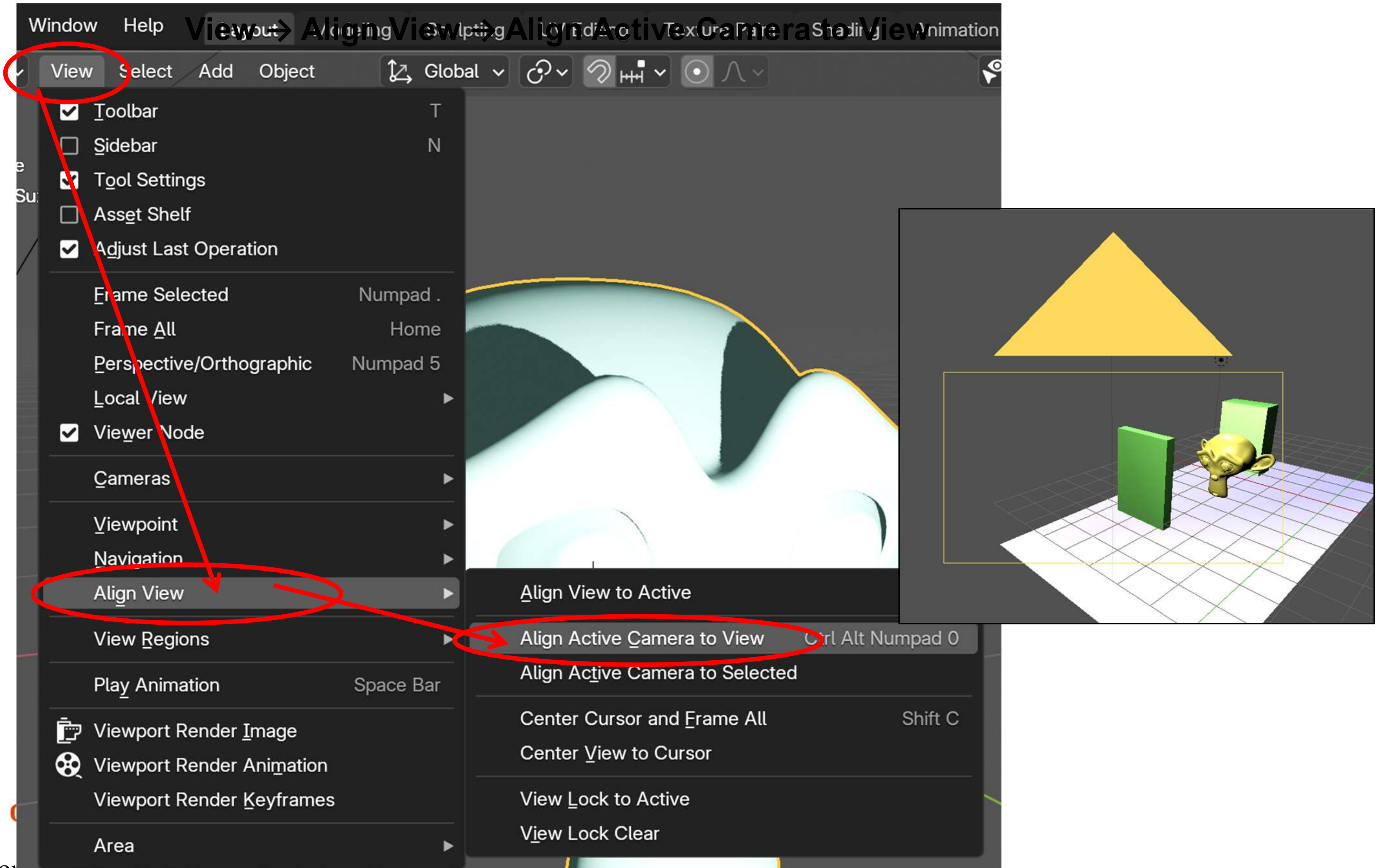
g → z → z



Aligning The Camera to Your Current Screen View

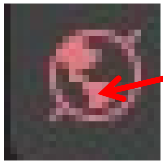
But, if you like your current screen view and want to move the camera there, just do this:

View → Align View → Align Active Camera to View

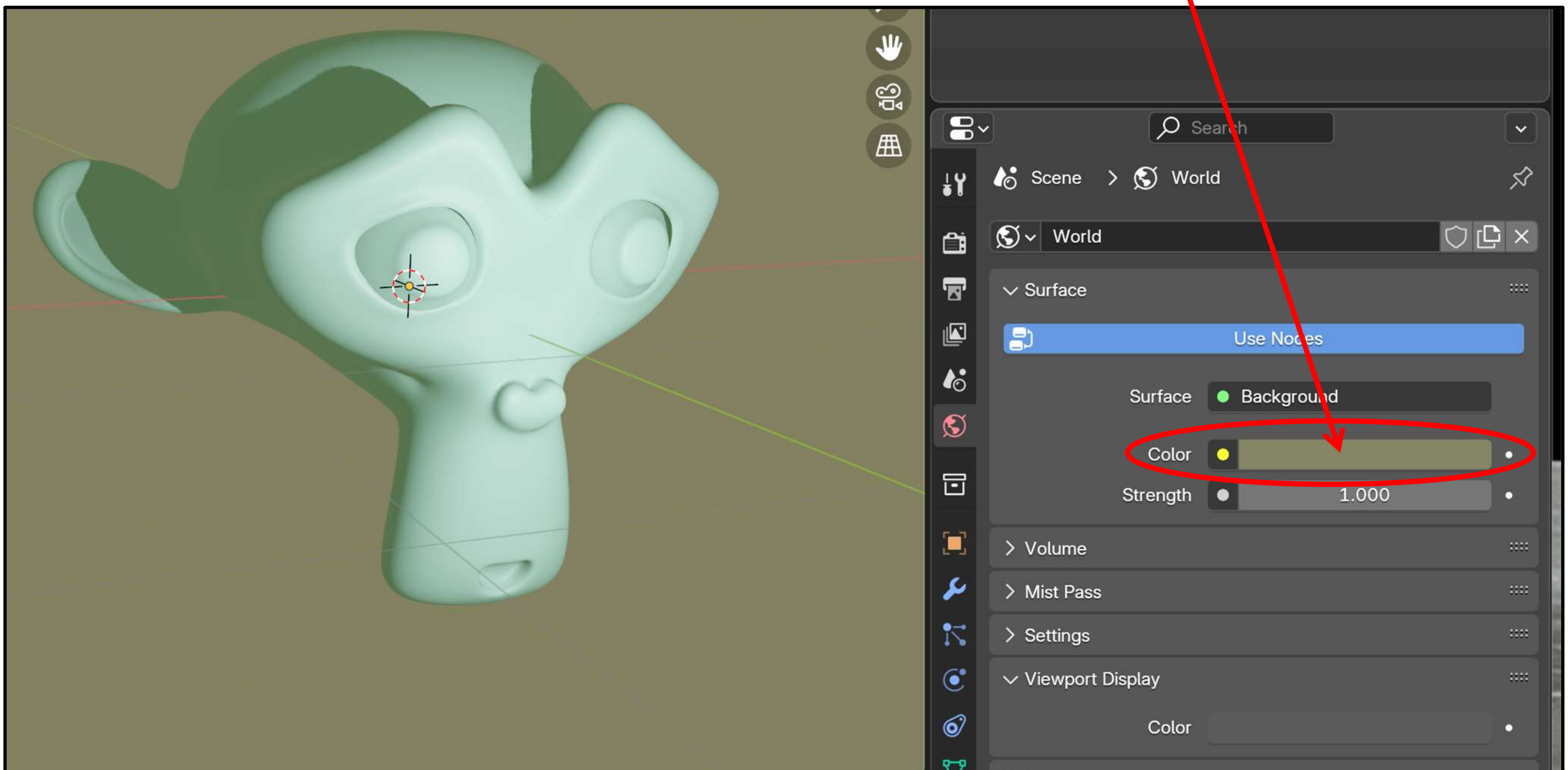


Setting a Background Color

Click on the **World Properties button**

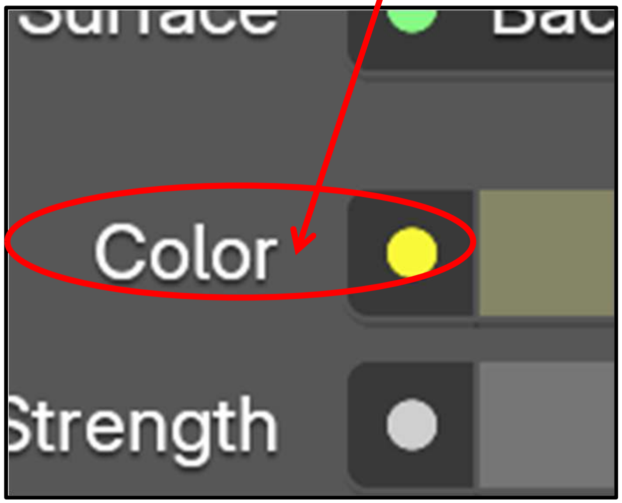


Click on **Color** and dial in the background color

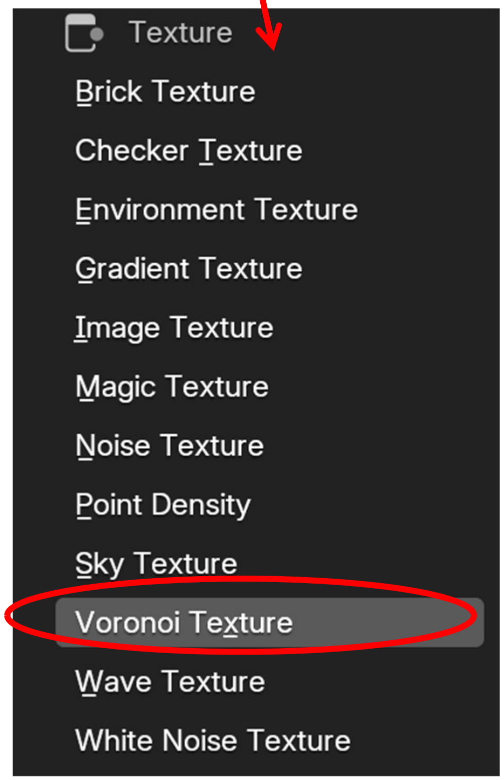


Setting a Background Texture

Click on the **yellow dot** next to **Color**



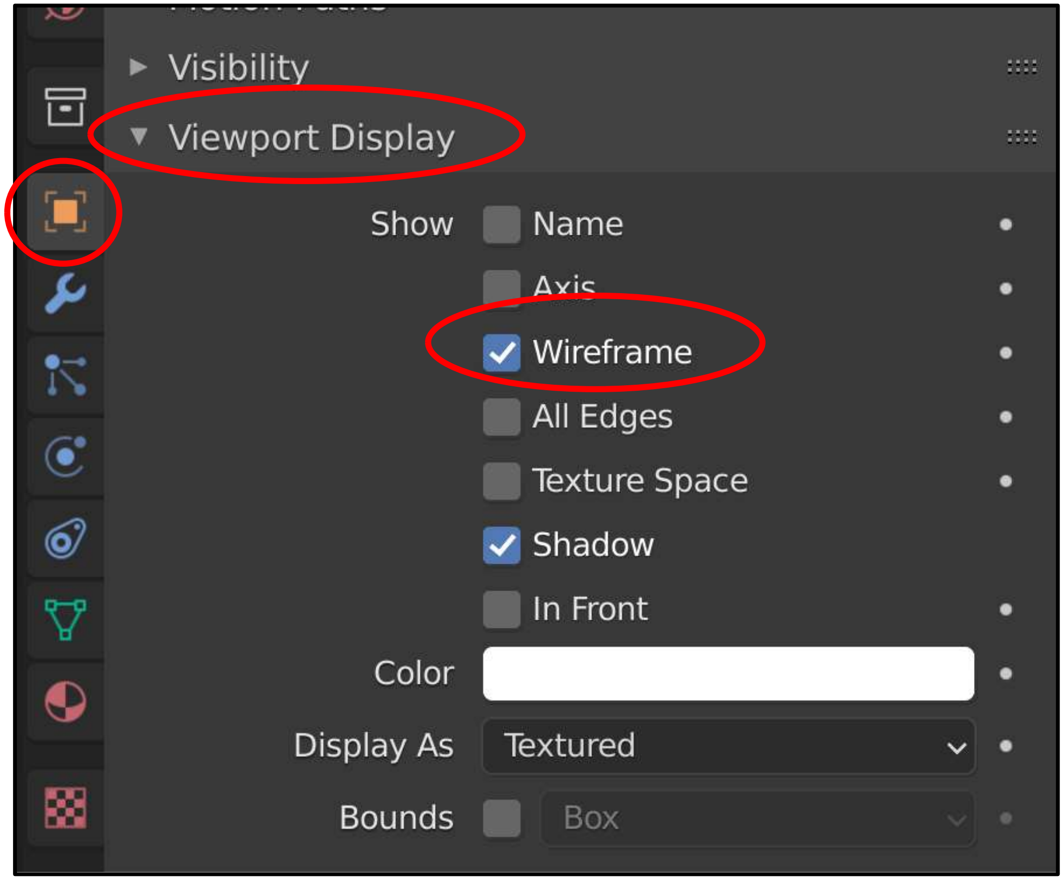
That brings up a whole bunch of options

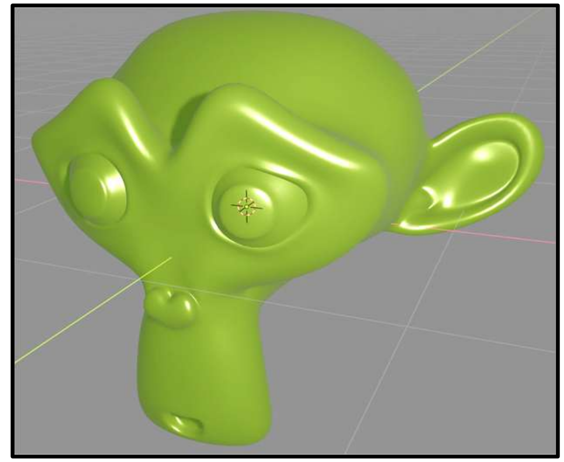


As always, I am partial to **Voronoi** ☺

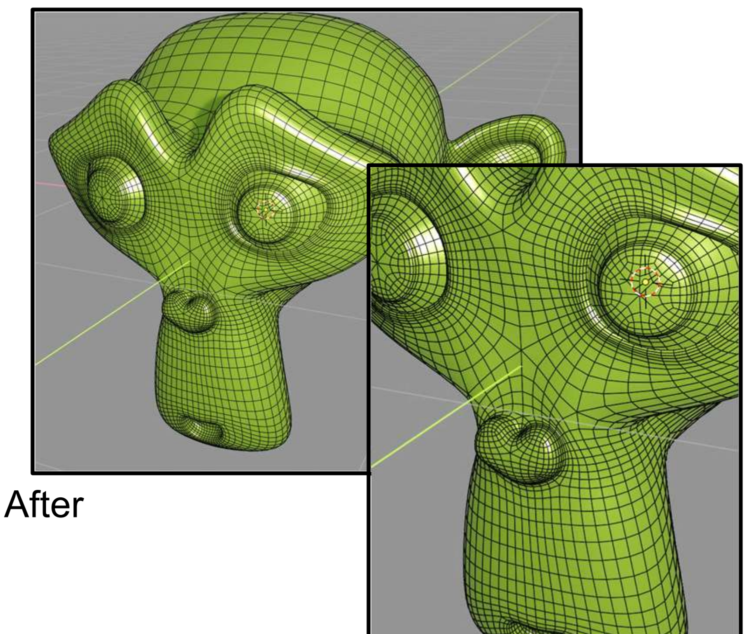
Superimposed Wireframes

I don't know why I find this so pleasing to look at. I just do.





Before



After

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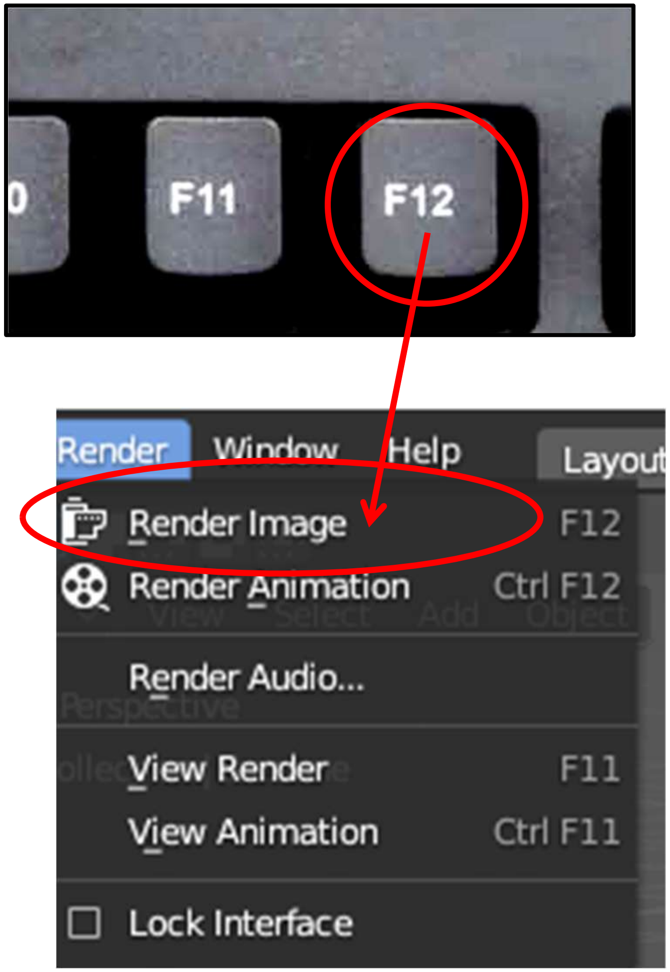
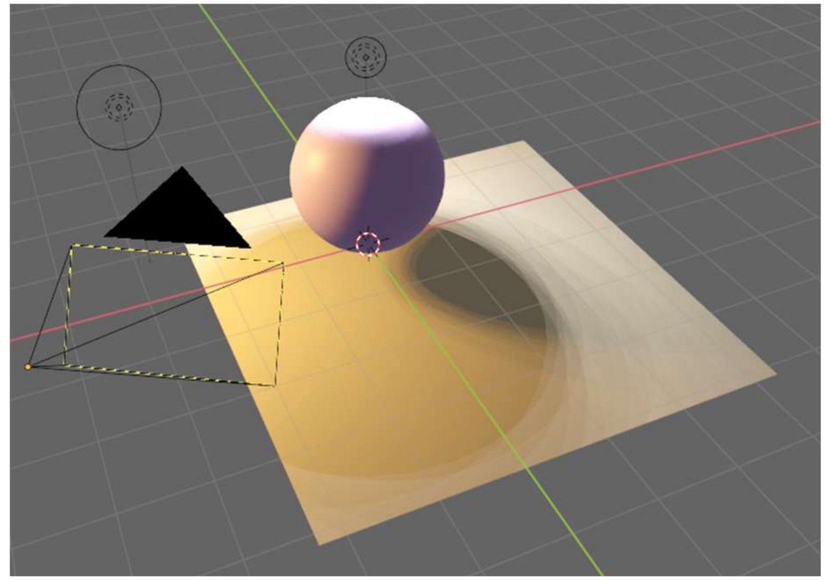
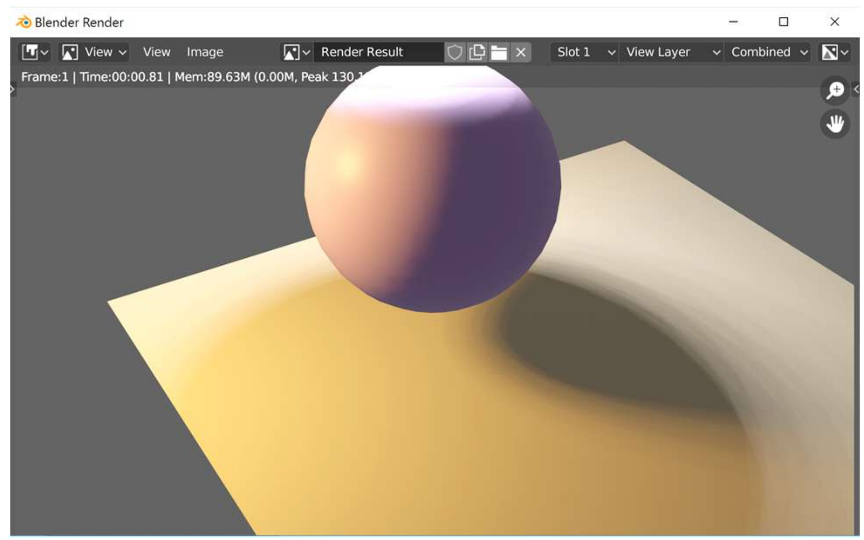
Triggering a Rendering



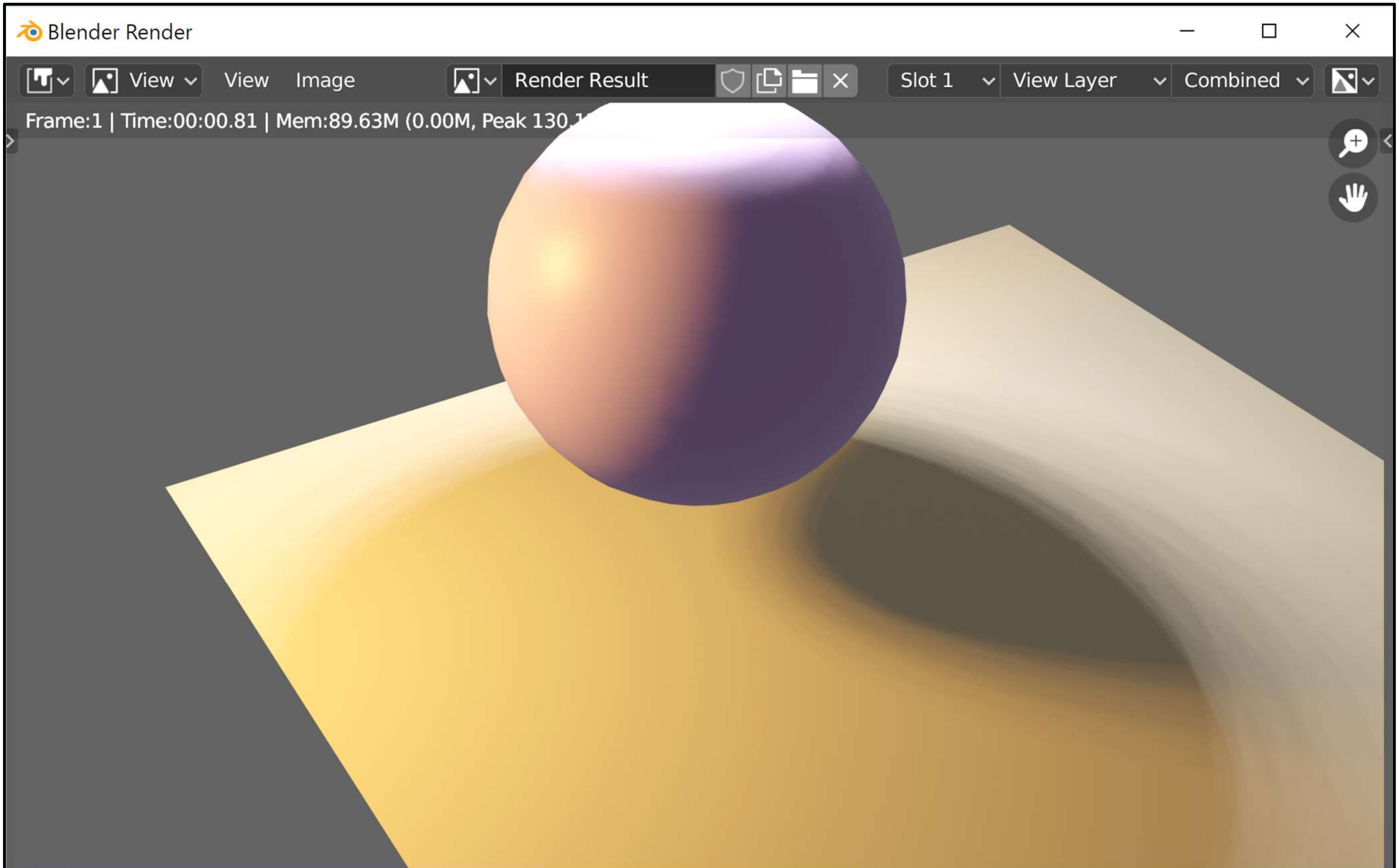


What you see on your screen

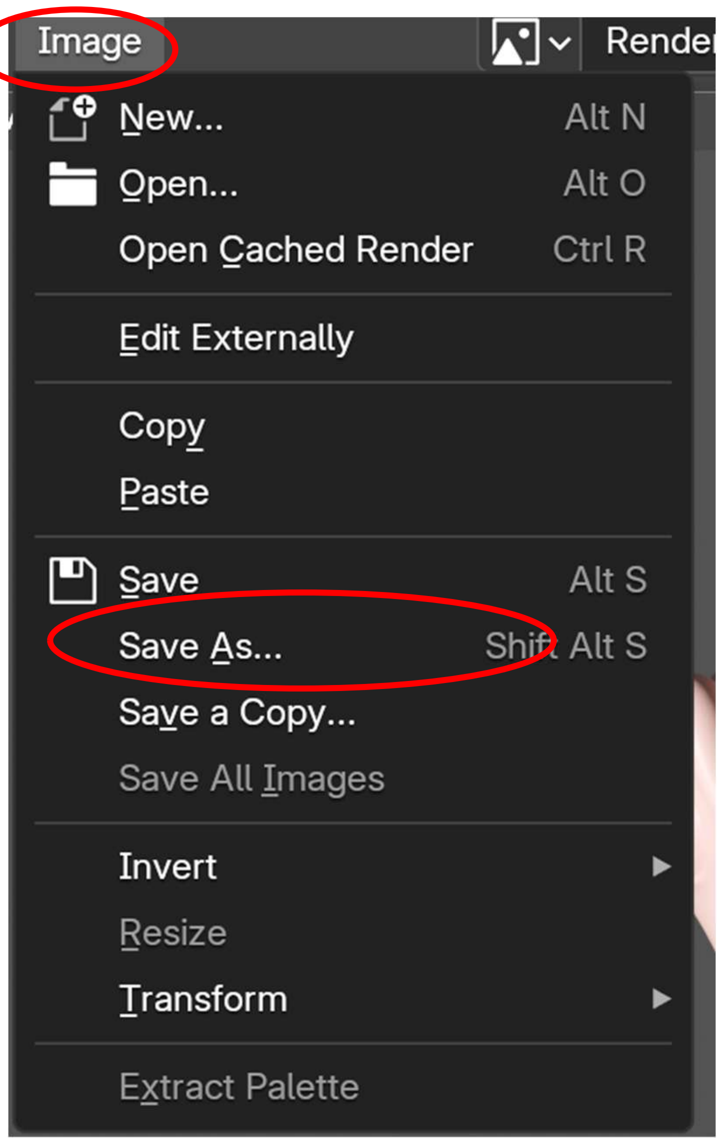


What you see on the separate render window

What You See in the Separate Render Window



Saving a Rendered Image to a File

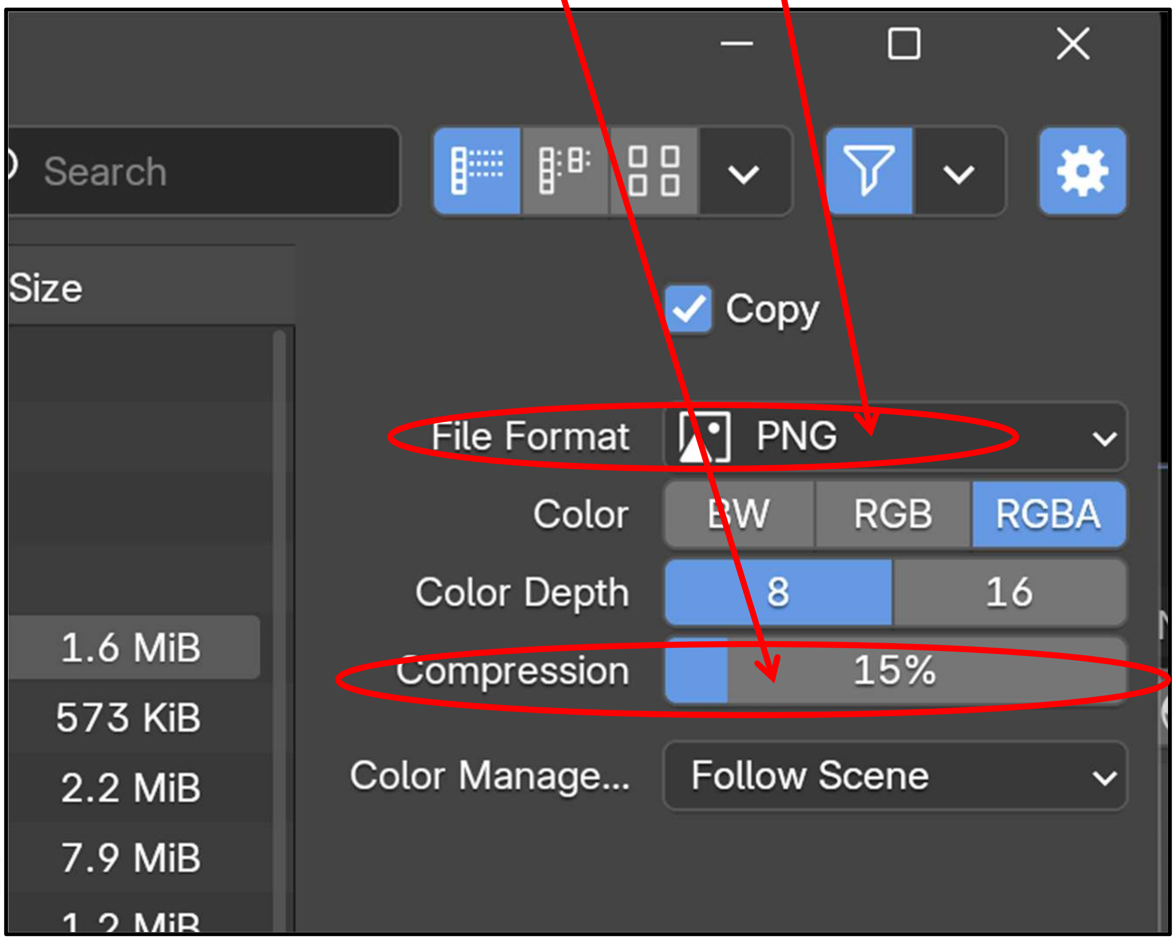


Save As doesn't appear until the full rendering has completed.

Saving a Rendered Image to a File

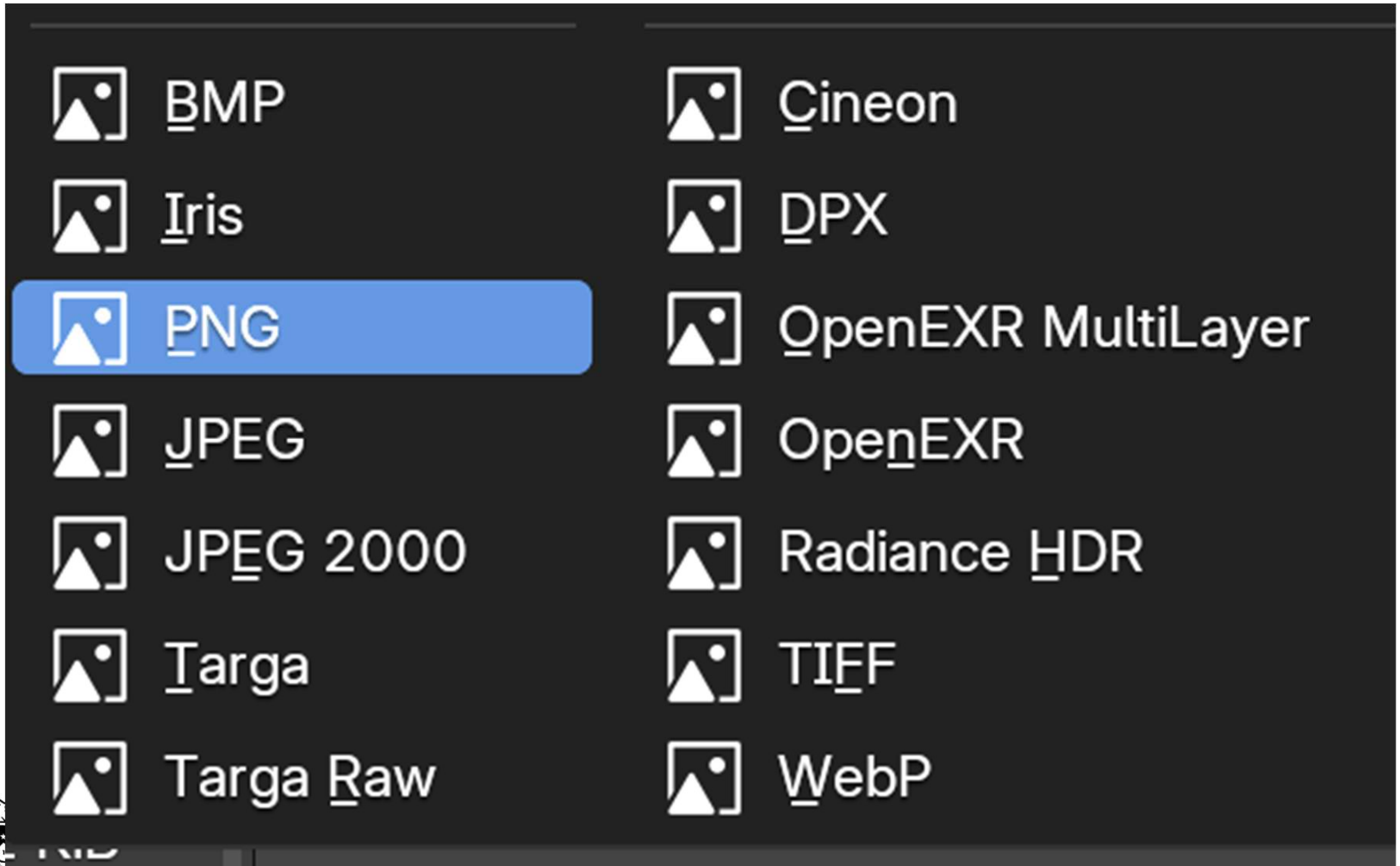
Amount of compression

Image file type



Saving a Rendered Image to a File

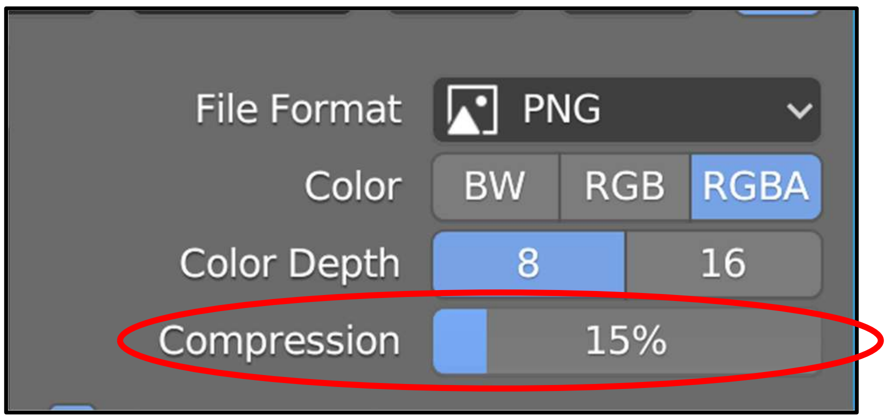
Different image file types
(PNG is good if you don't have any preference)

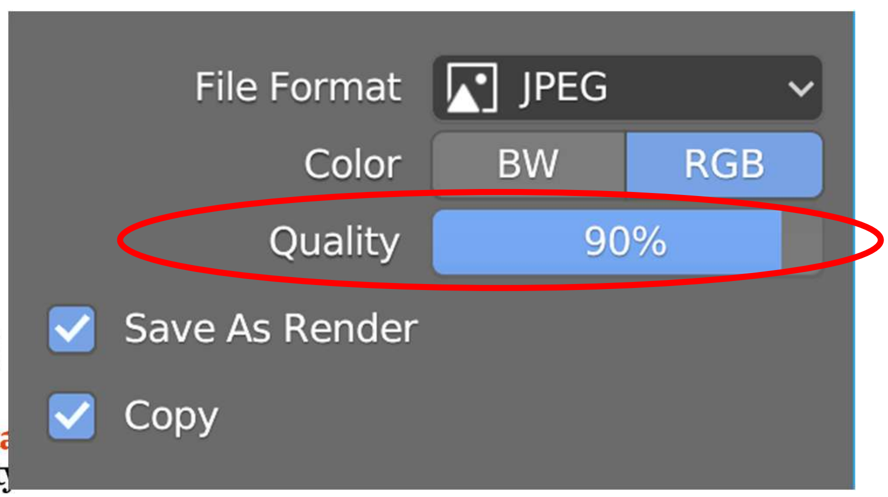


Saving a Rendered Image to a File

If this is called ***Compression***, then smaller numbers will give you a larger image file with greater image quality.

If this is called ***Quality***, then larger numbers will give you a larger image file with greater image quality.

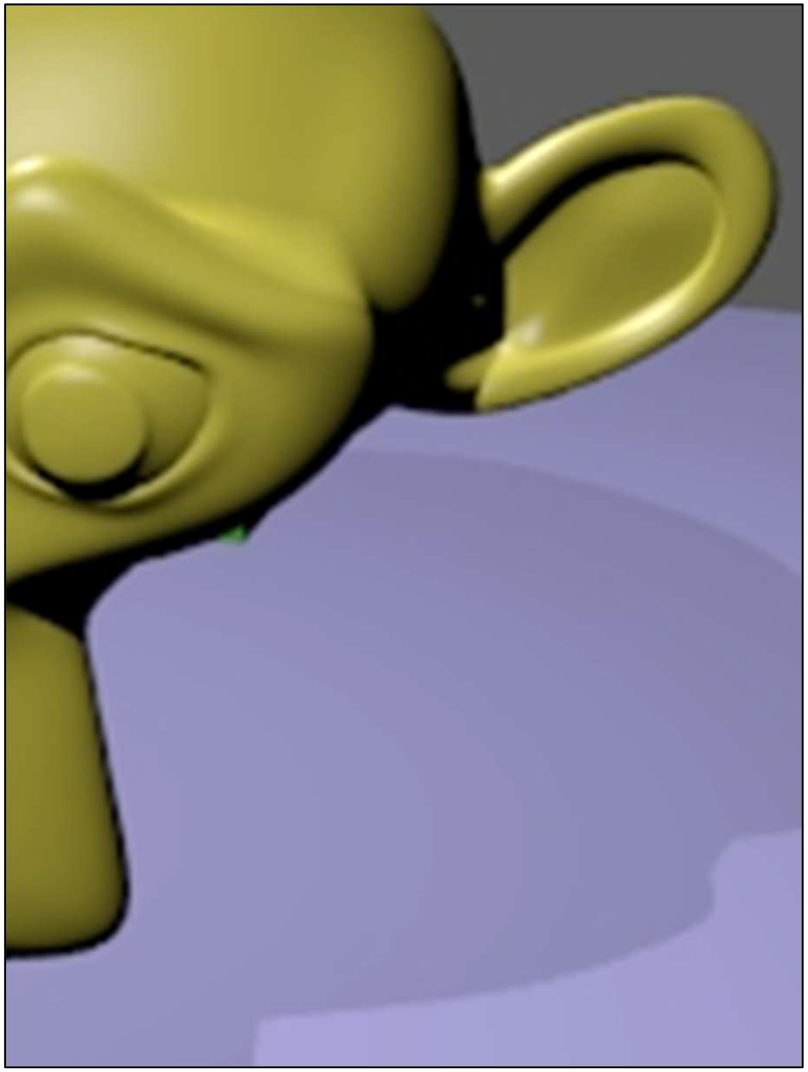




Saving a Rendered Image to a File

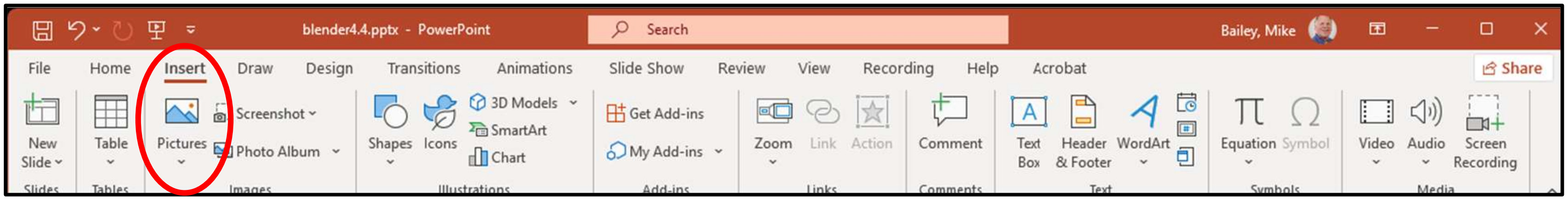
There is an important trade-off between image file size and the image **Quality** you set.
There is also a trade-off between image size and web page download time.

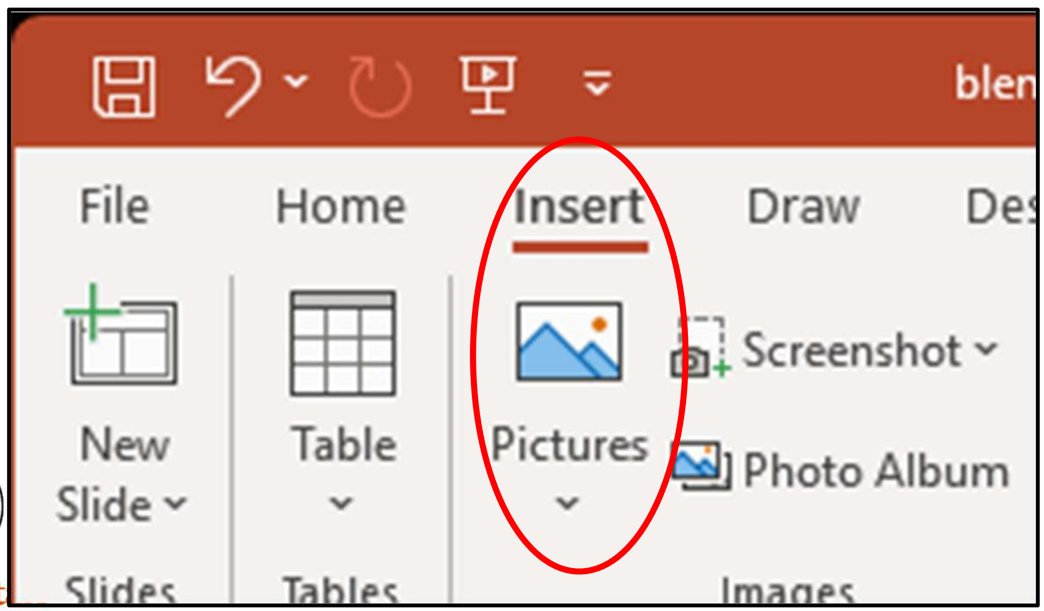
JPEG: **10% Quality** setting
11 KBytes



JPEG: **100% Quality** setting
72 KBytes

Importing an Image into PowerPoint





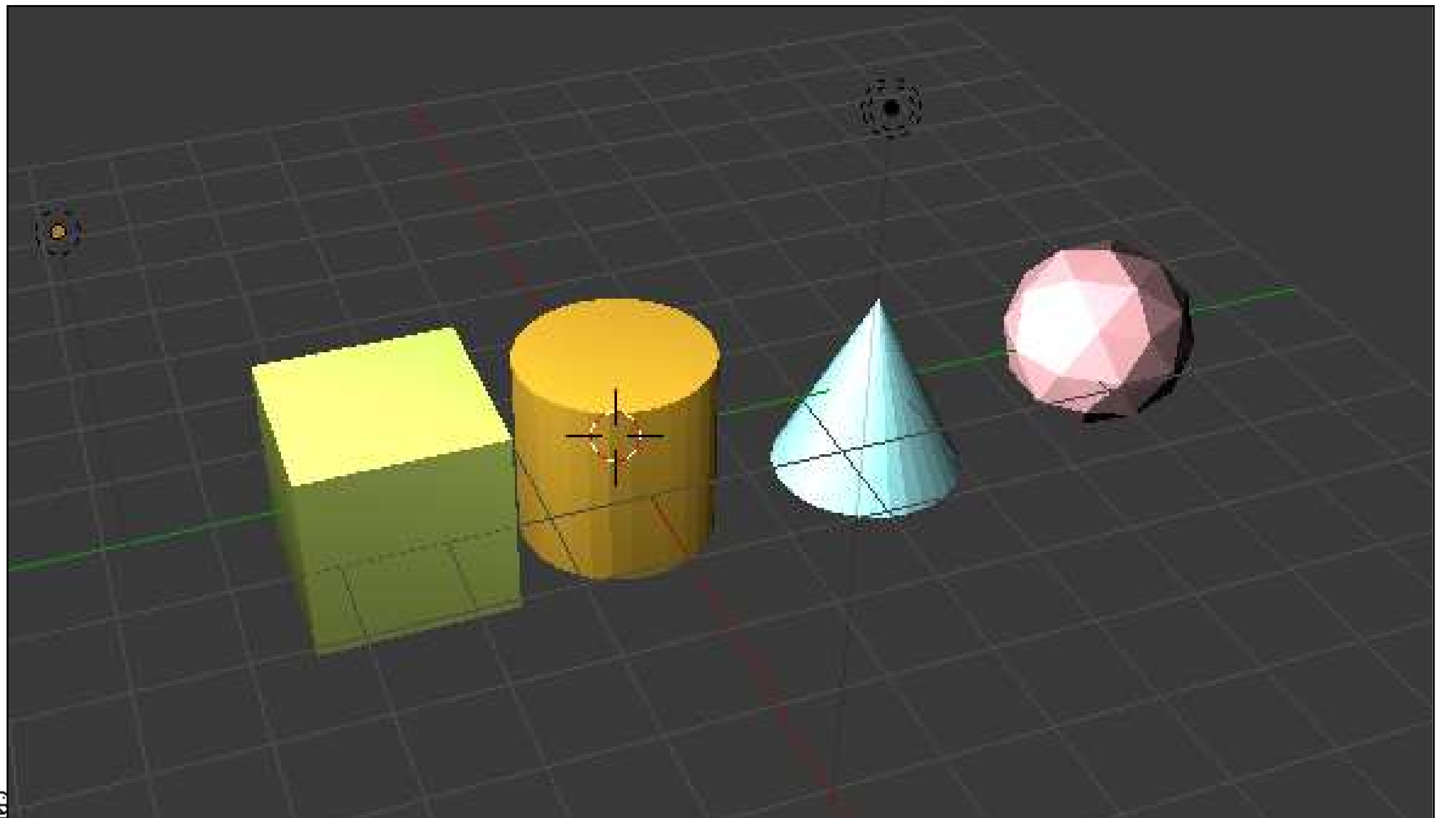
Importing an Image into HTML (i.e., a web page)

Add this line to your HTML file:

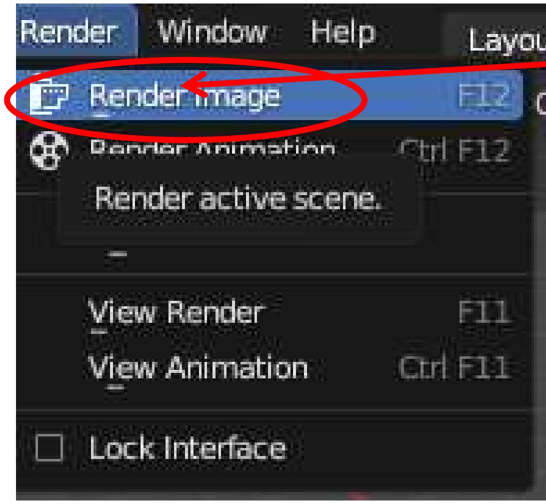
<img src=“ball.png”>

Another Type of Rendering

There is an additional internal renderer called ***Freestyle***. Suppose you start with this scene:

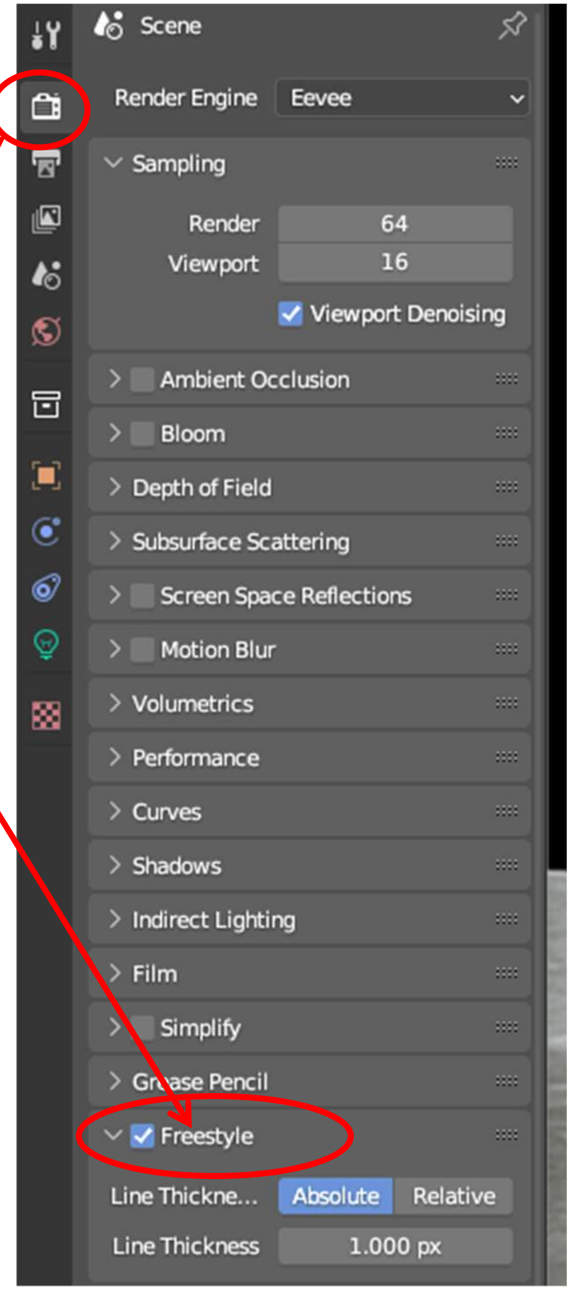


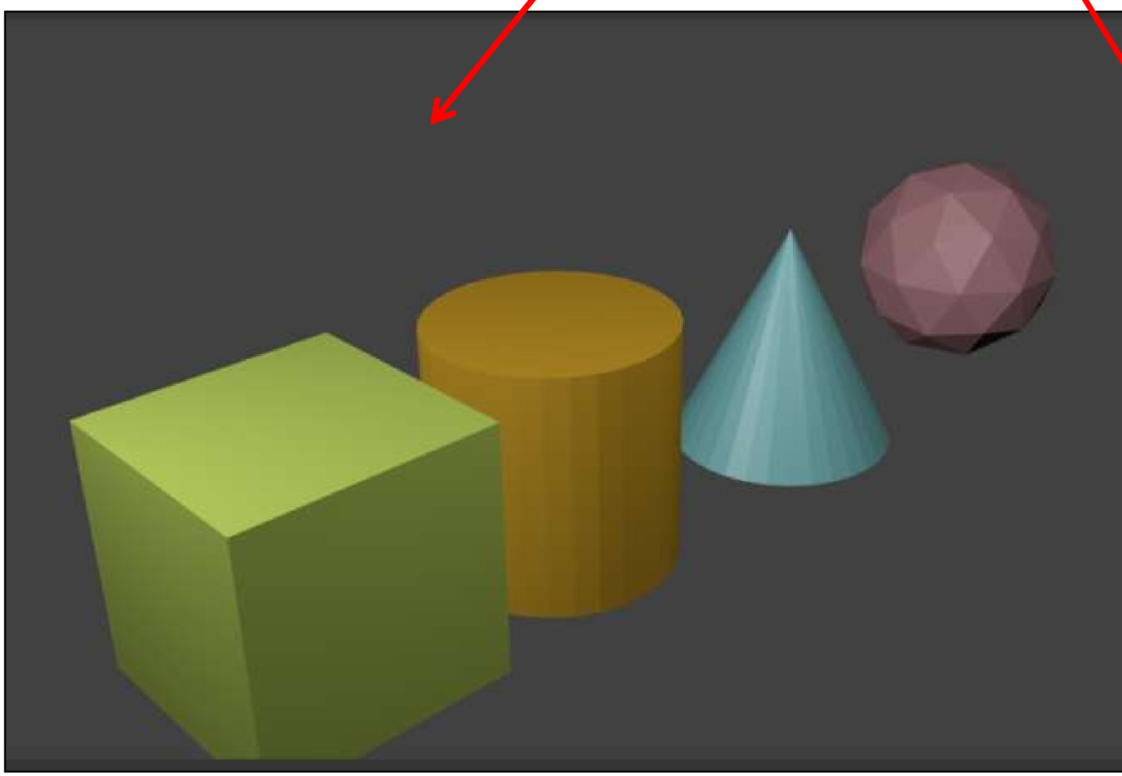
Another Type of Rendering



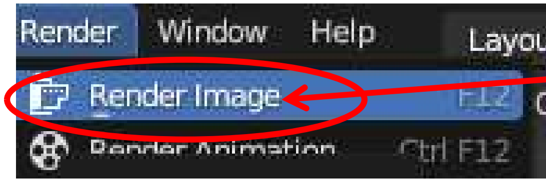
You render it, and the image looks like this:

Now, go to the **Render Properties** menu and turn on **Freestyle**

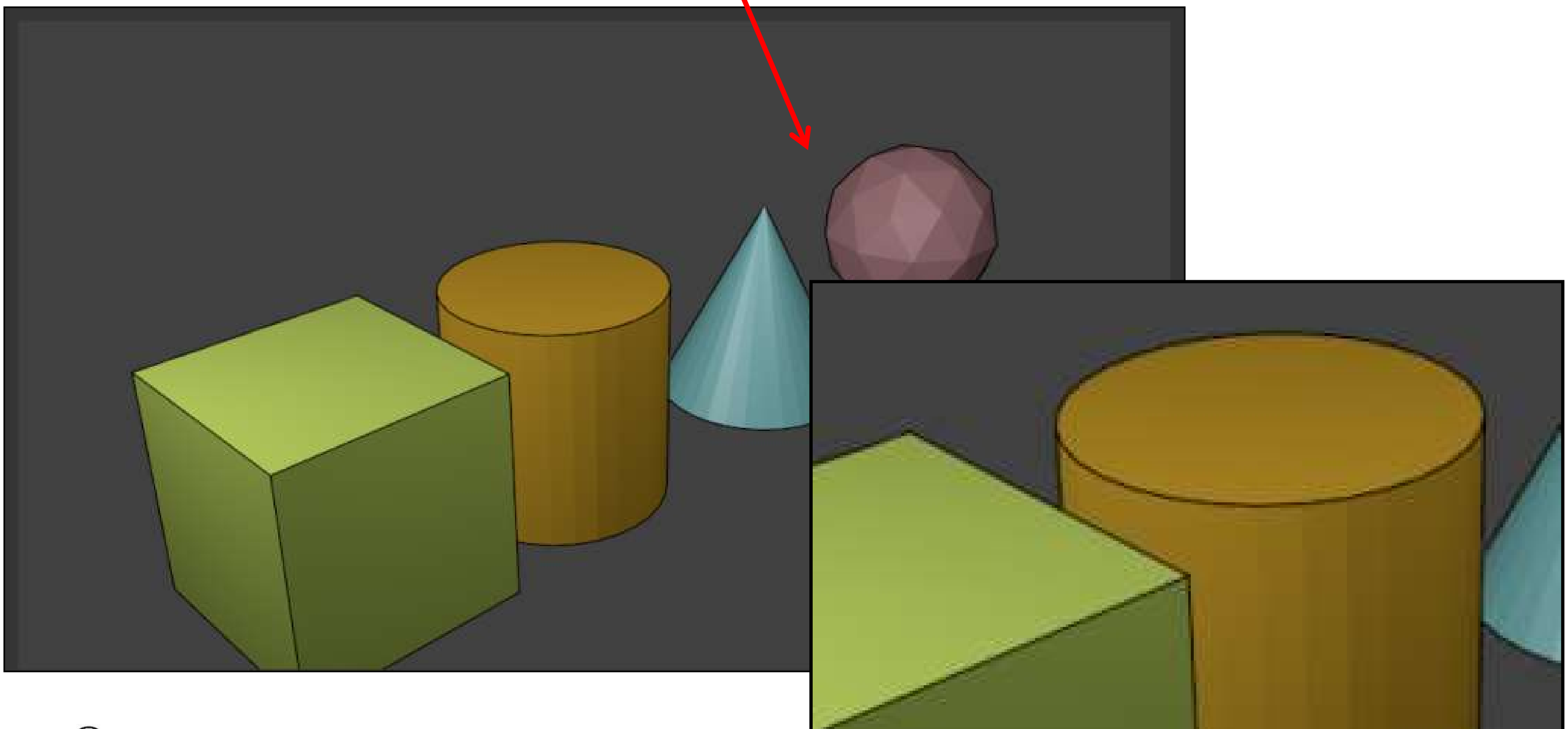




Freestyle Rendering

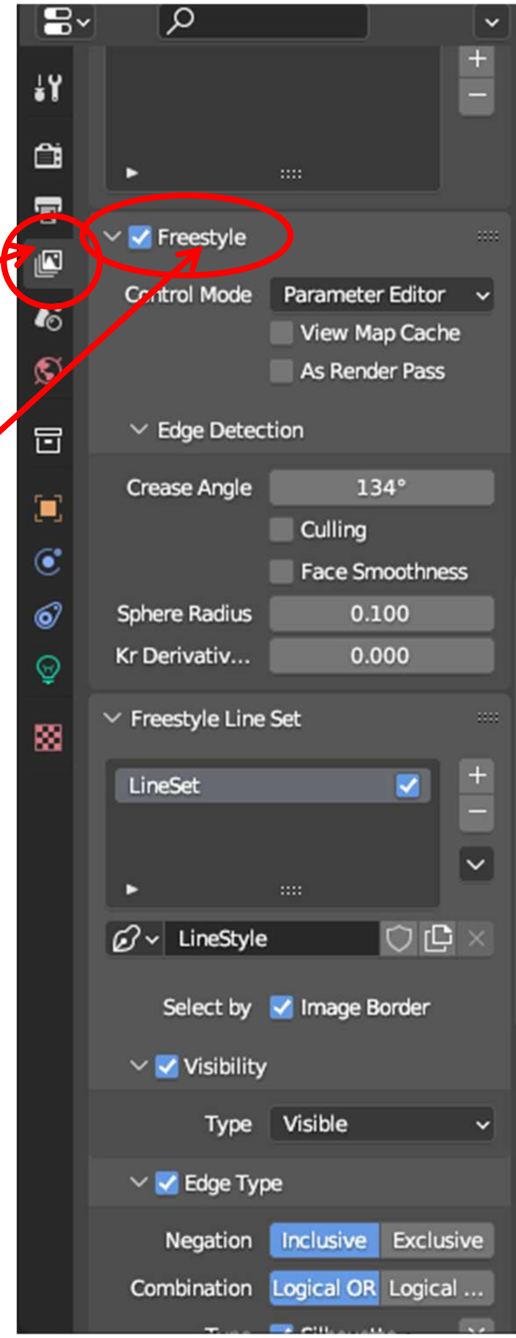


You render it again, and now you get this:



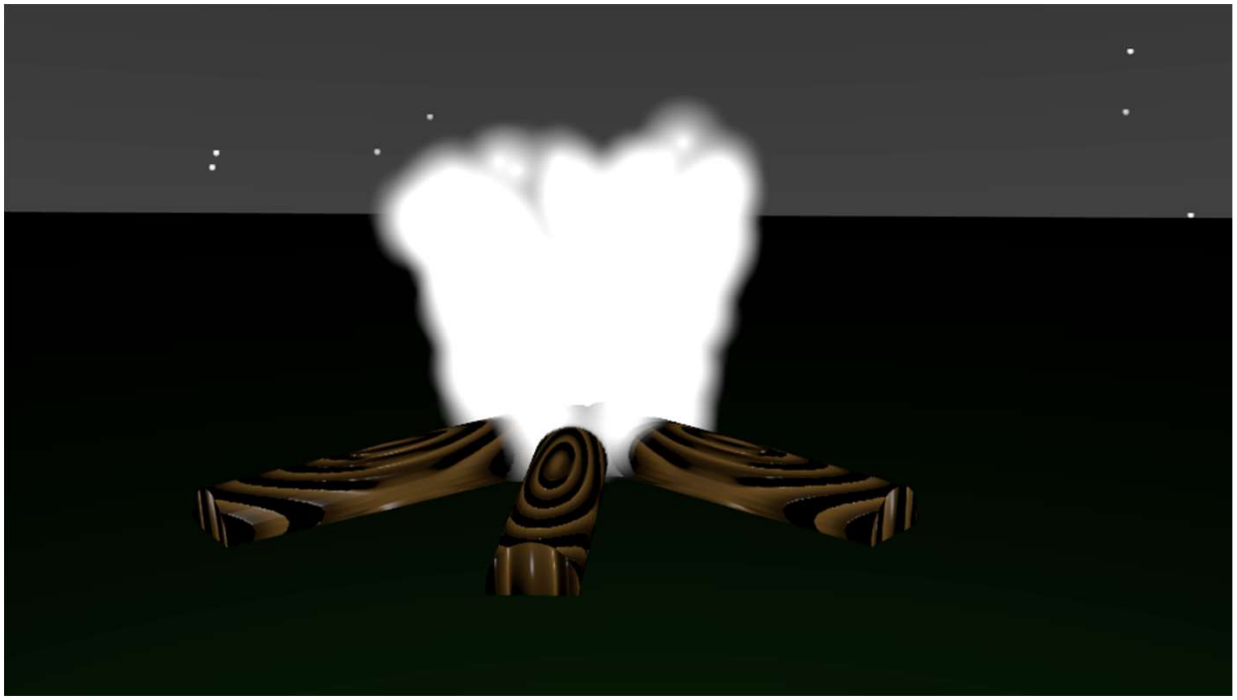
The computer graphics world calls this **Non-Photorealistic Rendering**, or **NPR**. It is good for illustrations where you want to see objects and outlines more than you want to see realism.

Freestyle Rendering



If you look under the **View Layer Properties** button, you will find a lot of Freestyle adjustments that you can make.

8. Particle Systems



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Particle System Examples

Paramount

Pixar

Disney/Pixar

Sony/Marvel

Particle System Examples

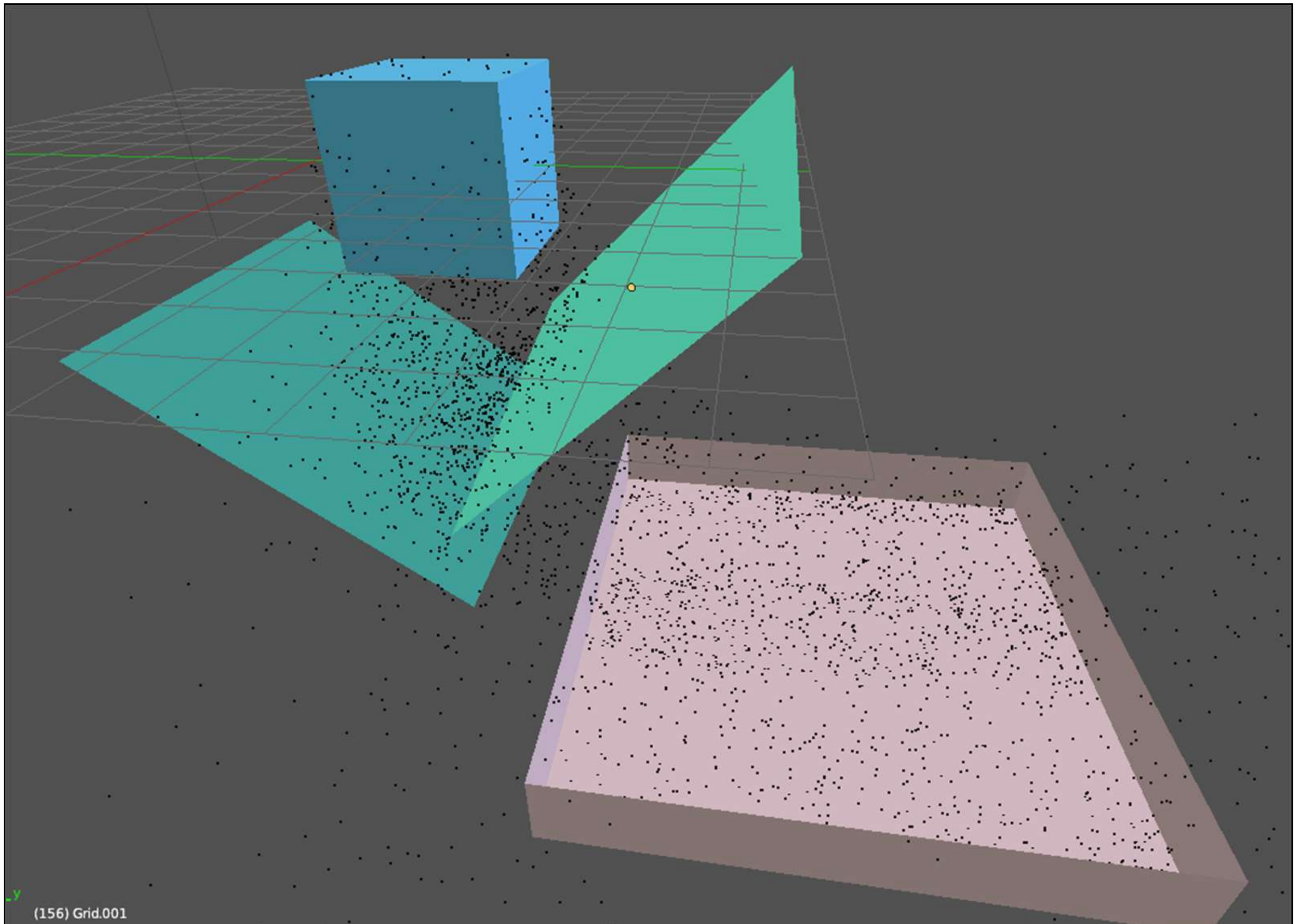
(Particles don't have to actually *be* particles.)

20th Century Fox

Disney

Disney

Particles Bouncing Off Other Objects



particles.blend

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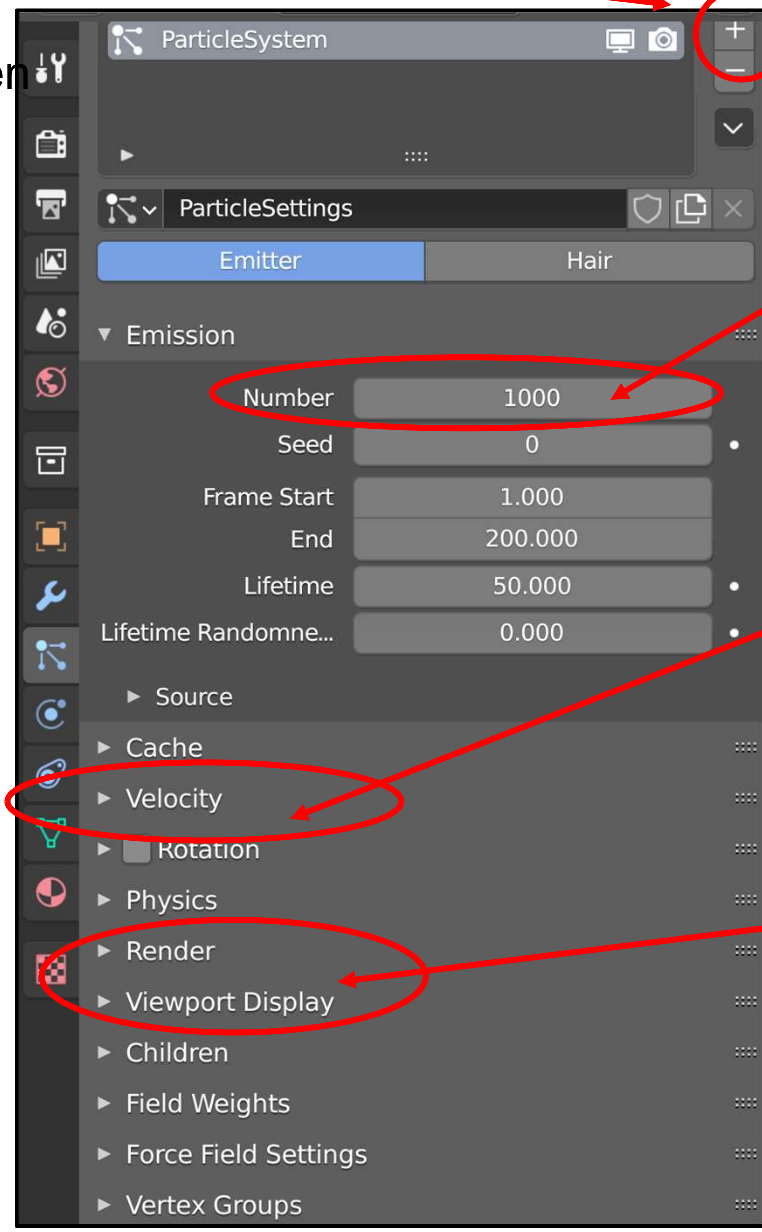
Particles– The Setup

1. Select the object to emit the particles from, then click this property button

2. Click the **+** sign to start a new particle system

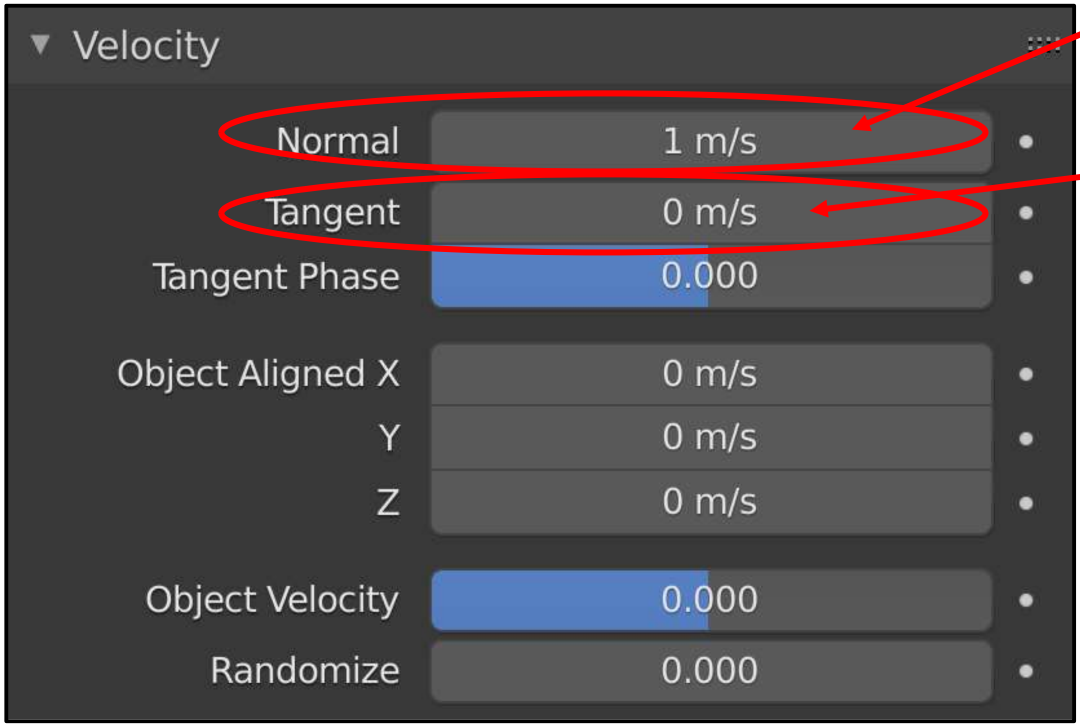


3. Set the number of particles

Optional: Set the particles' initial velocities – see the next slide

Optional: Set the rendering properties -- see two slides from here

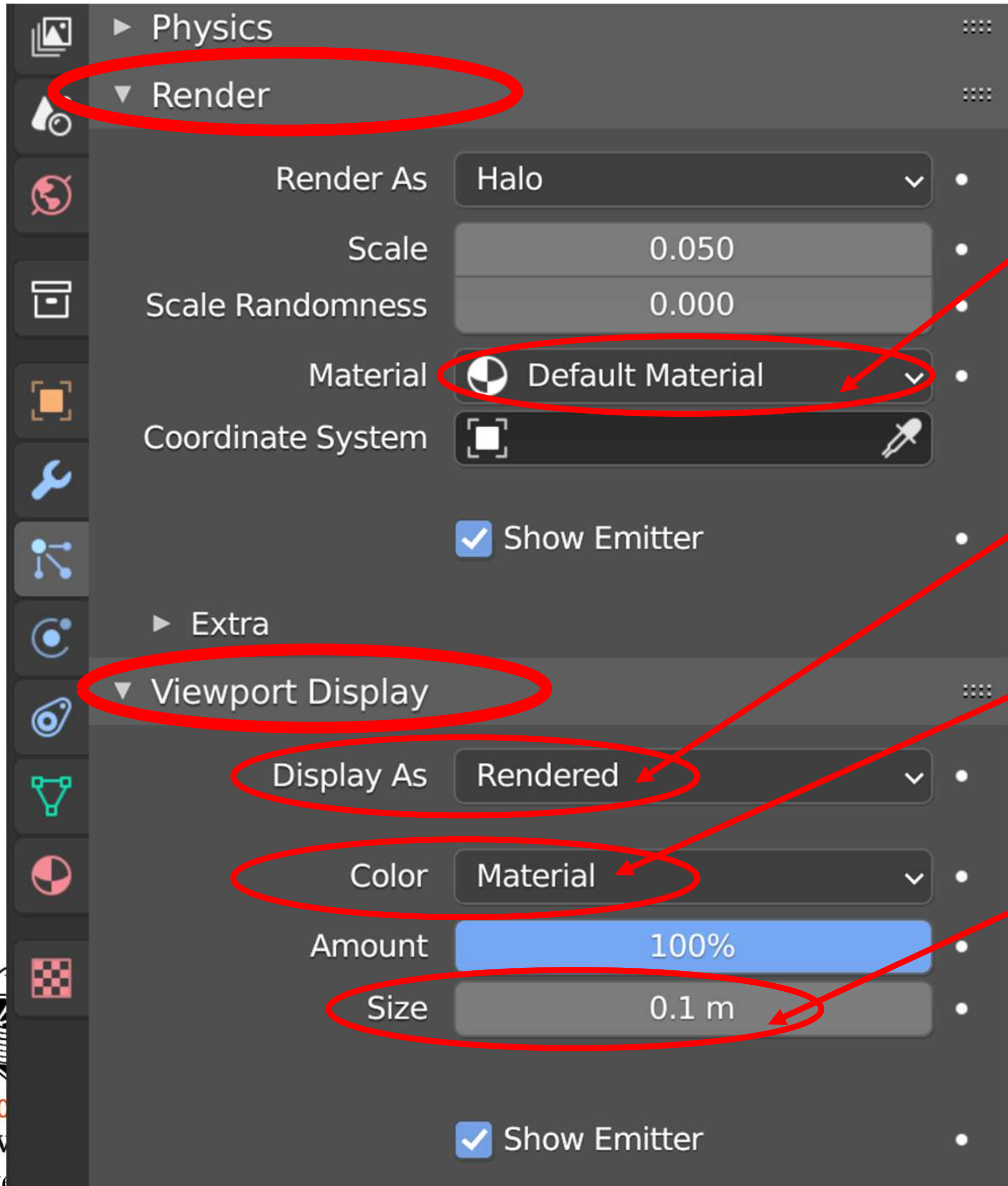
Particles – Expand the *Velocity* Dialog Box



The velocity perpendicular to the surface

The velocity parallel to the surface

Particles – Expand the *Render* and *Viewport Display* Dialog Boxes

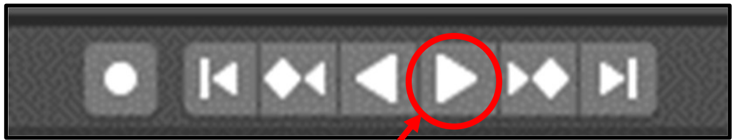


What material definition to color the particles with

What particles to draw (this is fun to change!)

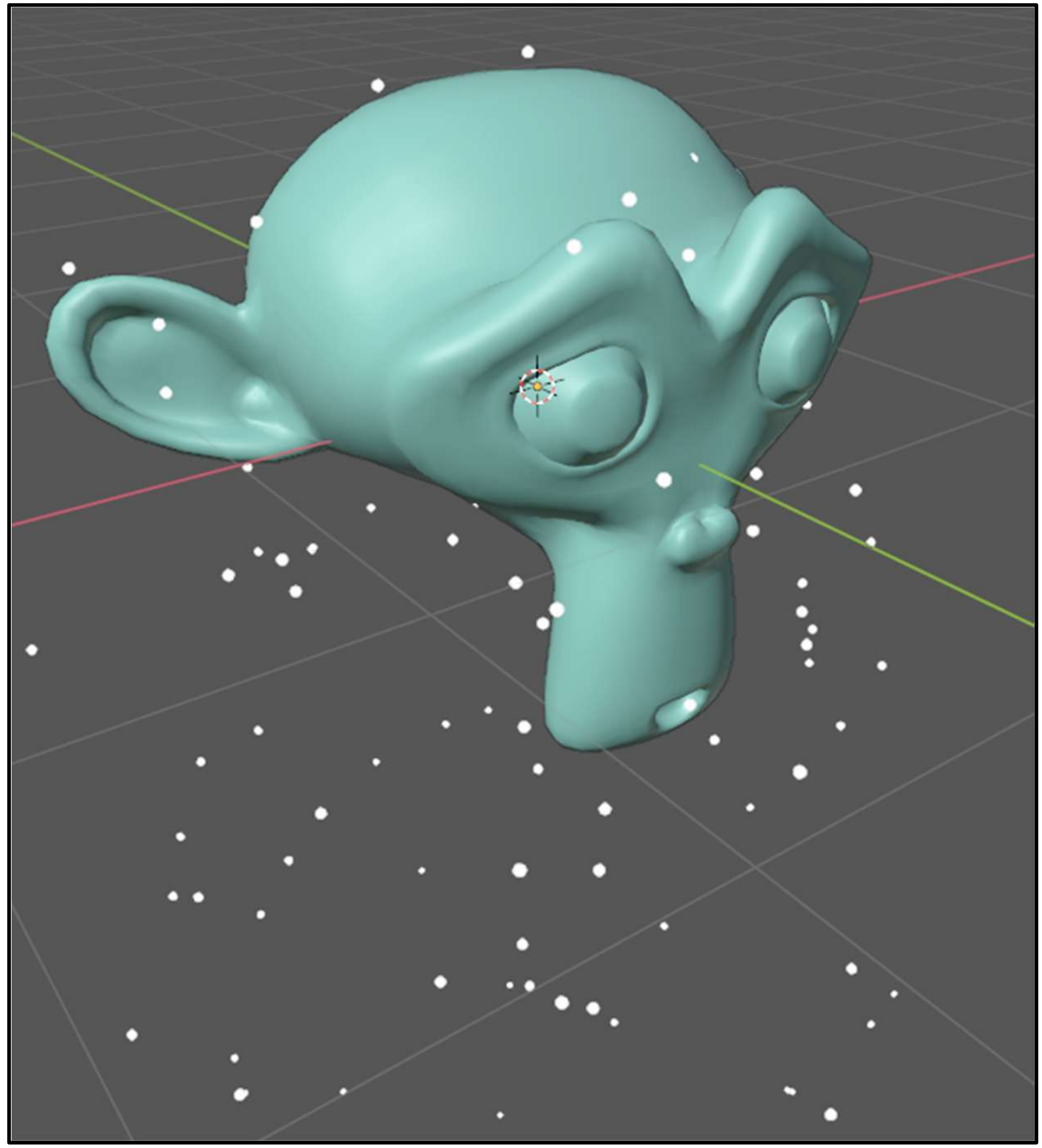
If you like physics, change this to velocity

Start with a small size, like this, but then experiment



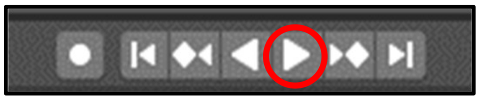
Click here to at the bottom of the screen start the particle animation

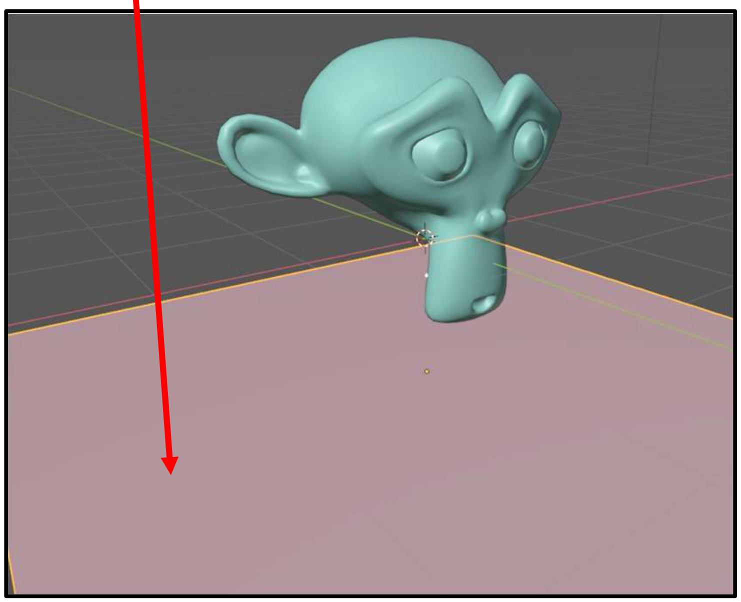
Hit the **ESC** key when you want it to stop

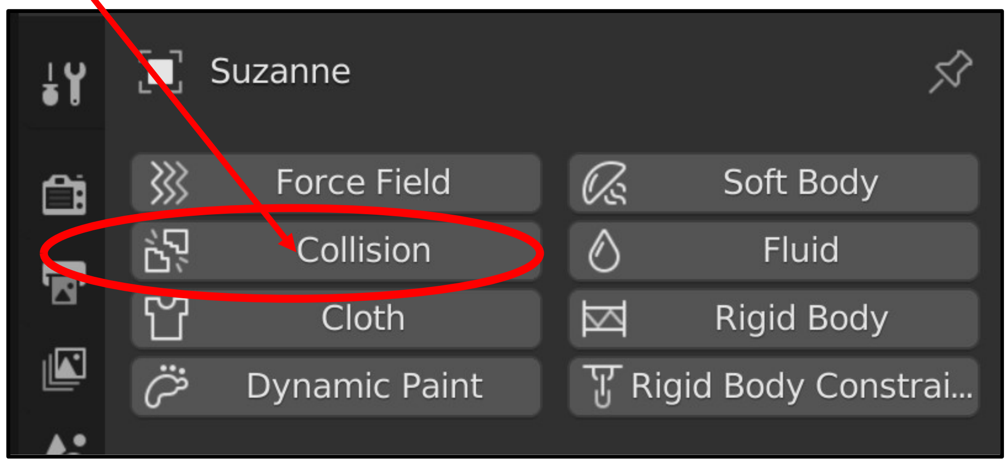


Particles Bouncing Off Other Objects

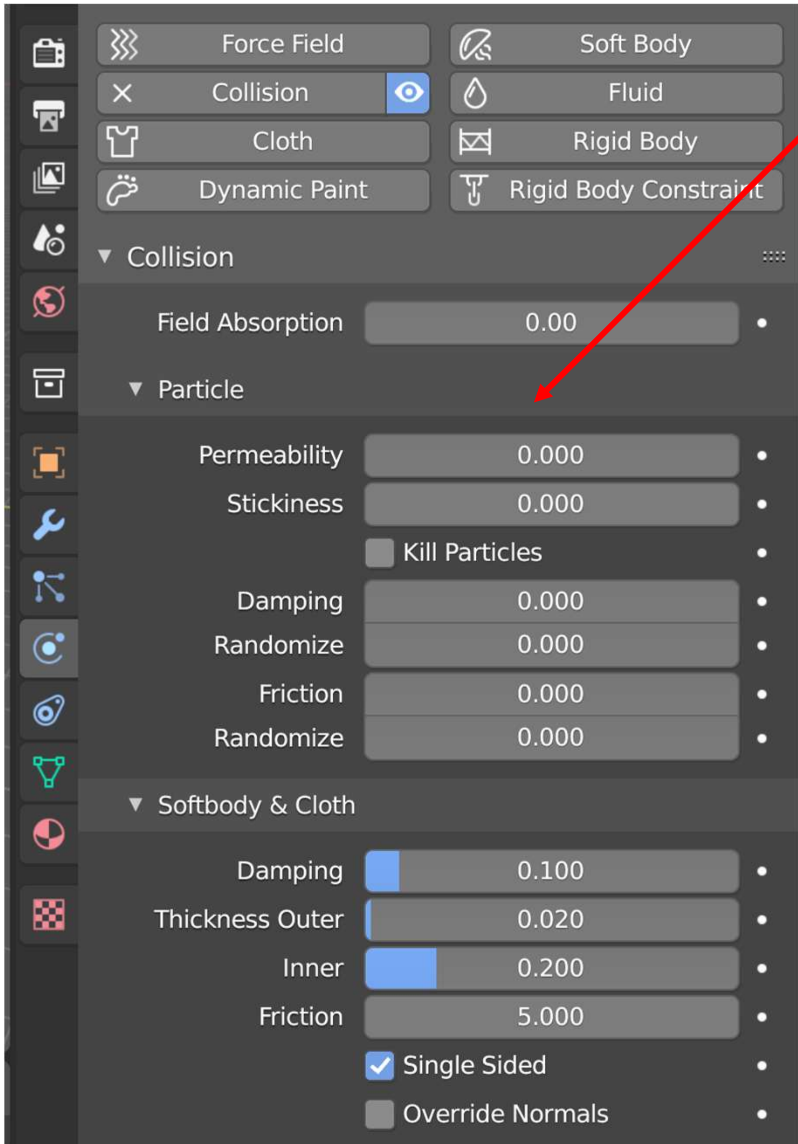
1. Draw a plane to bounce particles from
2. Click the **Physics Property Button**
3. Click on the **Collision** option
4. Turn on the animation





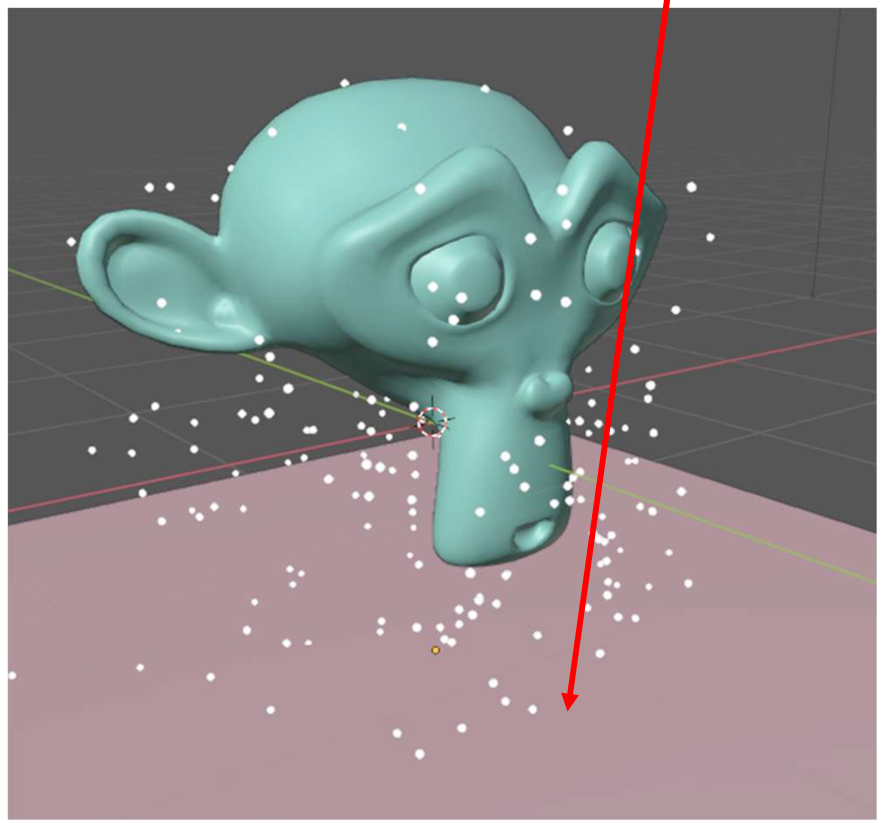


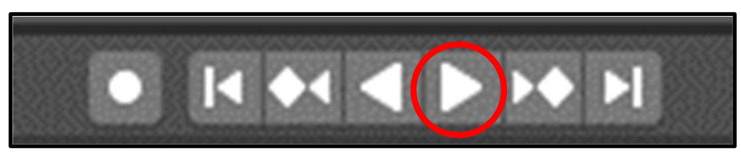
Particles Bouncing Off Other Objects



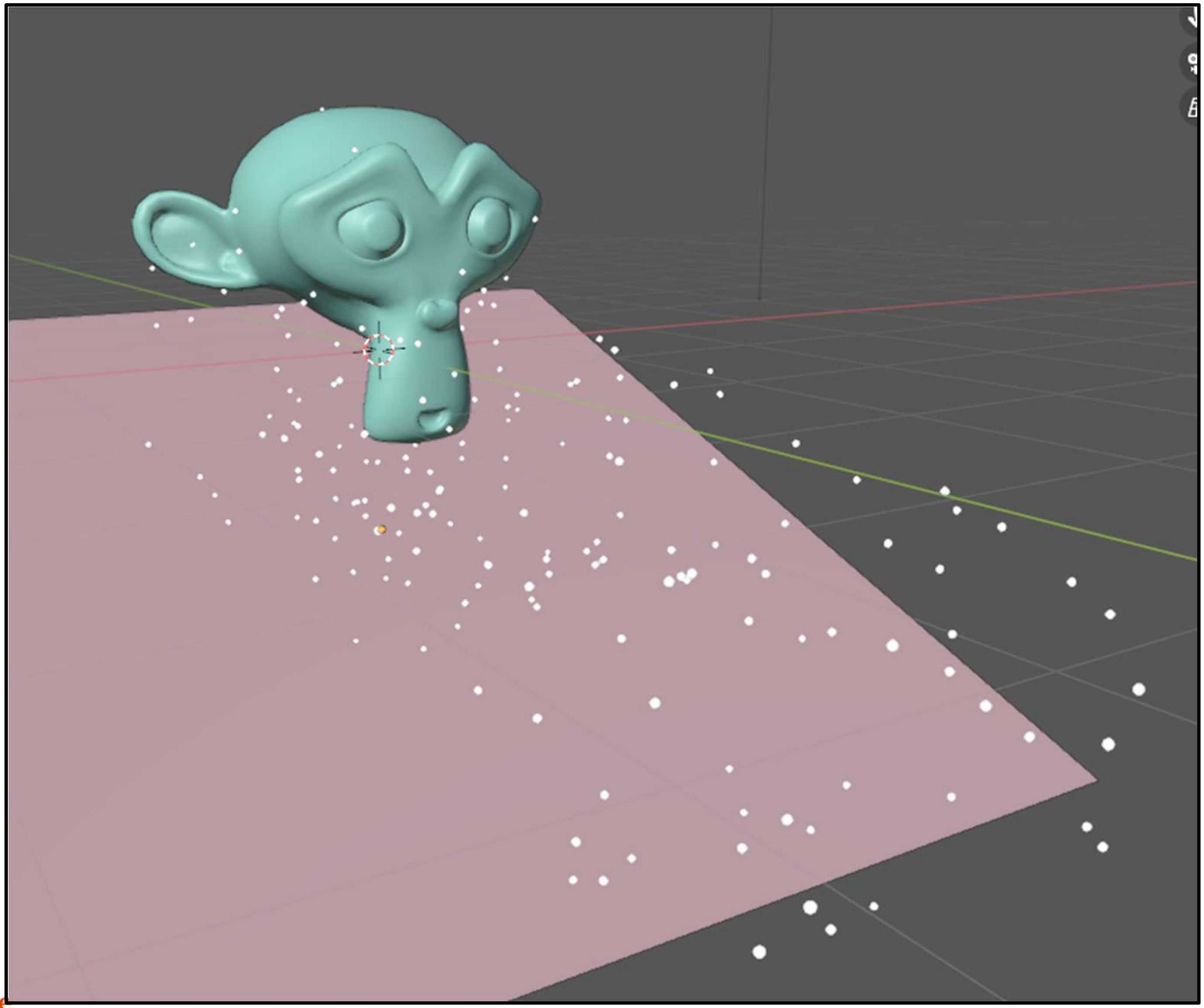
Physics properties of the surface being bounced off of

Bouncing particles

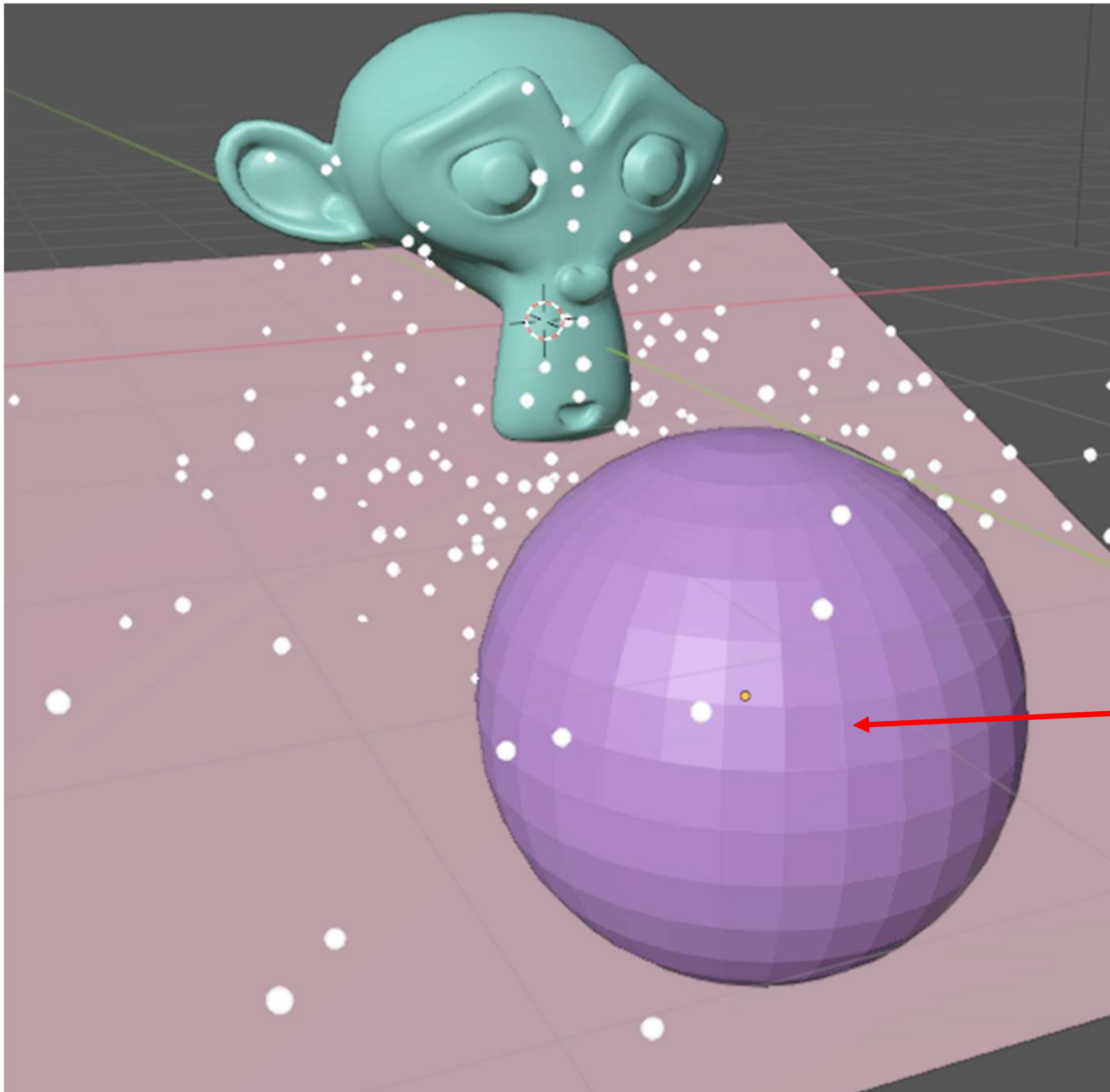




Something fun – Tip the Plane

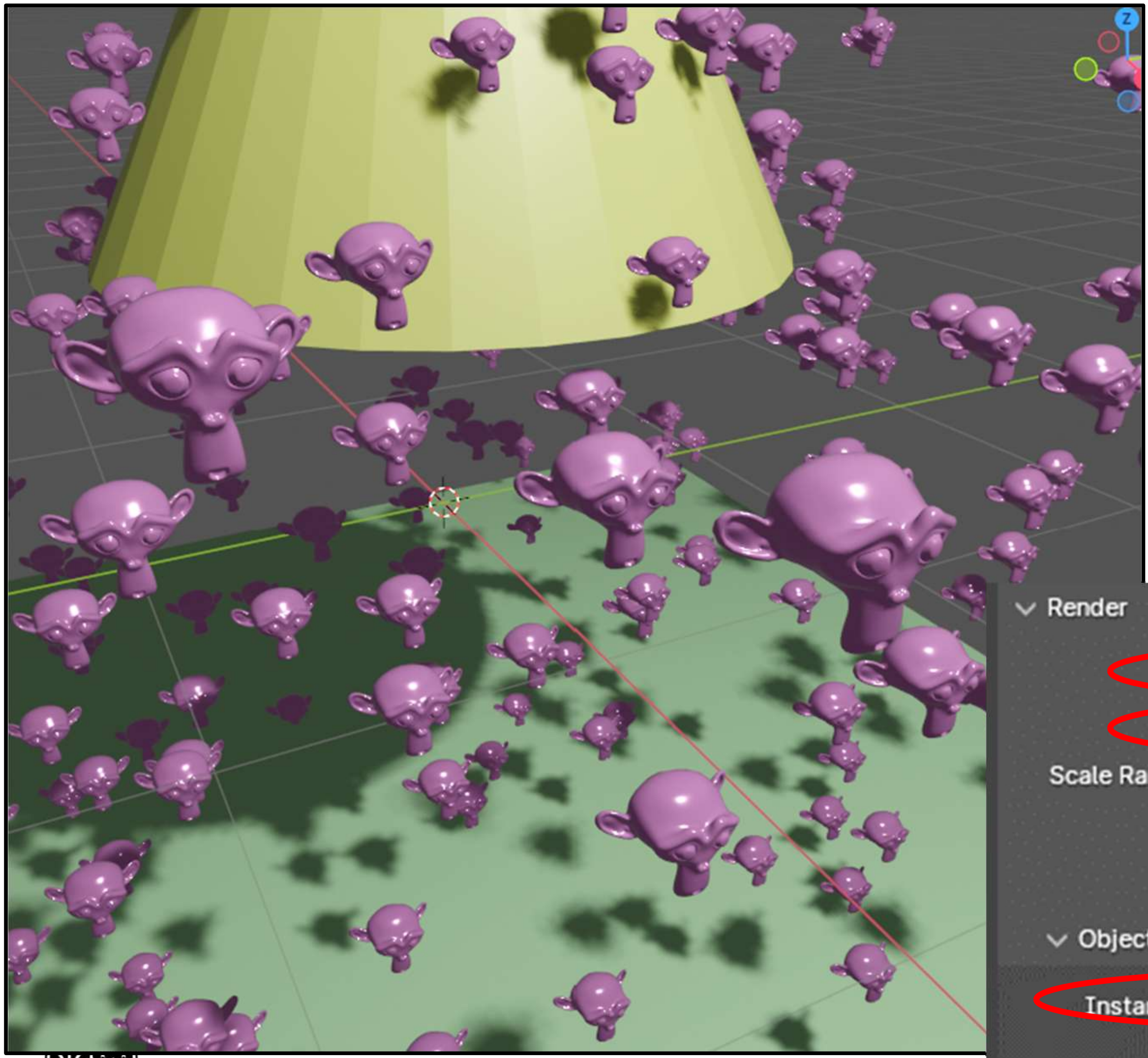


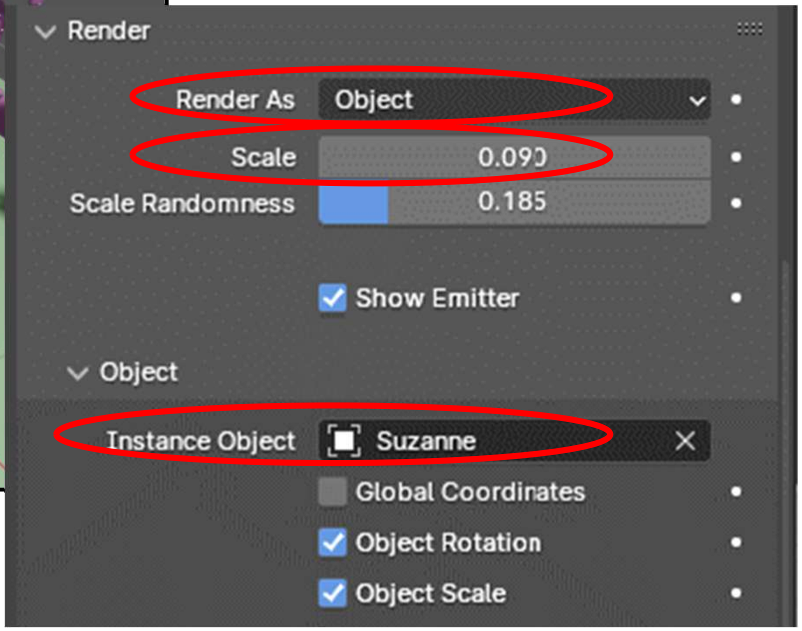
Something Fun – Put Something Else in the Way



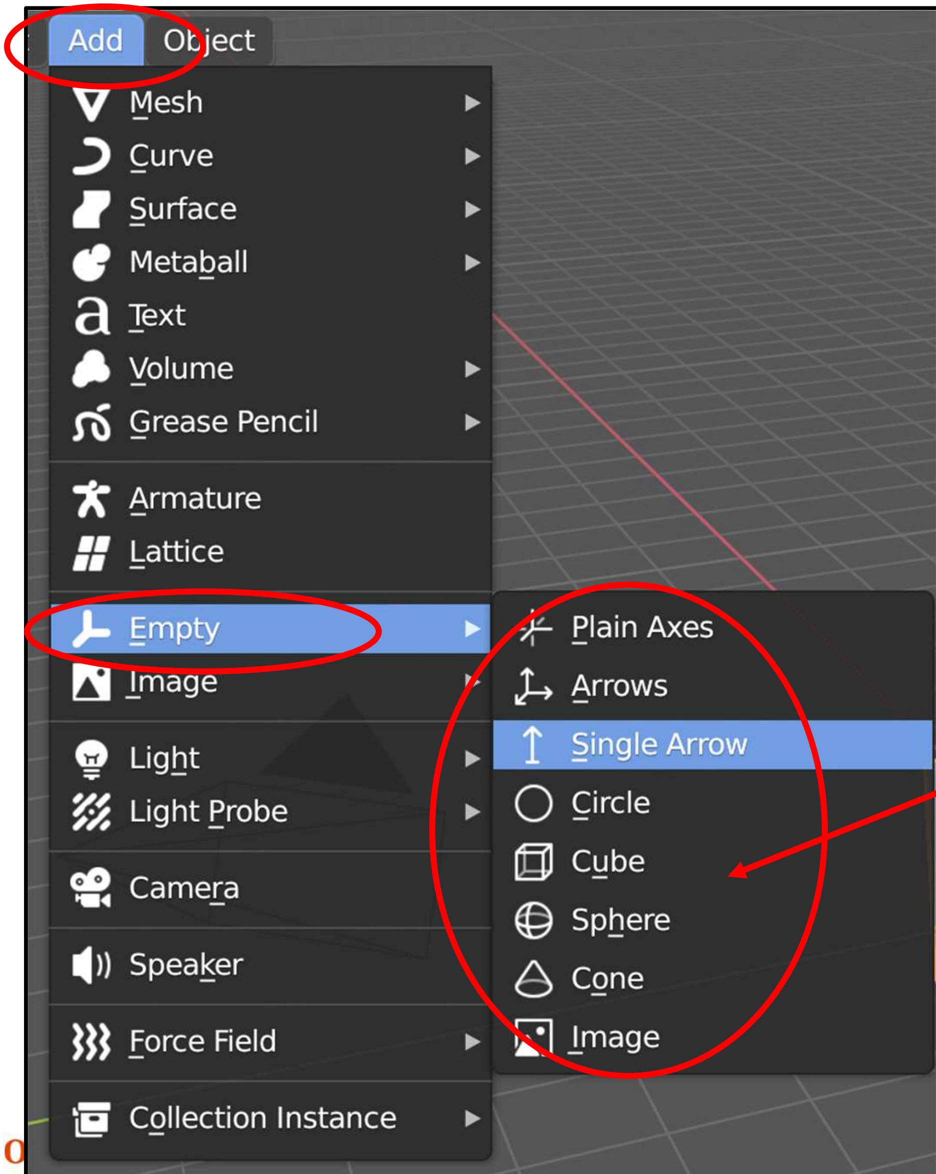
Need to make it a **Collision** surface too.

More Fun – Make the Particles Another Object





To Blow particles, We need a Force Field – Attach it to an Empty Object

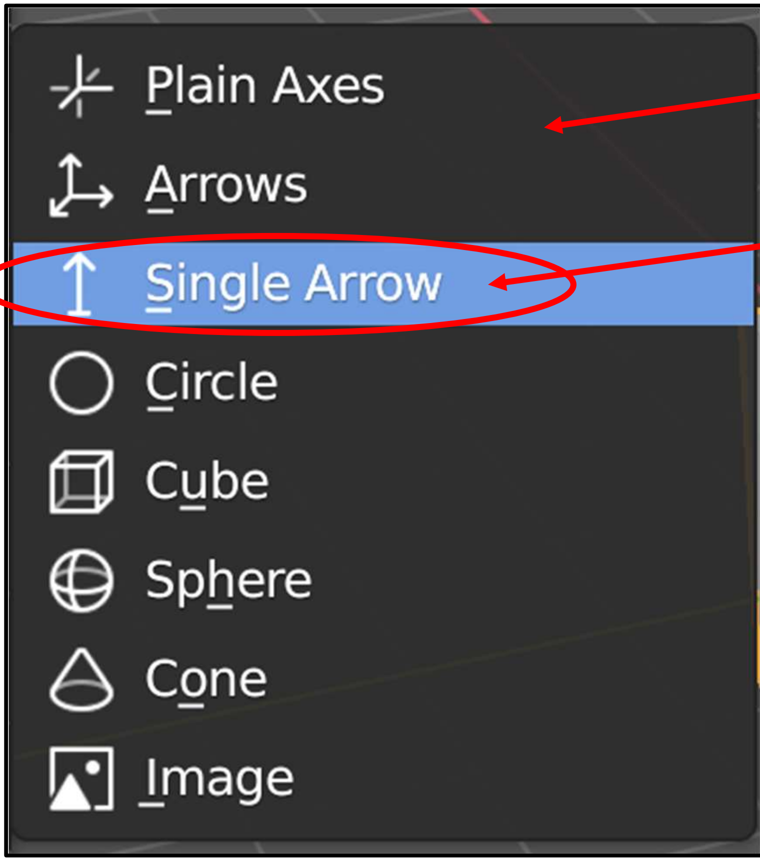


Ironically, one of the most useful objects is the one you can't see. Blender calls this an **Empty**.

It's invisible on the screen, but you can treat it like a real object, and can attach forces to it. These forces will influence the behavior of other objects.

Find the **Empty** under the **Add** tab at the top of the screen. When you click on it, this sub-menu pops up.

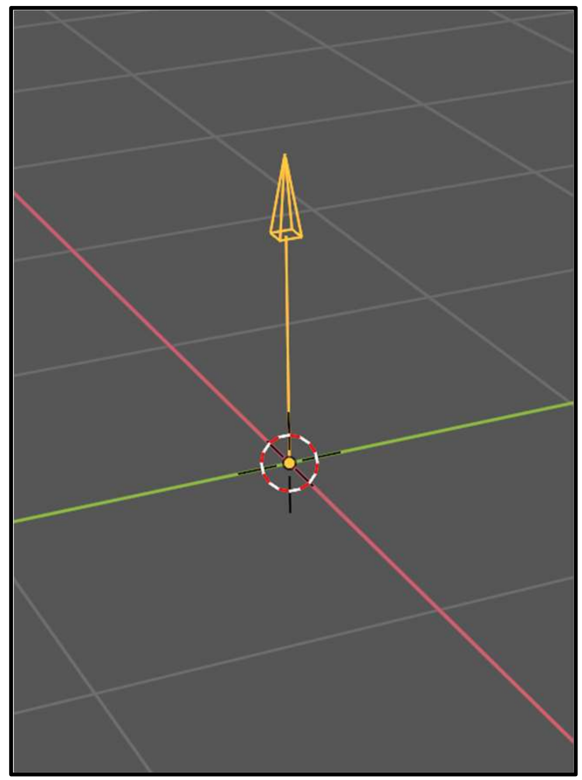
We need a Force Field – Attach it to an Empty Object



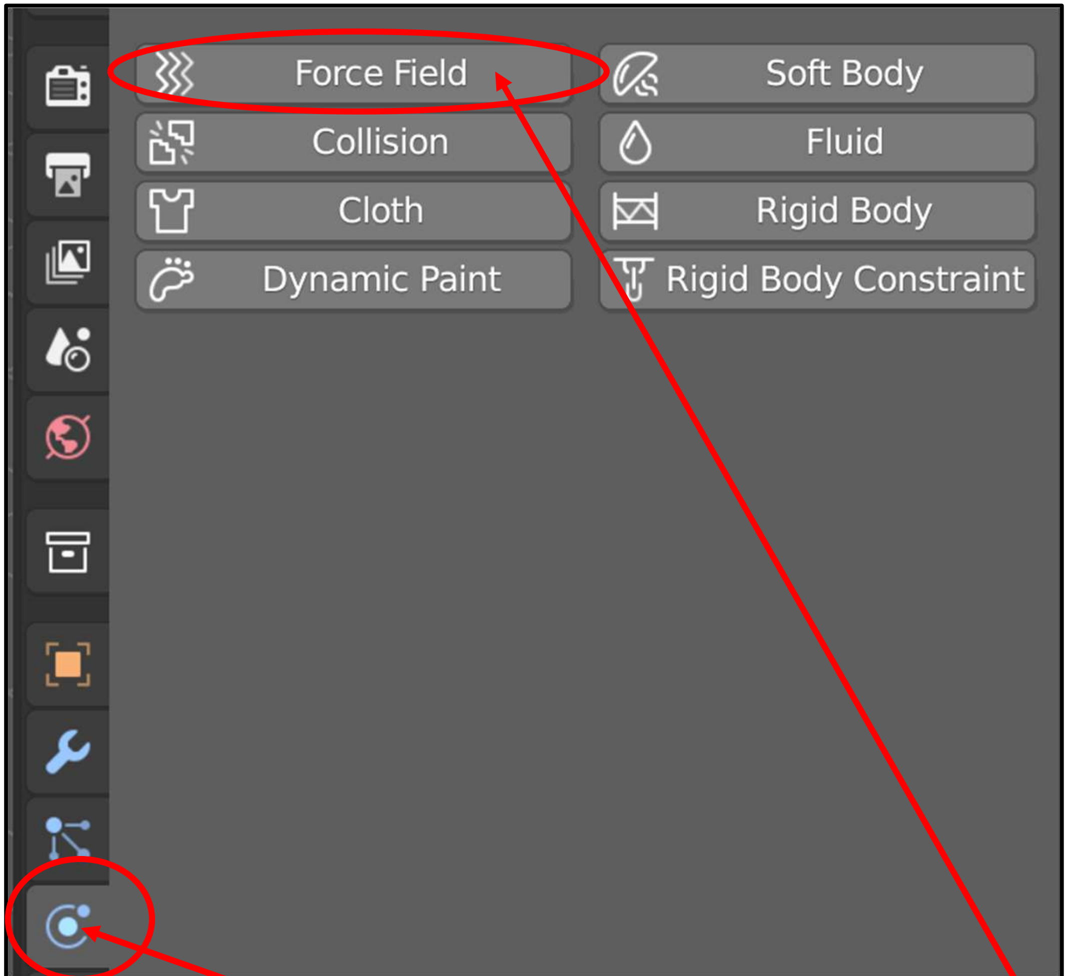
Surprise! Even though it is invisible, an **Empty** has a shape!

For this exercise, pick the **Single Arrow**

On the screen, it will look like this:.



Blowing the Particles -- Force Fields



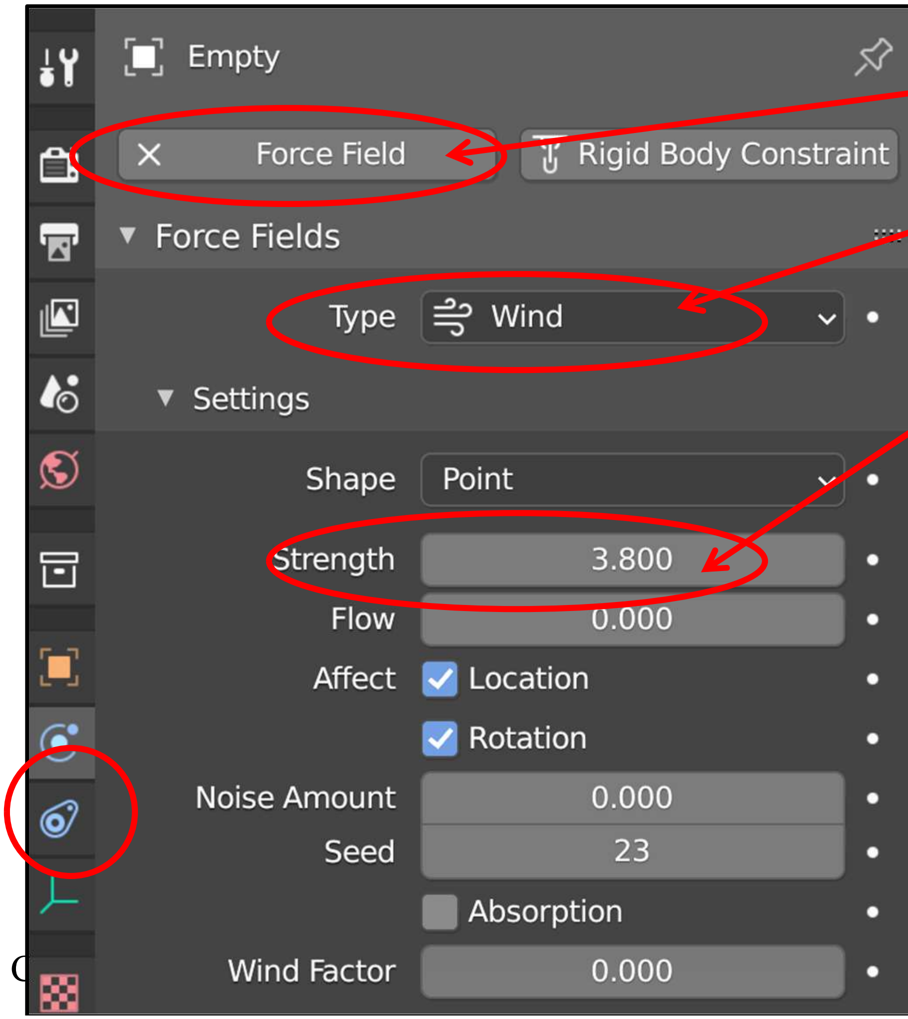
A really good use for **Force Fields** is to blow particles and cloth around

With the **Empty** Object selected, click on the Physics icon and then click on **Force Field**

Position and Orient the Empty

Using the usual object-rotate commands, orient the **Empty** so that it is pointing at the particles.

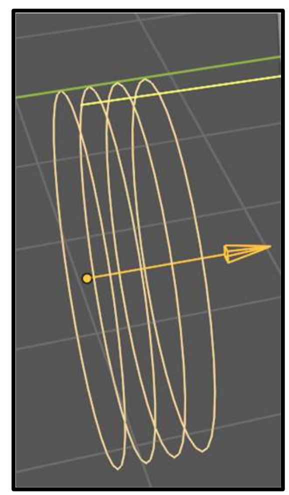
Hint: it is easiest to *position* it in Global Coordinates **(g → x)** and easiest to *rotate* it in Local Coordinates **(r → x → x)** .



And, under **Force Field Type**, select **Wind**

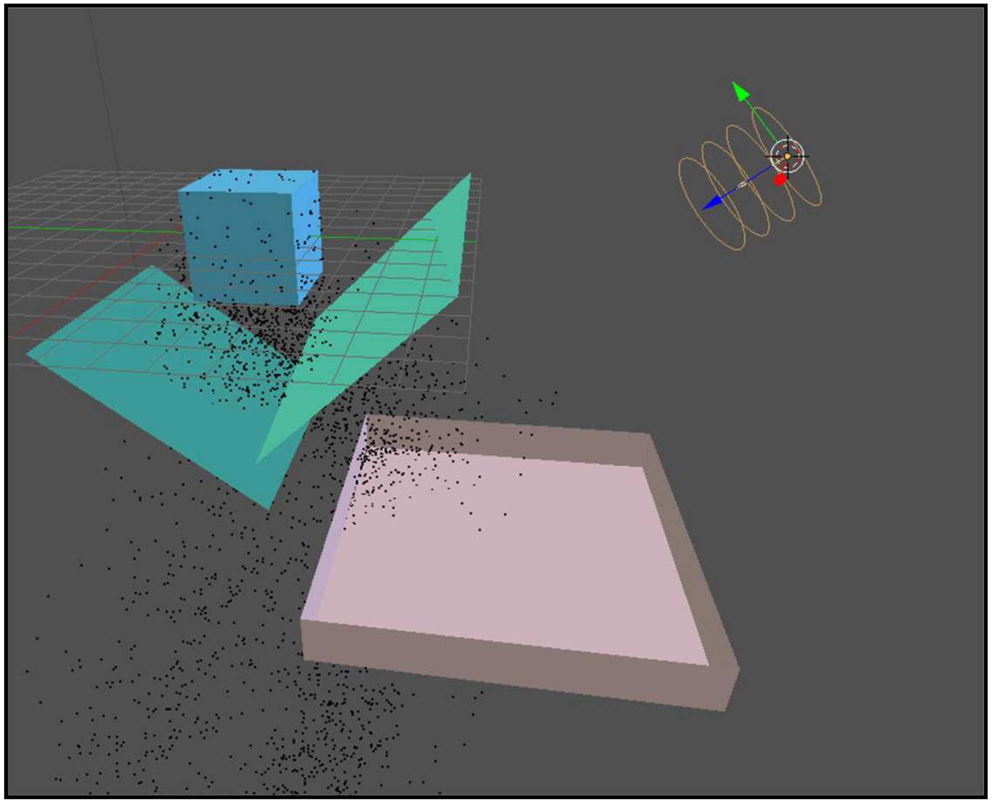
You will use this to change the **Strength** of the wind

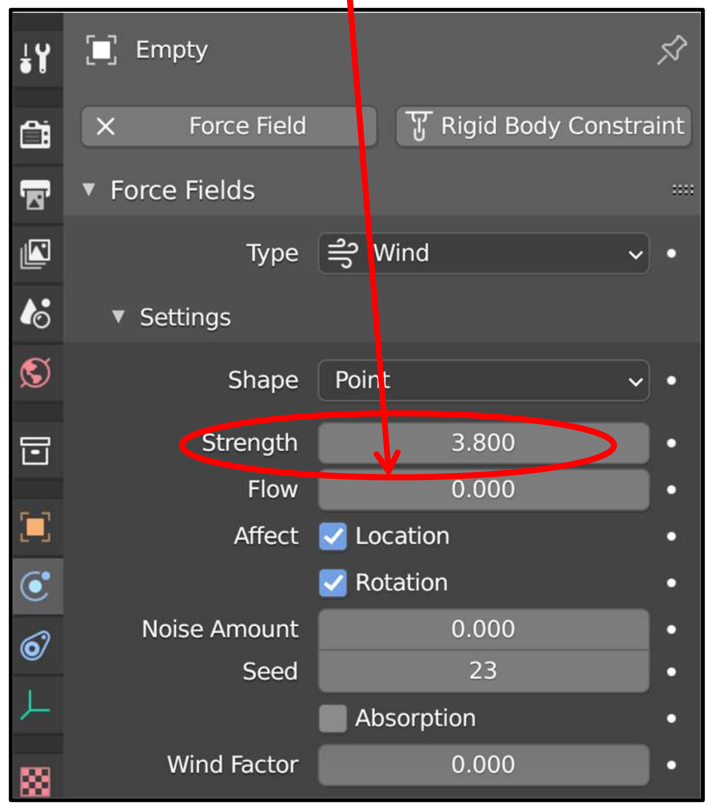
It will look like this on the screen:



Blowing the Particles

Turn on the animation (Control-'a'). You can adjust the orientation and the **Strength** of the Wind while the animation is playing to get just the effect you want.

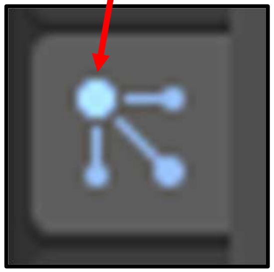




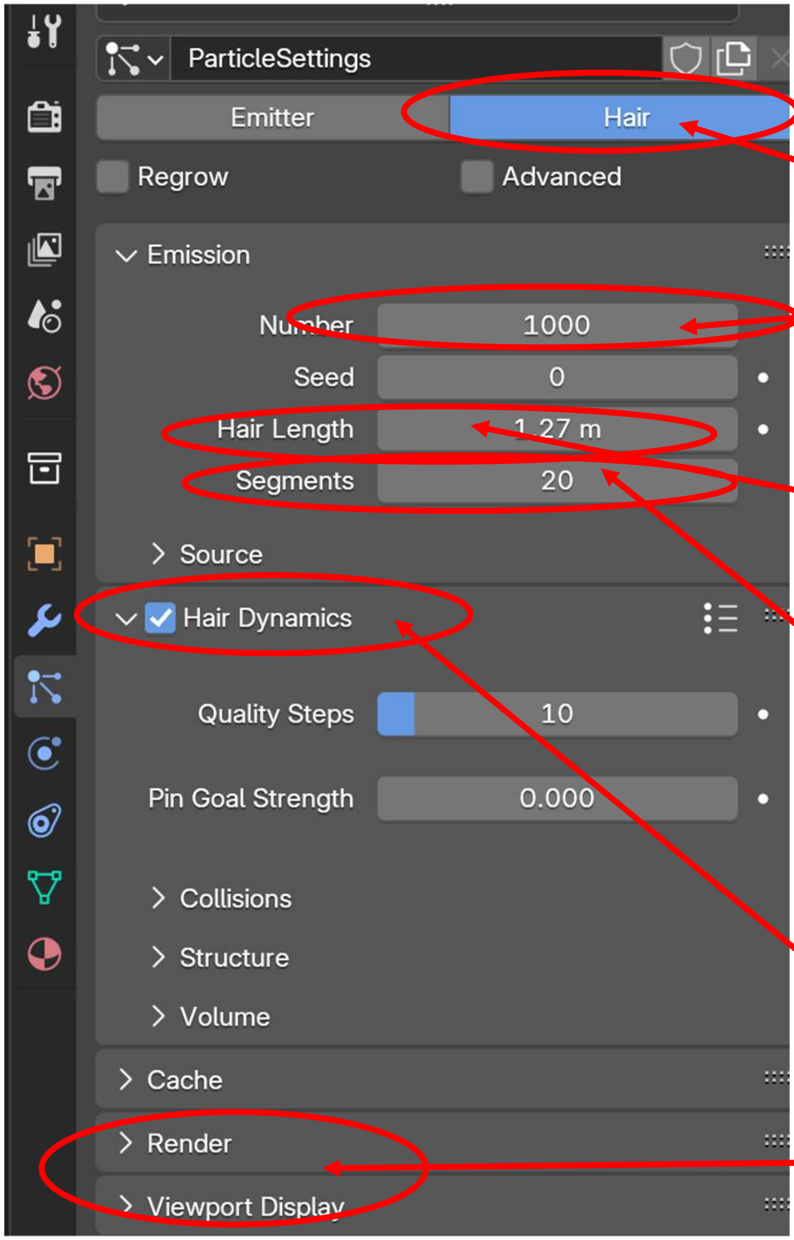
blowing.blend

Particle Systems for Hair

1. Select the object to emit the hair from, then click this property button



2. Click the **+** sign to start a new particle system



3. Select **Hair**

4. Set the number of strands

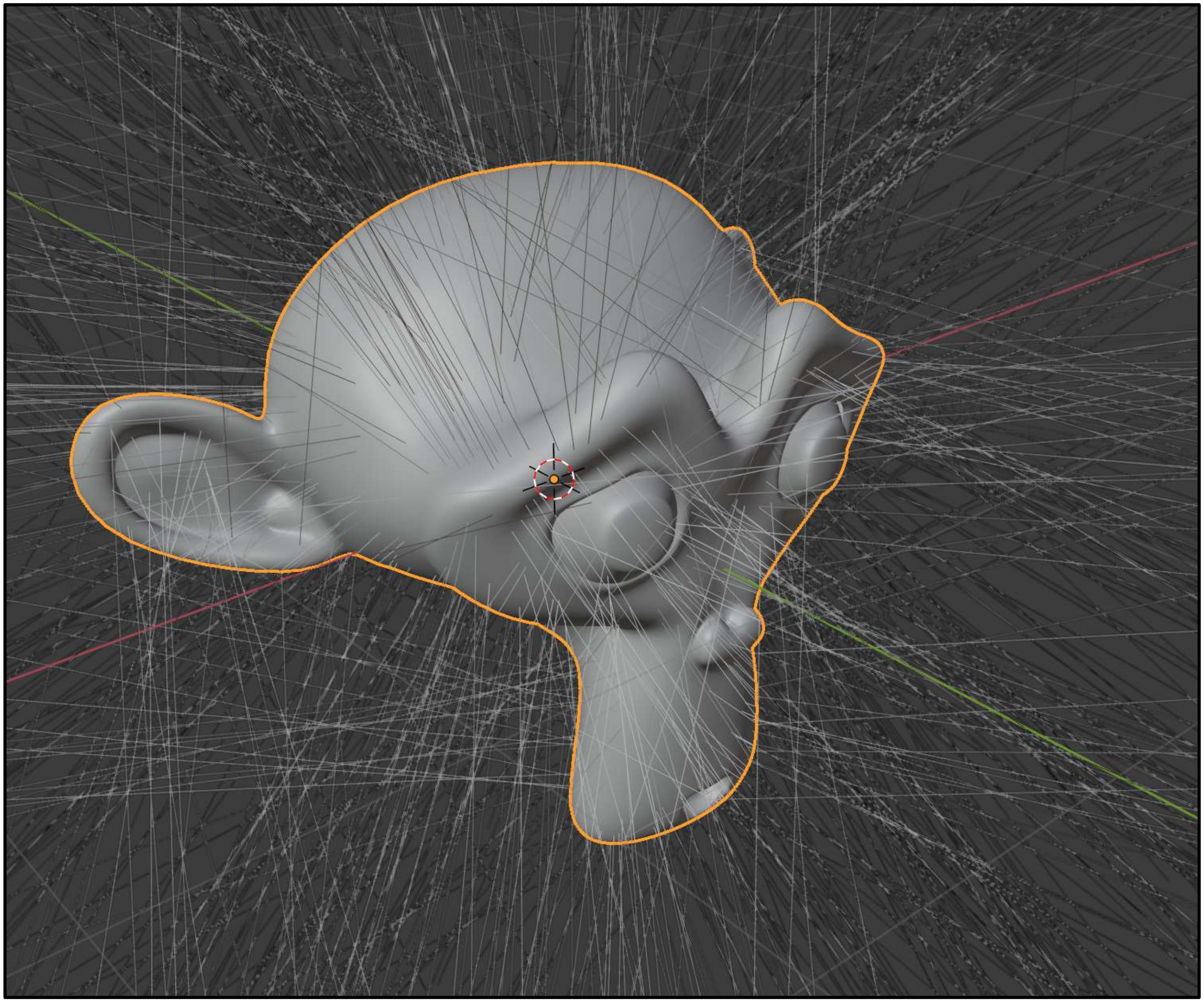
5. Set the hair length

6. Set the number of segments per strand (bigger looks better but renders slower – try 10-20)

7. Apply physics to the hairs – click this on

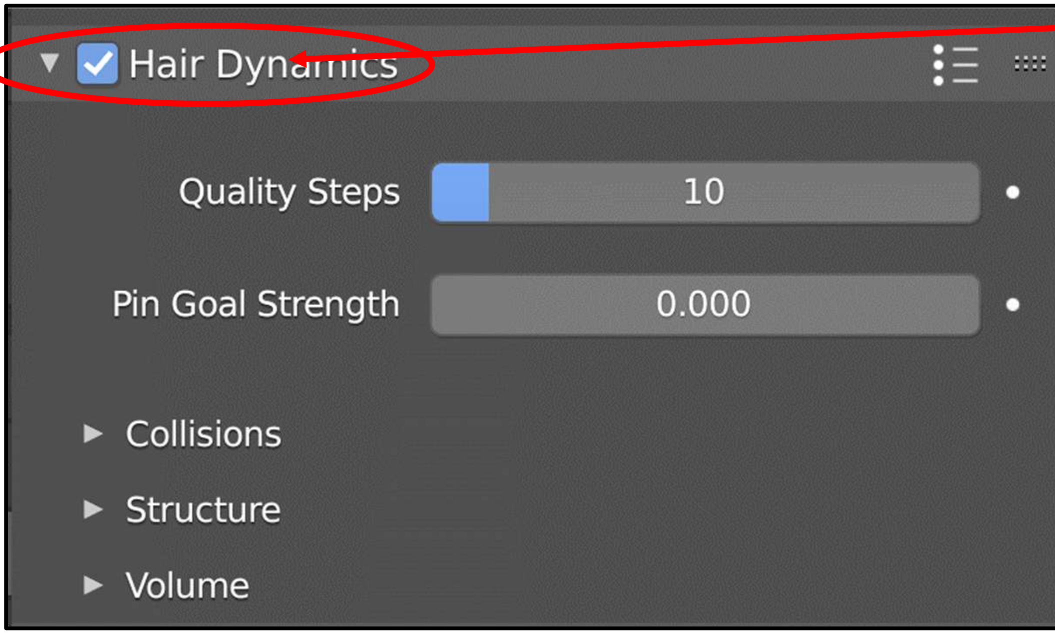
8. Set the rendering properties

It Will Start Out Looking *Terrible*

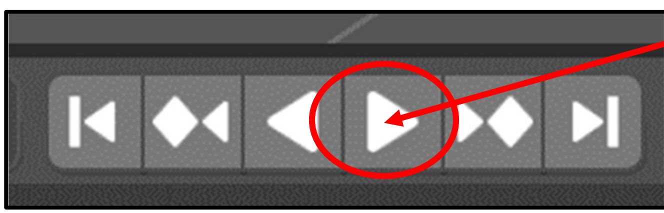


Try setting the **Hair Length** to something small-ish like **0.5** or **1.0**

Making the Hair Droop

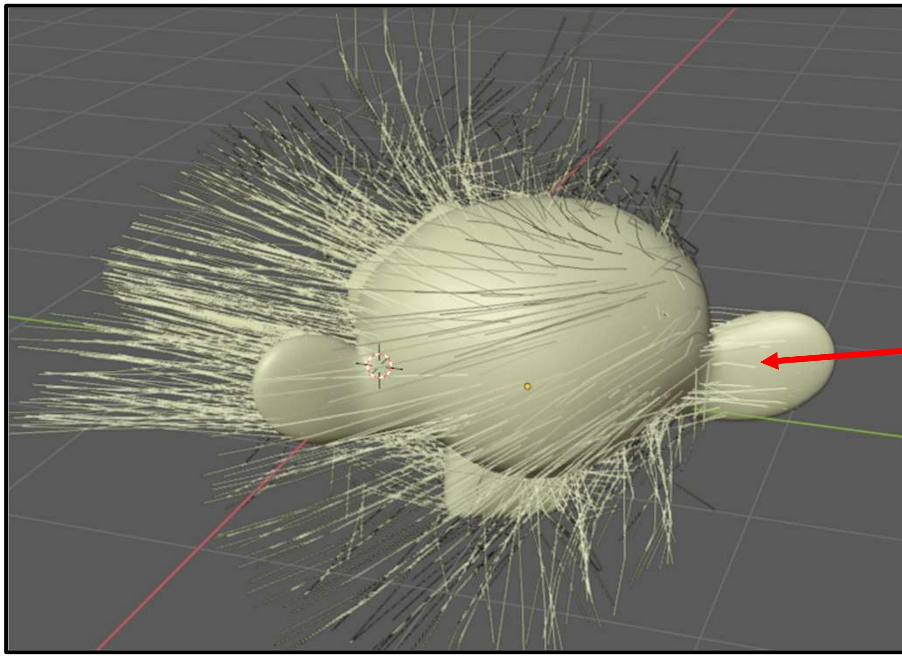


Turn on and expand **Hair Dynamics**



Start animating to start the hair-droop simulation

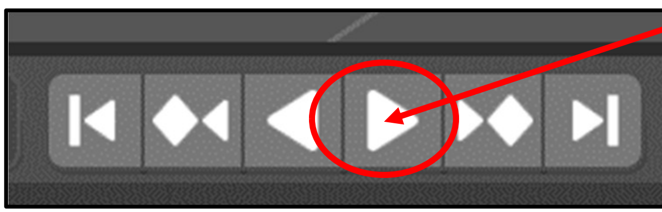
Animating the Object and the Hair



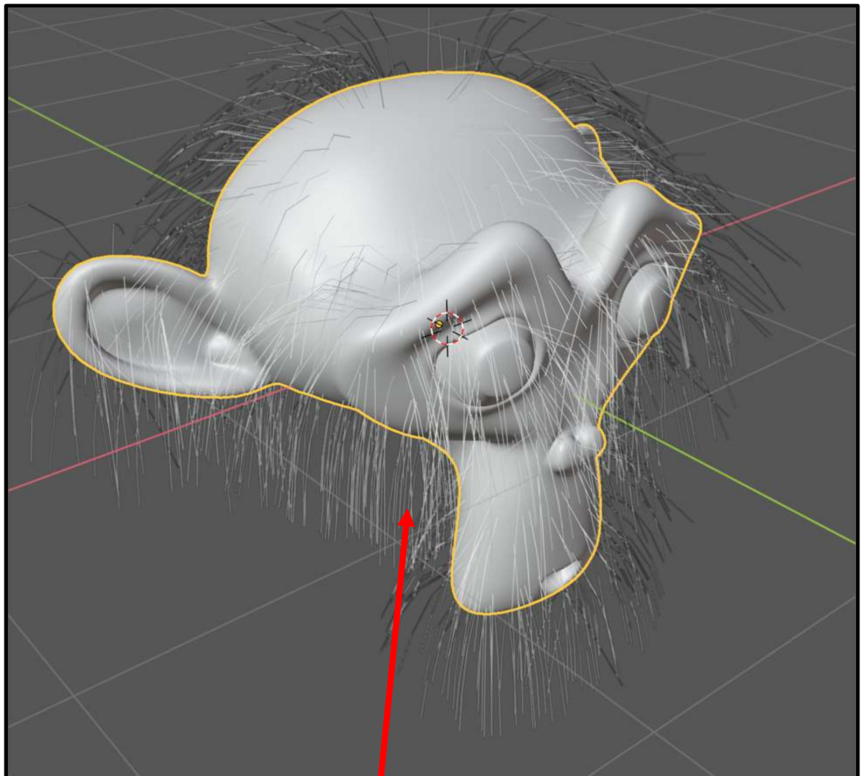
At this point, I like to keyframe-animate the object with the hair or just translate the head ('gy').

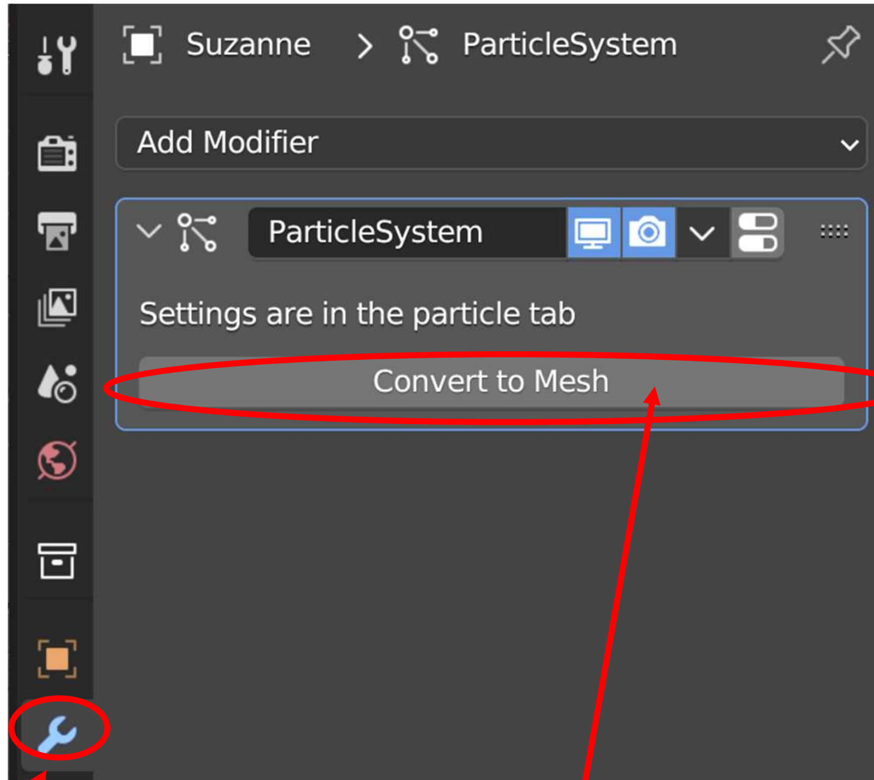
Here Suzanne is translating and rotating, as the hair movement is showing.

Start animating



Making the Droop Permanent



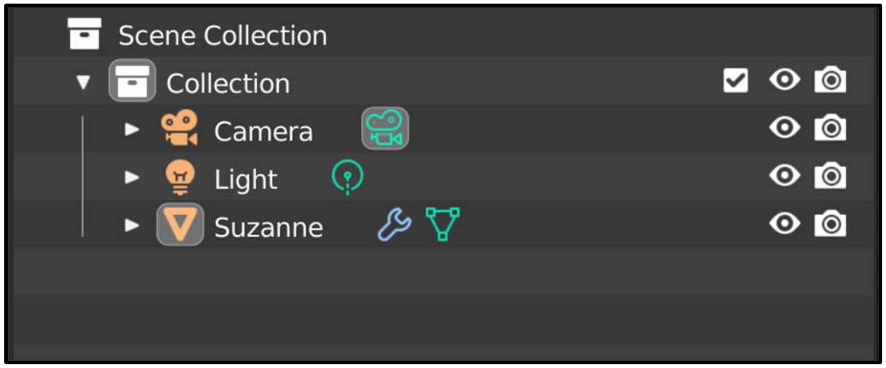


Get the droop the way you want it

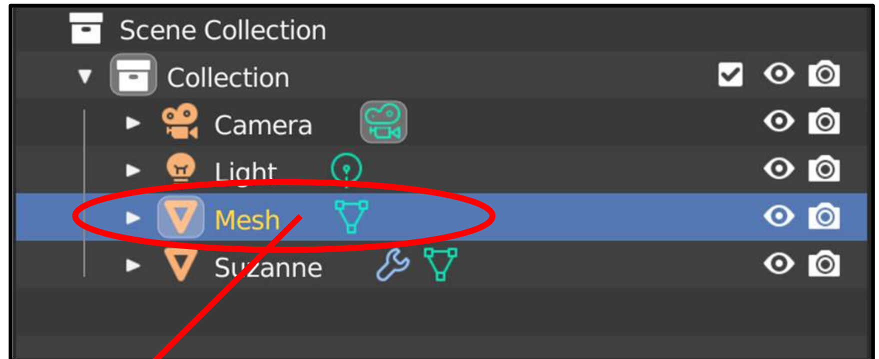
Select **Modifiers** – a ParticleSystem modifier will already magically be there

Click on **Convert to Mesh**. This will turn the hair into a mesh object.

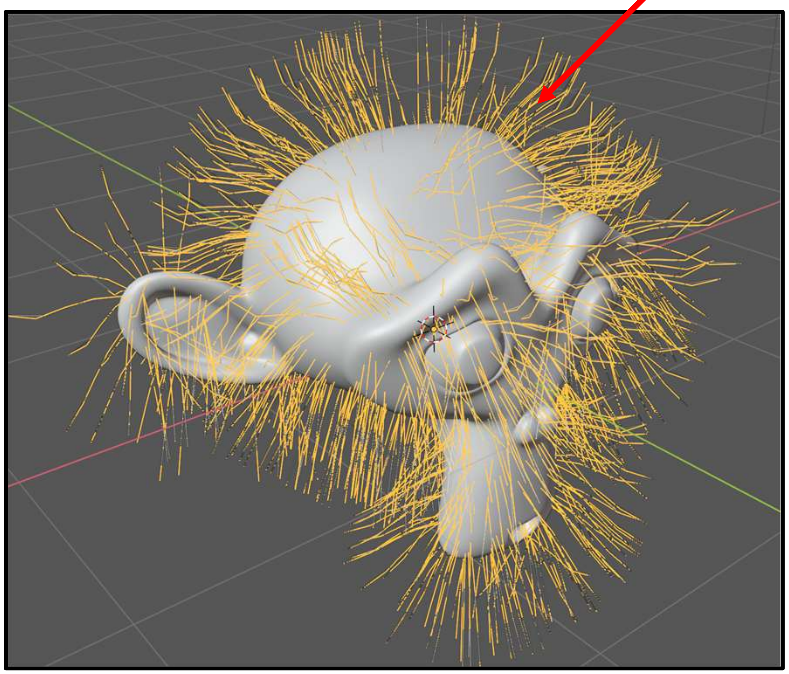
Making the Droop Permanent



Before clicking **Convert**

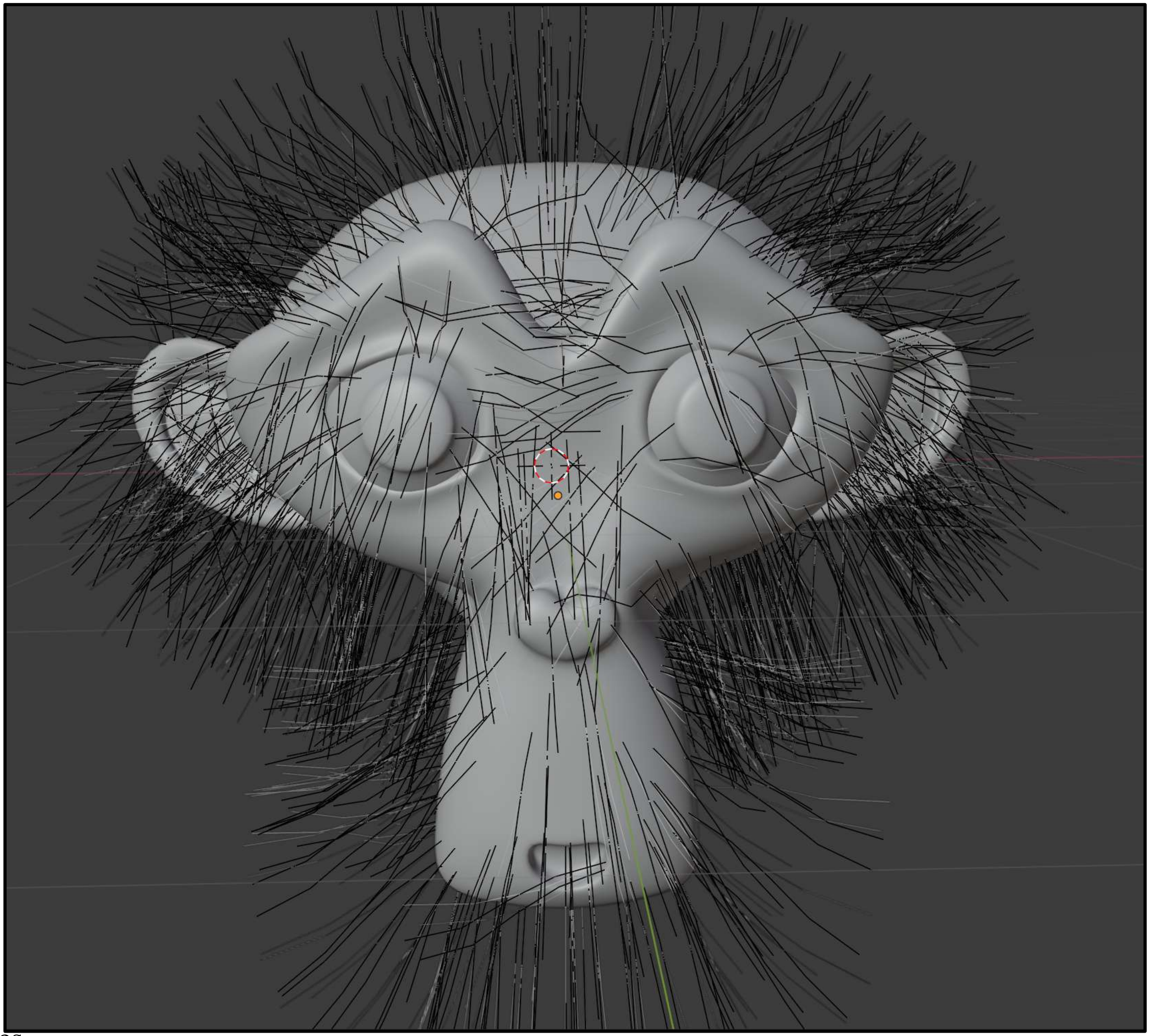


After clicking **Convert**



But this new mesh is *independent* of the object that particle'd it. To make them one object again, select both and hit **RMB→Join** (or **Control-j**)

Making the Droop Permanent



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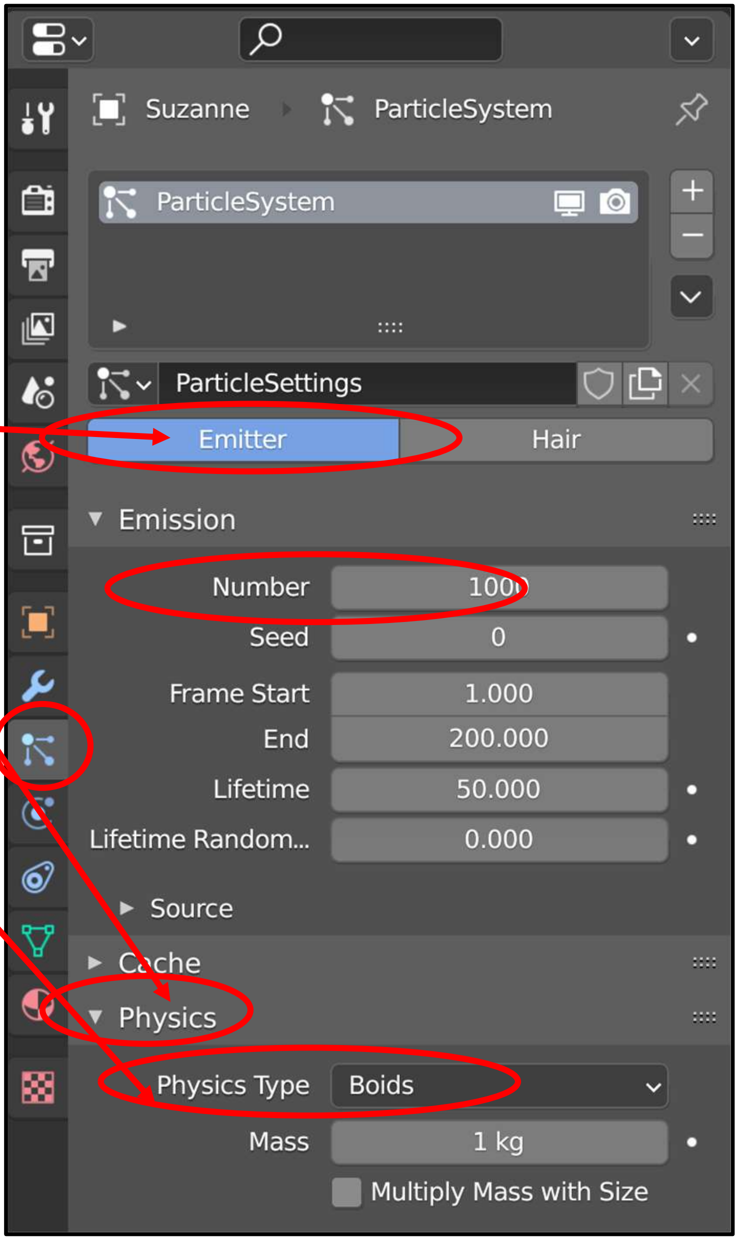
Boids Particle Systems

Boids are a special particle system technique to simulate living things that naturally want to group together such as flocks of birds, schools of fish, etc.

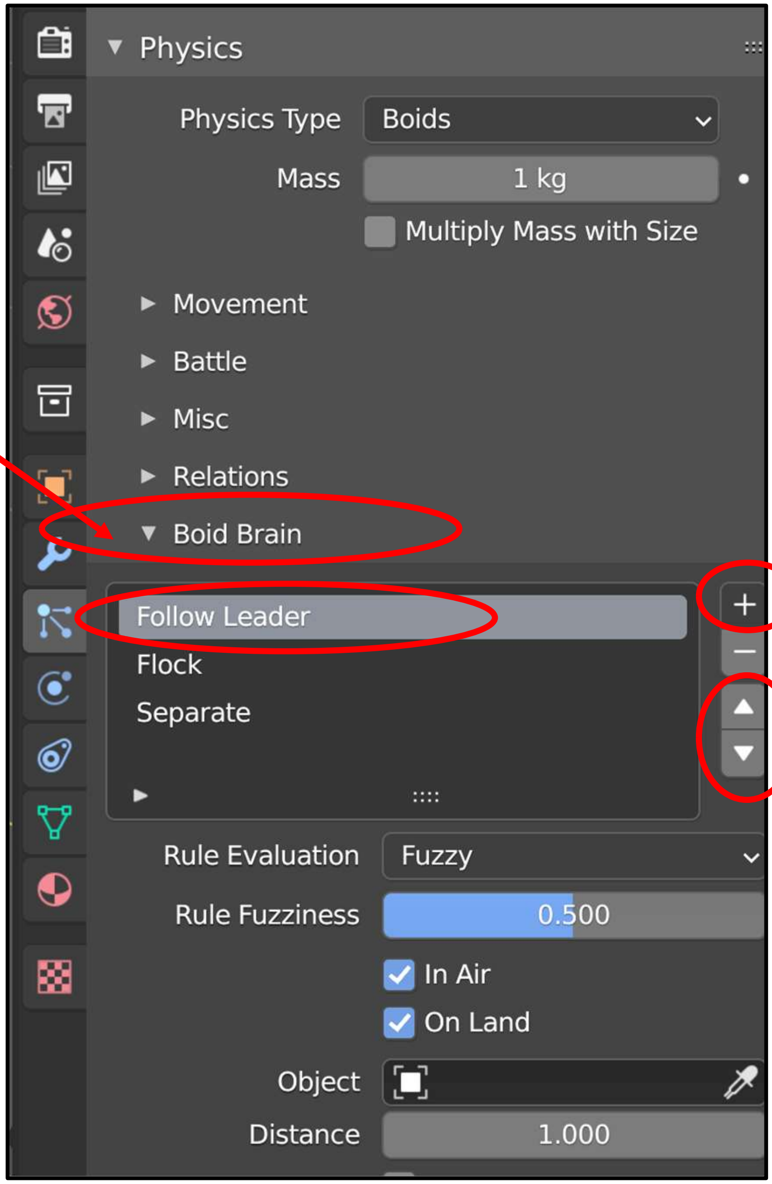
As before, create an object and attach a particle system to it. Select **Emitter** for the type. Under the **Physics** tab, change Newtonian to **Boids**.



Boids Particle Systems

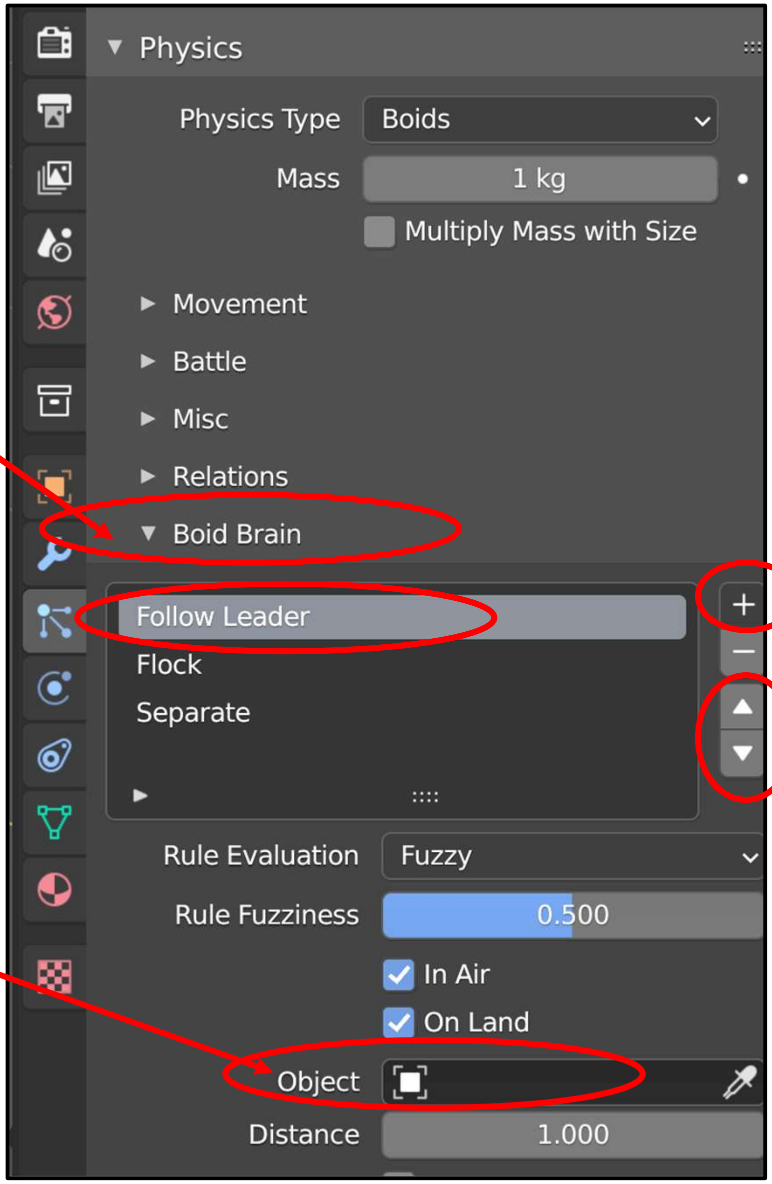
Select the **Boid Brain** tab.

Click the **plus sign** (+),
Select **Follow Leader** from the menu,
and use the **arrow symbols** to move it to the top of the list



Boids Particle Systems

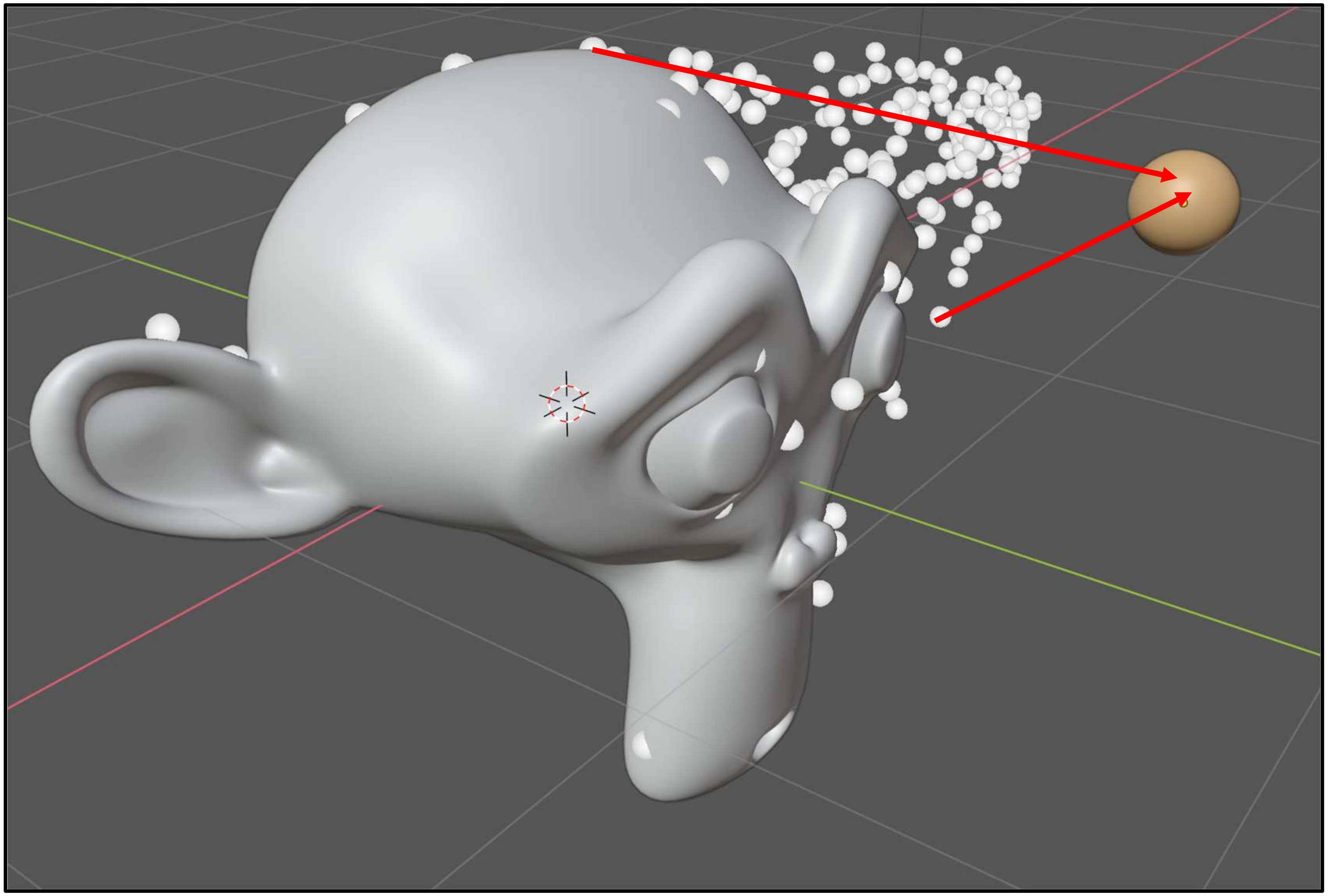
Create a new object and animate it (keyframe or physics). This will become the “leader” that the boids will follow. If you want to see it, leave it visible. Otherwise, turn its eyeballs off in the **Outliner**.



Now select the object that the boids were created from. In the boids menu area, click in the **Object** area and select the name of the object you animated.

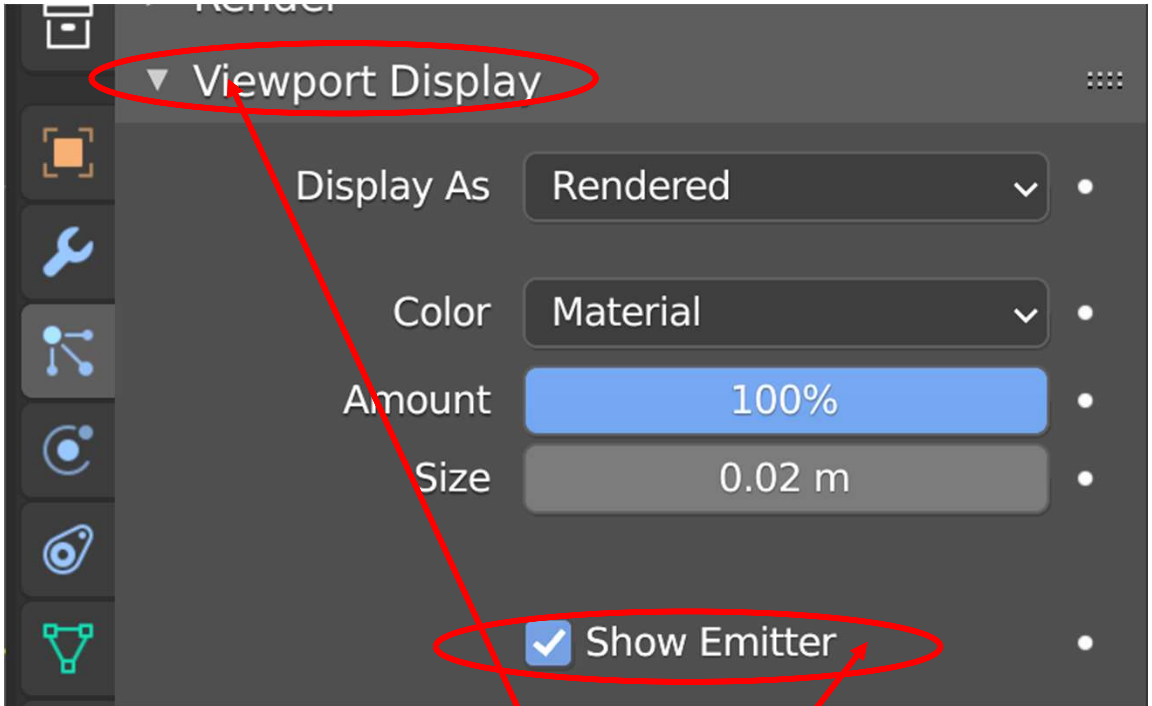
Now, turn on animation and watch the boids follow that object.

Boids Particle Systems

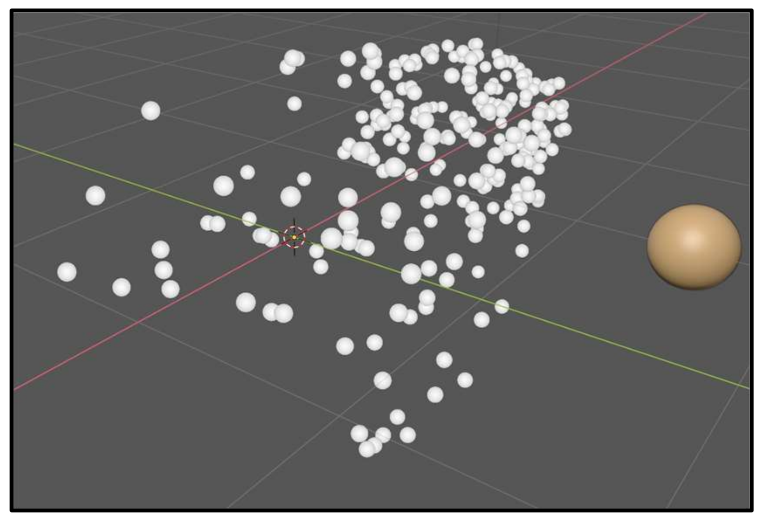


The boids now follow the leader

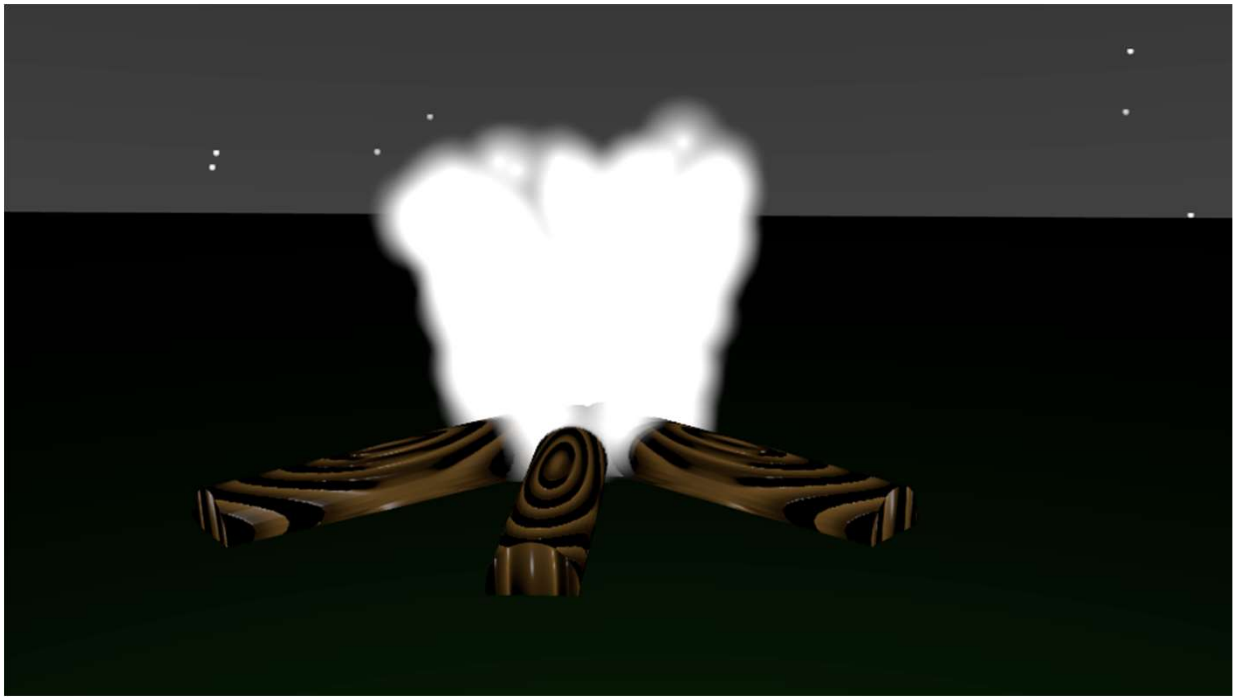
Boids Particle Systems



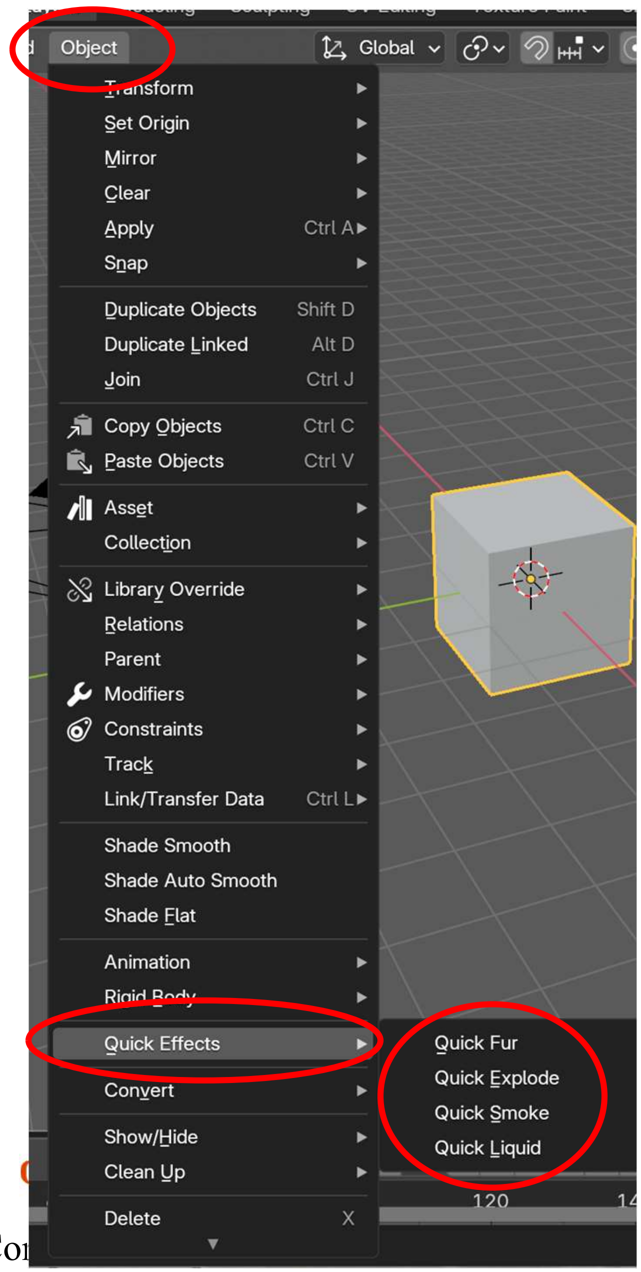
If you just want to see the boids and not the emitter object, go to the particle emitter object's **Viewport Display** tab and click the **Show Emitter** checkbox off.



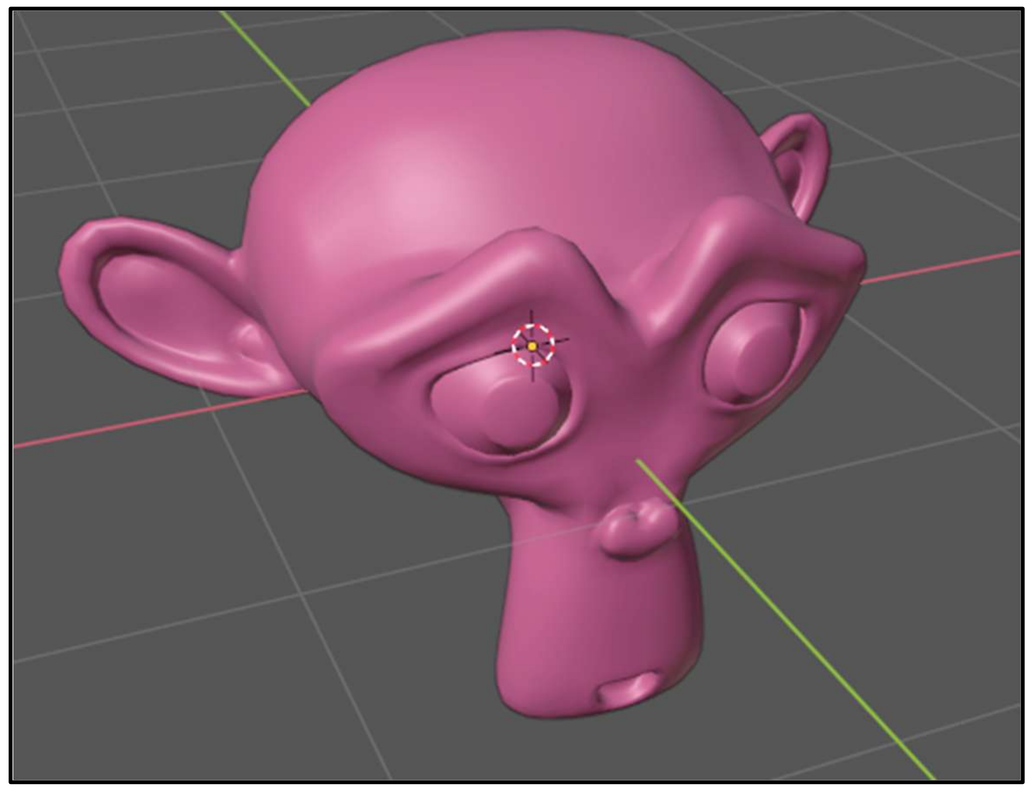
9. Physics Animation



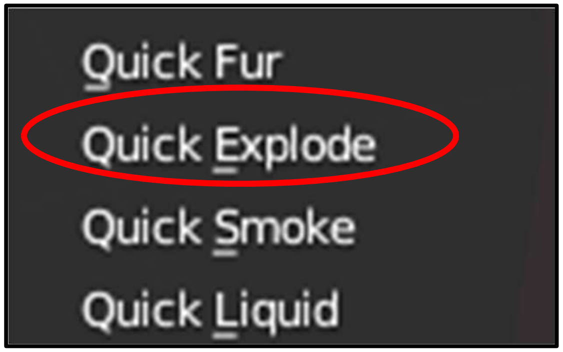
Quick Physics Cheats

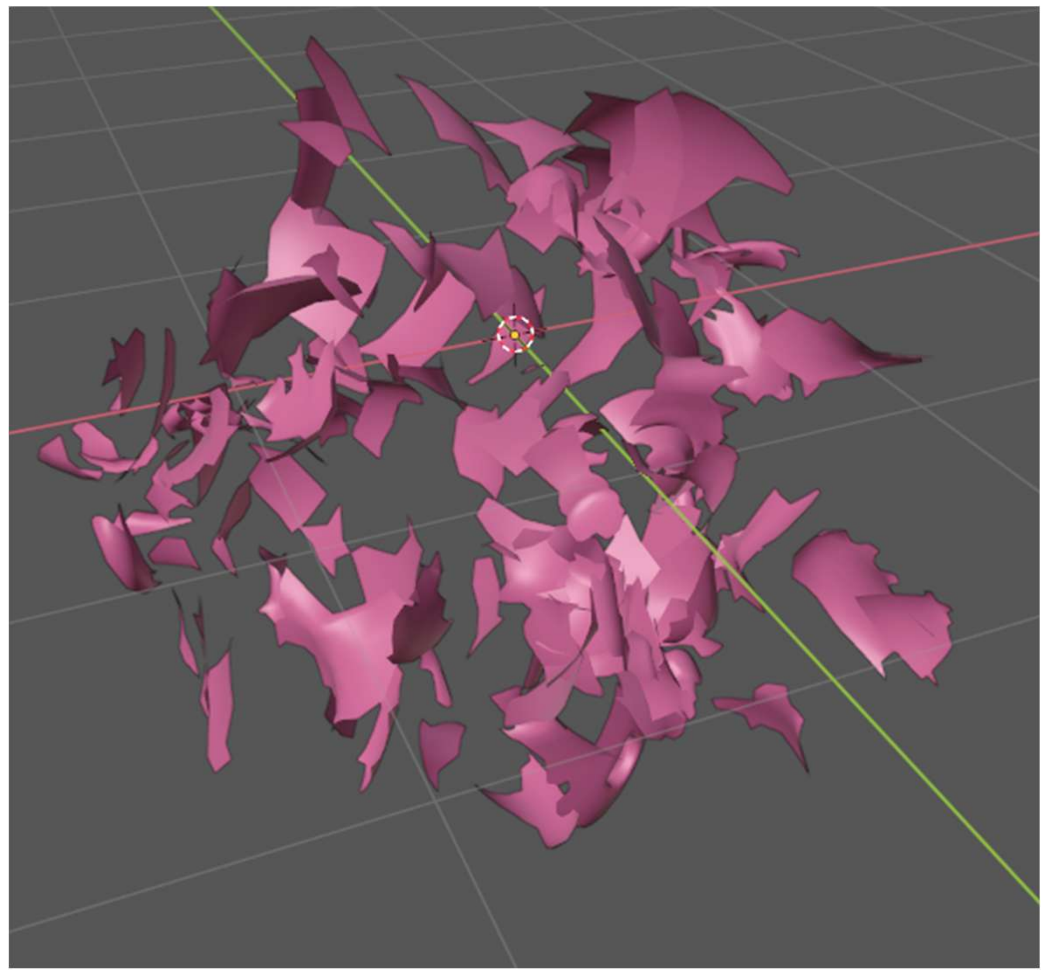


Original Scene

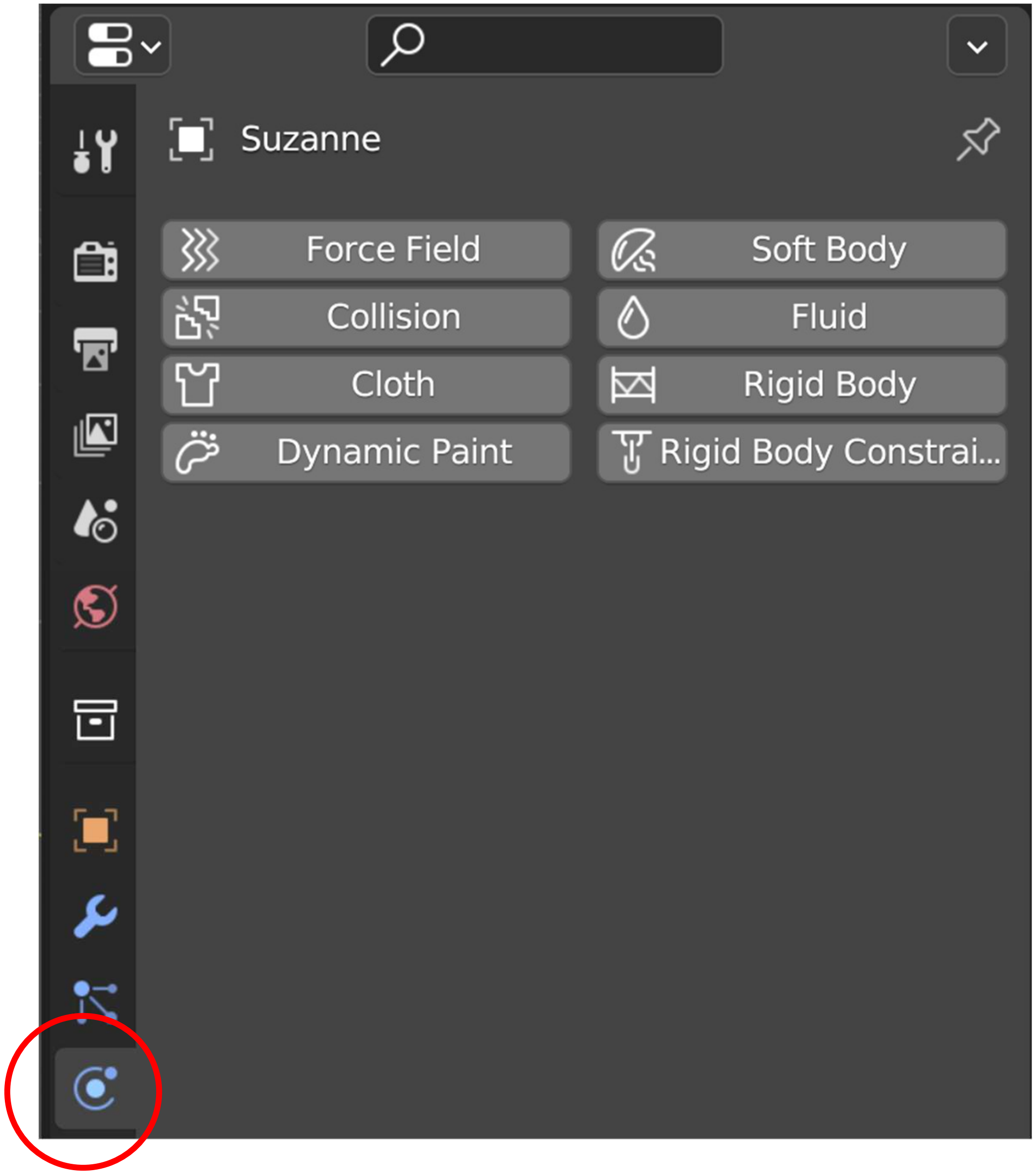


Quick Physics Cheats

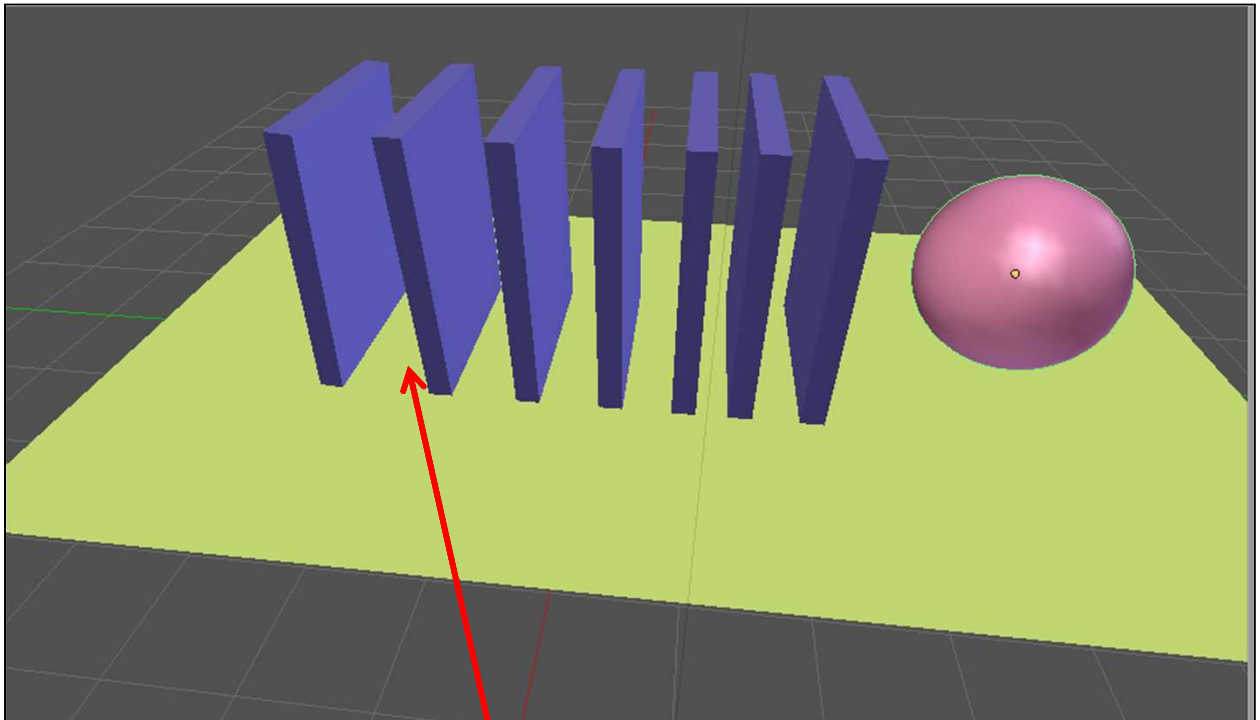




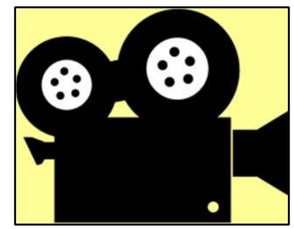
There are Eight Types of Physics Simulations



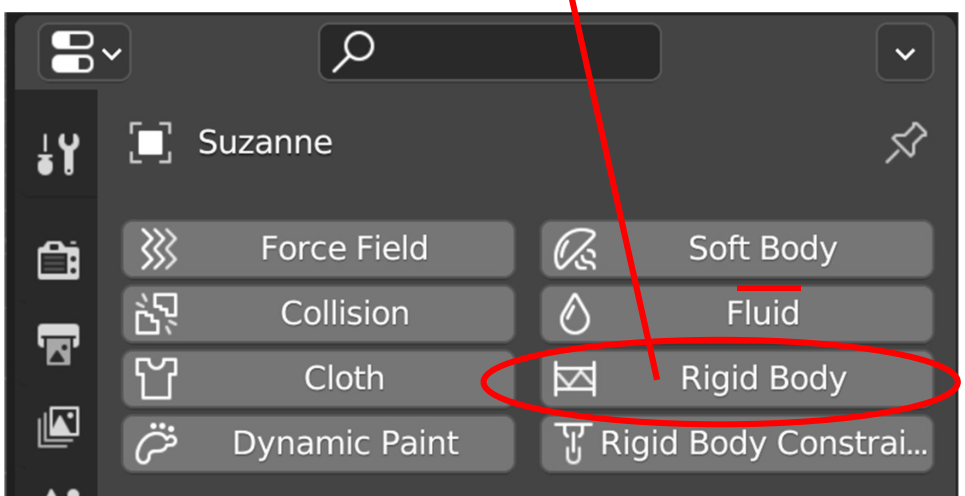
Rigid Body Collision Example



dominos.blend



dominos.mp4

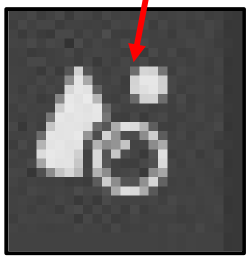


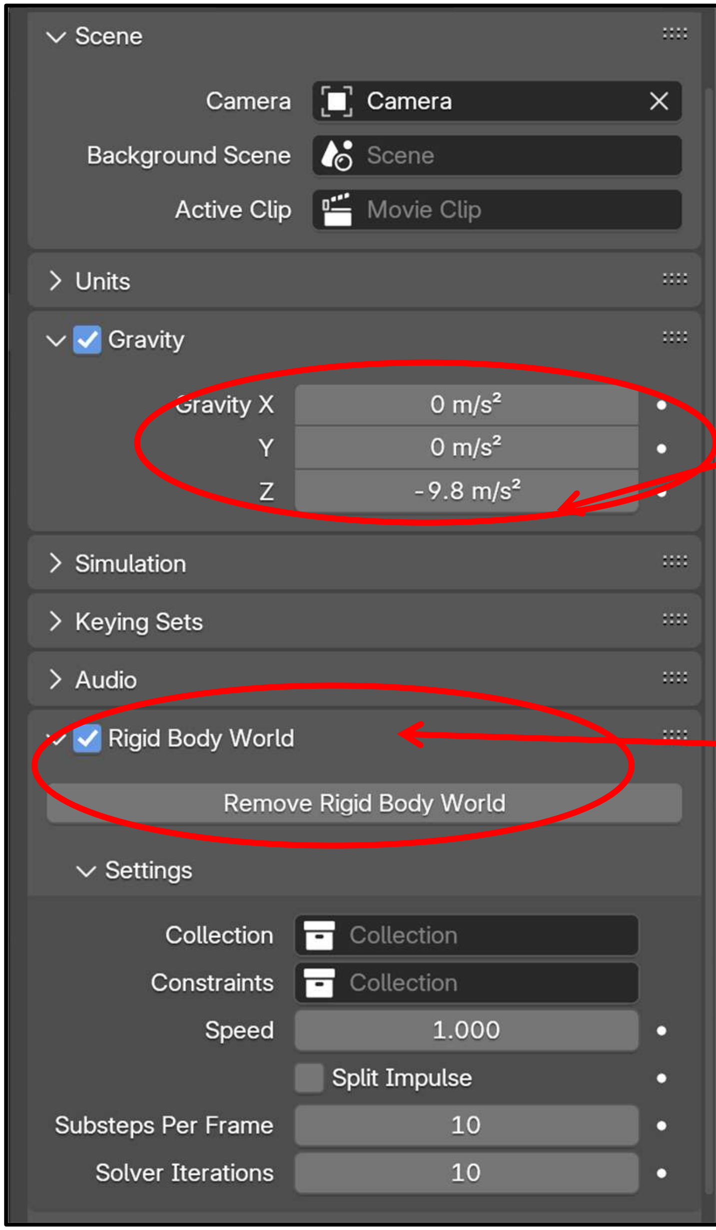
Set this up using what you know about modeling.

Slightly rotate the left-most domino to the right so that it will tip and start the sequence.

Let Blender Know You Want to do Rigid Body Physics

Click on the **Scene Properties Button**





Set Gravity
(this value indicates gravity points downward and has a value of **-9.8 meters/second^2**)

Be sure this is turned on

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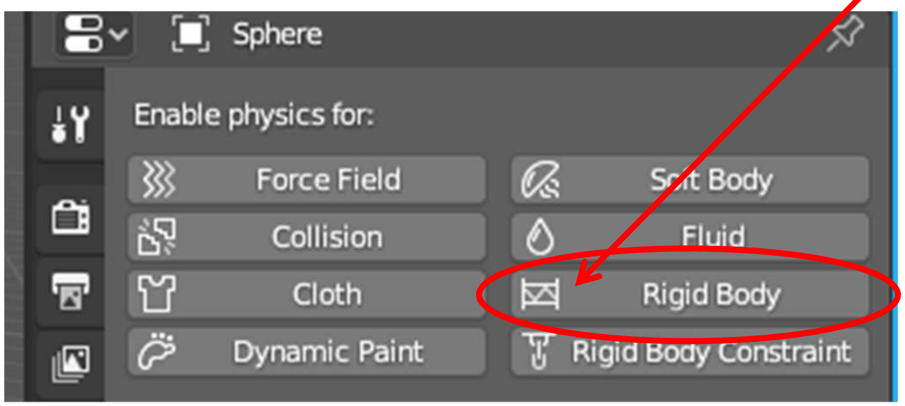
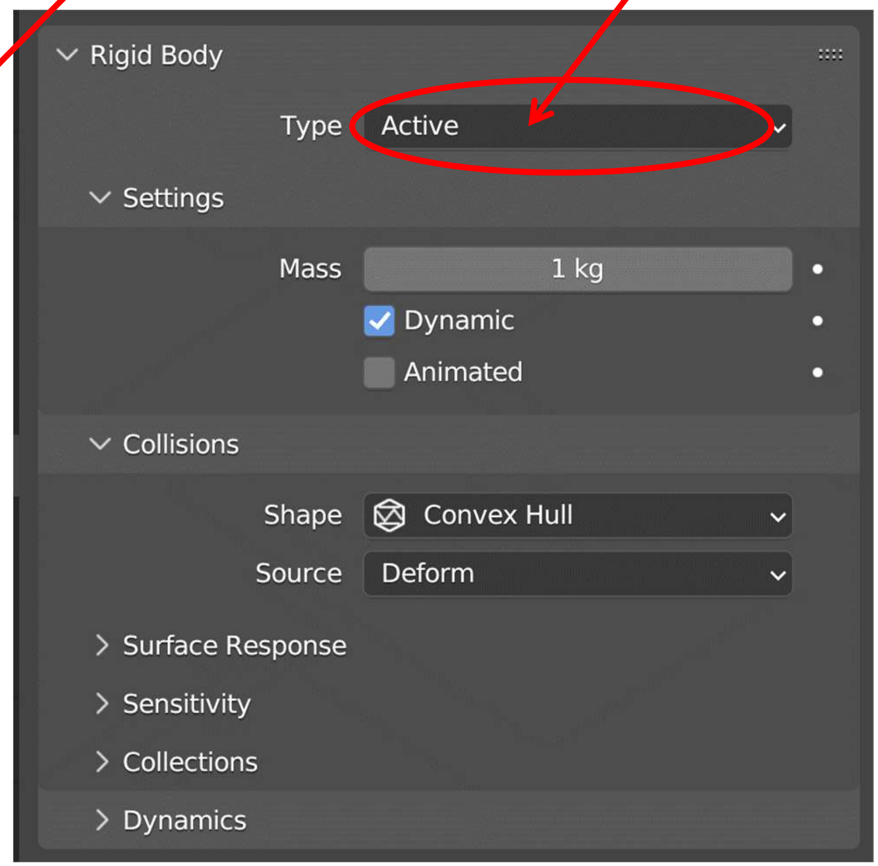
Computer Graphics

Tell the Physics which Objects will be Involved

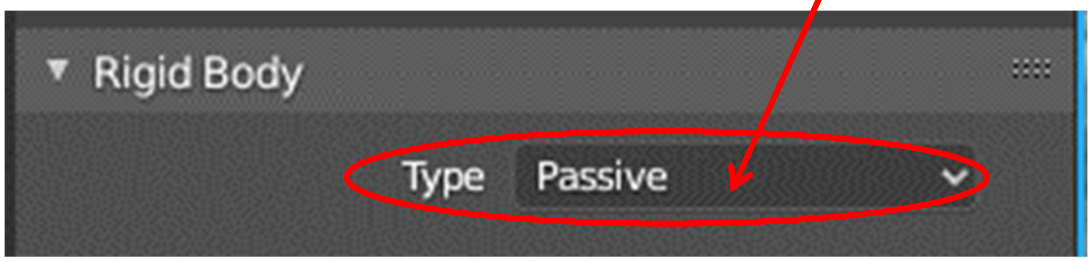
For each object that will be pulled by gravity (the dominos and the ball), select the object, click on the **Physics Property Button**, click on on **Rigid Body**, and set the Type to **Active**



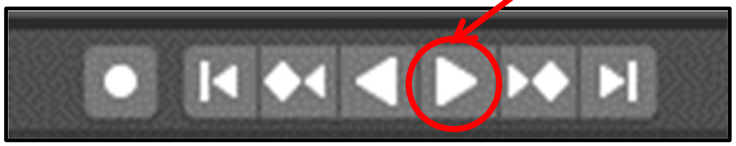


Tell the Physics which Objects will be Involved

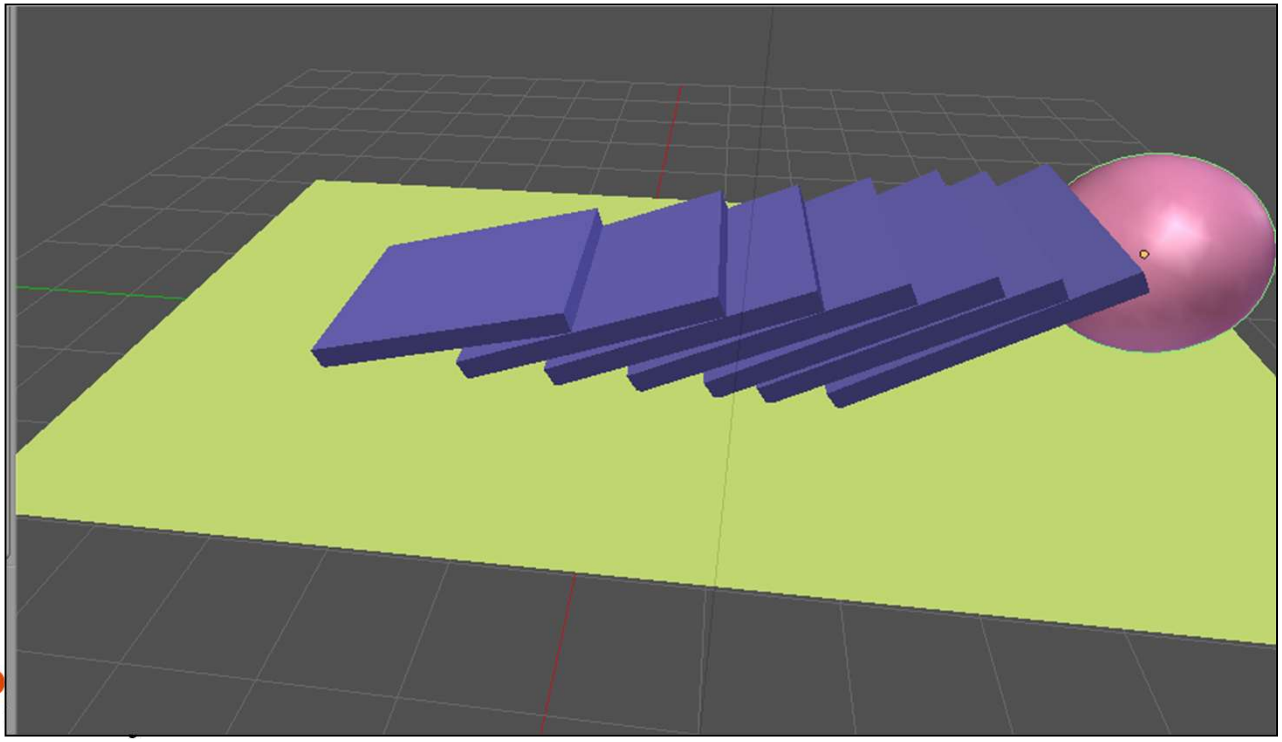
For each object that will *not* be pulled by gravity but will still be involved in the collisions (the floor), select it and set the Type to **Passive**



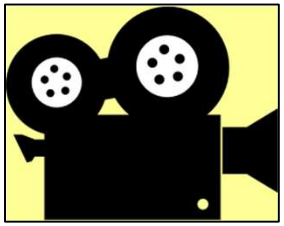
Turn the Animation On



Hit the **Escape** key to stop the animation



dominos.blend



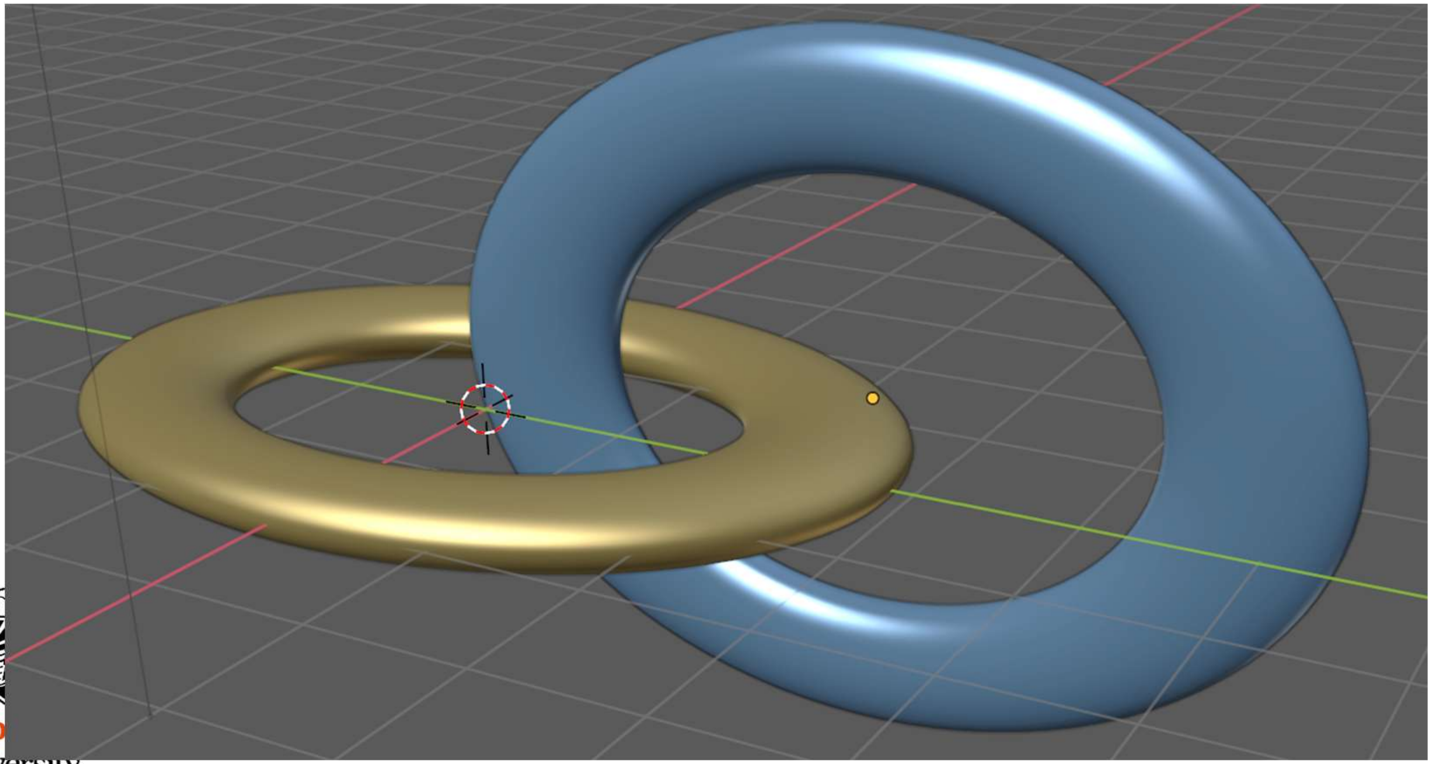
dominos.mp4

You Probably Need to Change “Convex Hull” to “Mesh”

Blender wants your simulation to run as fast as possible. For this reason, it defaults to wanting to use a simplified version of your geometry called a Convex Hull.

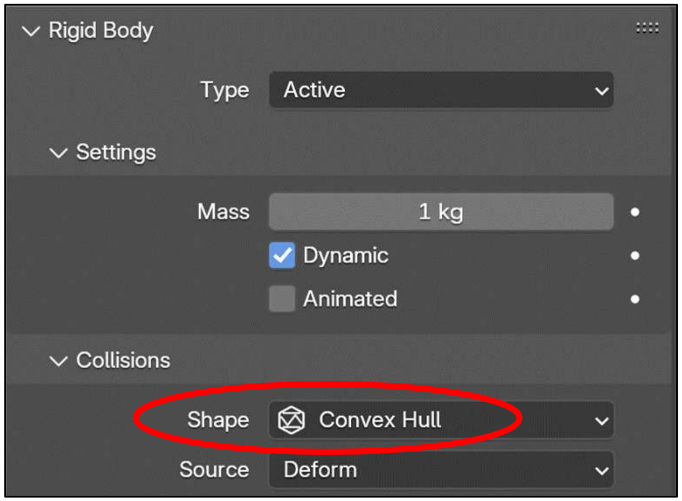
You probably don’t want this. In that case, change **Convex Hull** to **Mesh**.

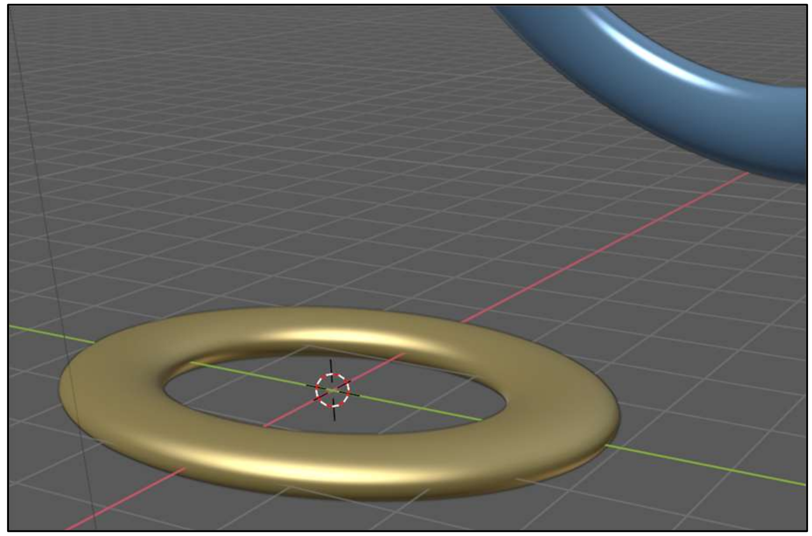
Consider links on a chain. The yellow one is *Passive* and the blue one is *Active*.



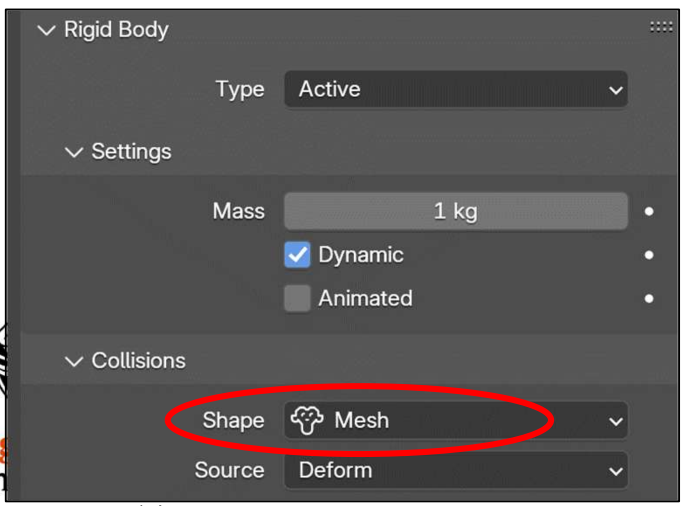
You Probably Need to Change “Convex Hull” to “Mesh”

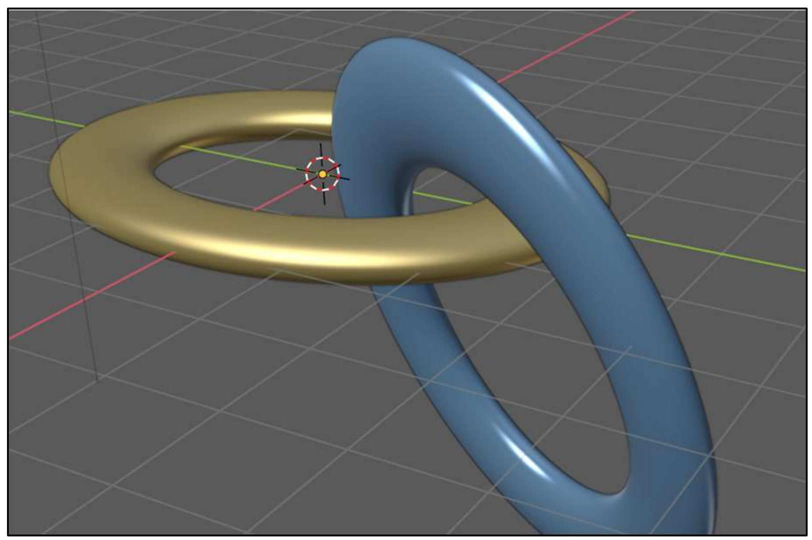
With both chain links using **Convex Hull**, they fly apart:





With both chain links using **Mesh**, they correctly behave like a chain:

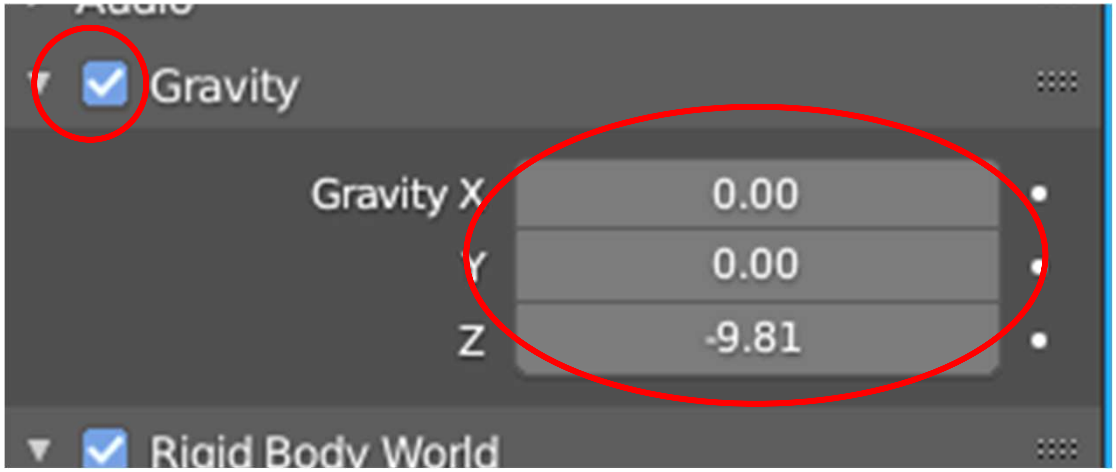




Setting Gravity

In order to do physics animations, Blender needs to have an idea of what Gravity is. The acceleration due to gravity near the surface of the earth is 9.81 meters/sec^2 (pointing down), which also equals 32.2 feet/sec^2.

You can set this by clicking on the **Scene Properties Button** and then scrolling down to the **Gravity** dialog area.



This is the default, but you can set Gravity to anything you want, including turning it off completely, or making it point upwards, or making it point sideways.

Gravity on Other Worlds

The acceleration due to gravity is not the same on all worlds. It depends on the mass of the body and its radius.

For fun, try setting the gravity to the Gravity Acceleration that other bodies have in our solar system:

Body	Gravity Acceleration (m/sec^2)	g's
Mercury	3.70	0.38
Venus	8.87	0.90
Earth	9.81	1.00
Moon	1.62	0.17
Mars	3.71	0.38
Jupiter	24.79	2.53
Saturn	10.44	1.06
Uranus	8.69	0.89
Neptune	11.15	1.14

https://www.universetoday.com/35565/gravity-on-other-planets/

Gravity on Other Bodies

Or, invent your own planet! Pick a different “m/sec^2”.

21st Century Fox

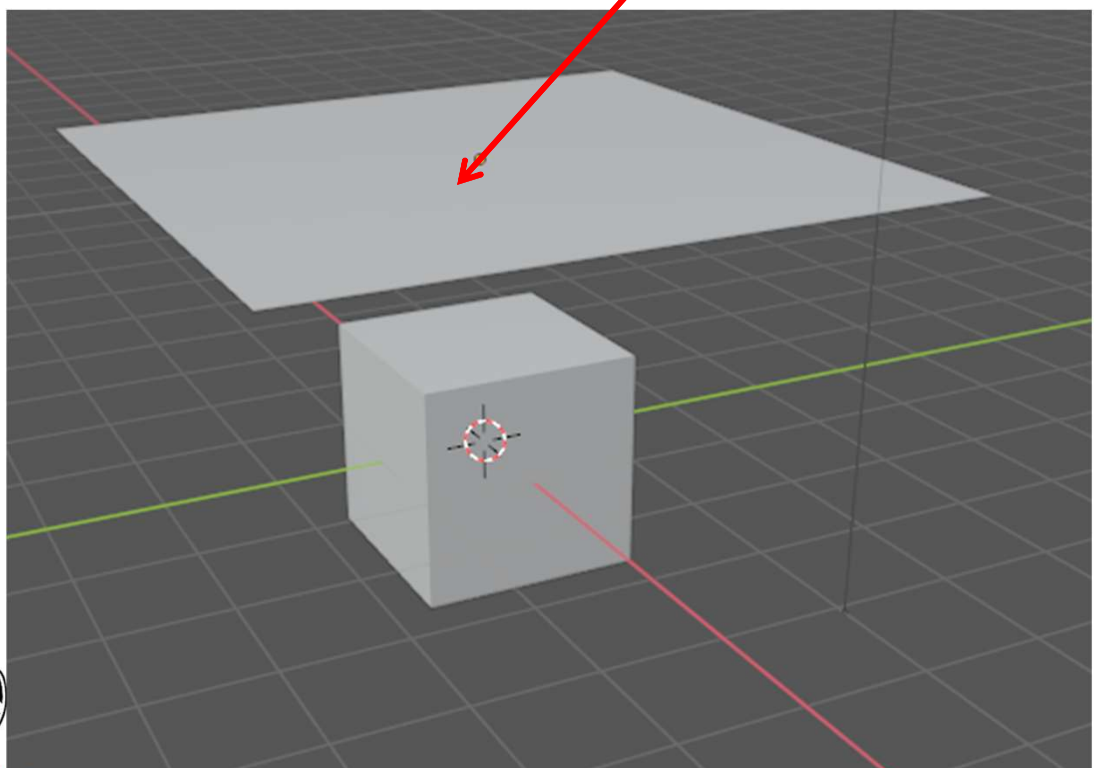
Another Cool Thing: Modeling Cloth

Pixar: *Geri's Game*

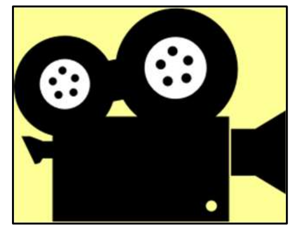
Modeling Cloth – Start with a Cube and a Grid

There is a difference in what different Mesh types will do. This needs to be a ***Grid*** – not a Plane!

Scale the ***Grid*** by 3 (**s3**) and move it in z (**gz**)



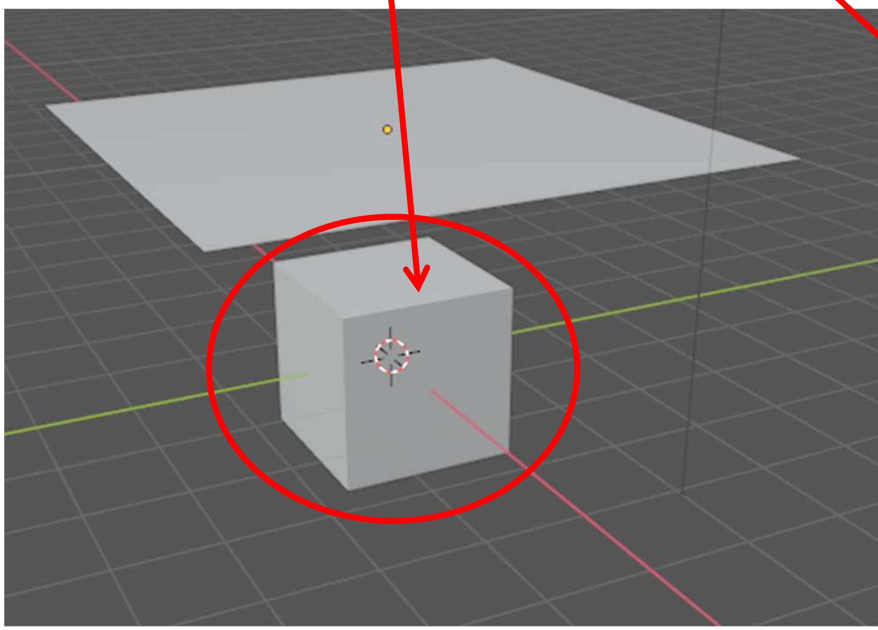
cloth.blend

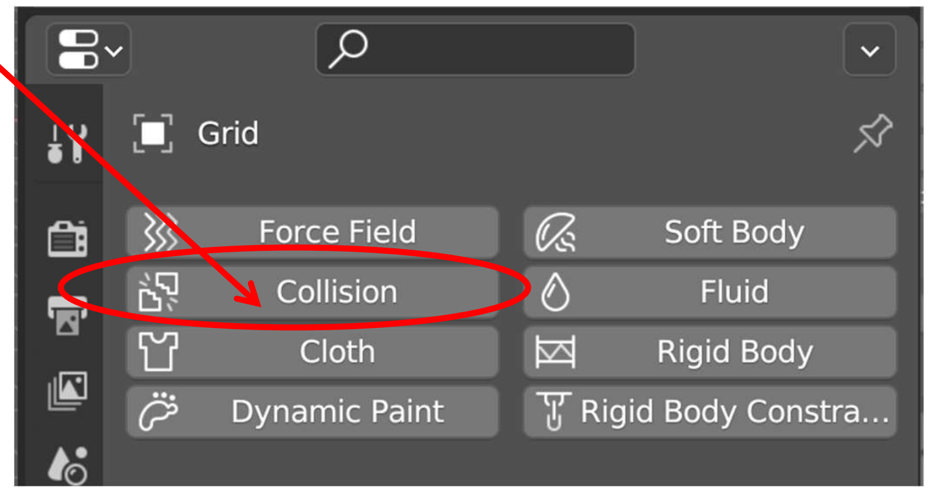


cloth.mp4

Modeling Cloth -- Enable Collision with the Cube

1. Select the cube.
2. Then go to the **Physics Property Button**
3. Then click on **Collision**

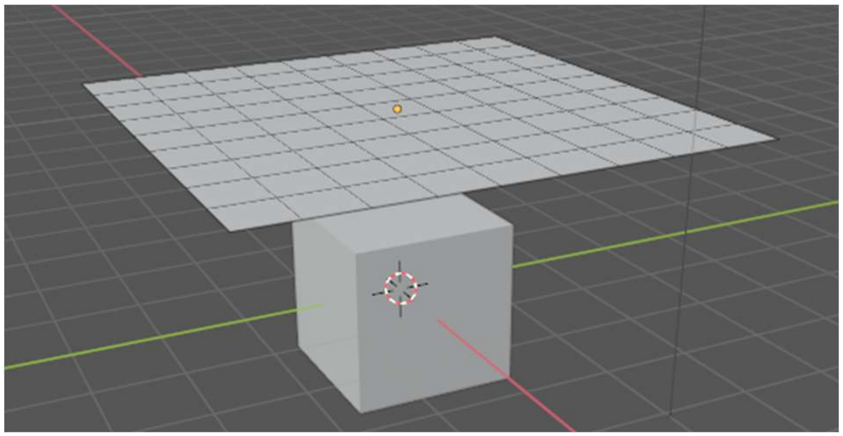


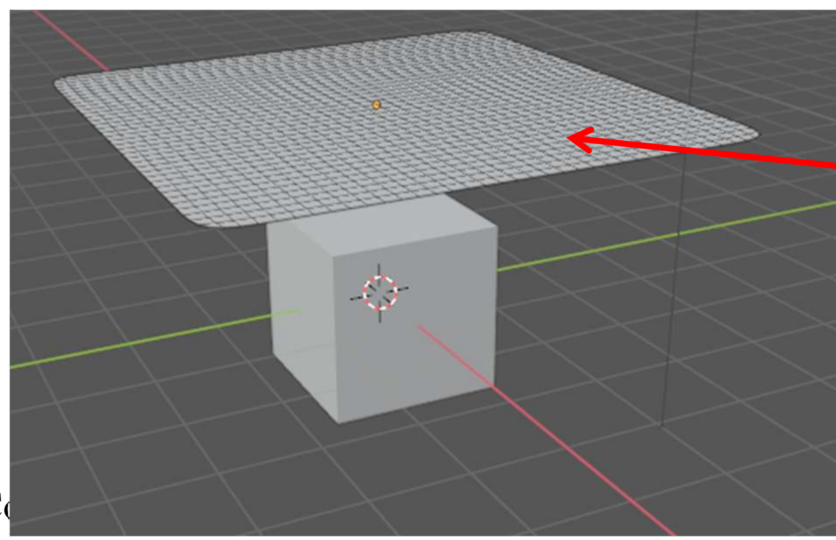


You don’t need to set any other parameters (unless you want to)

Modeling Cloth – Subdivide the Grid into More Pieces

If you select the grid and tab over to **Edit Mode**, you will see that it is already subdivided somewhat. To act as a cloth, we'd like it subdivided some more.



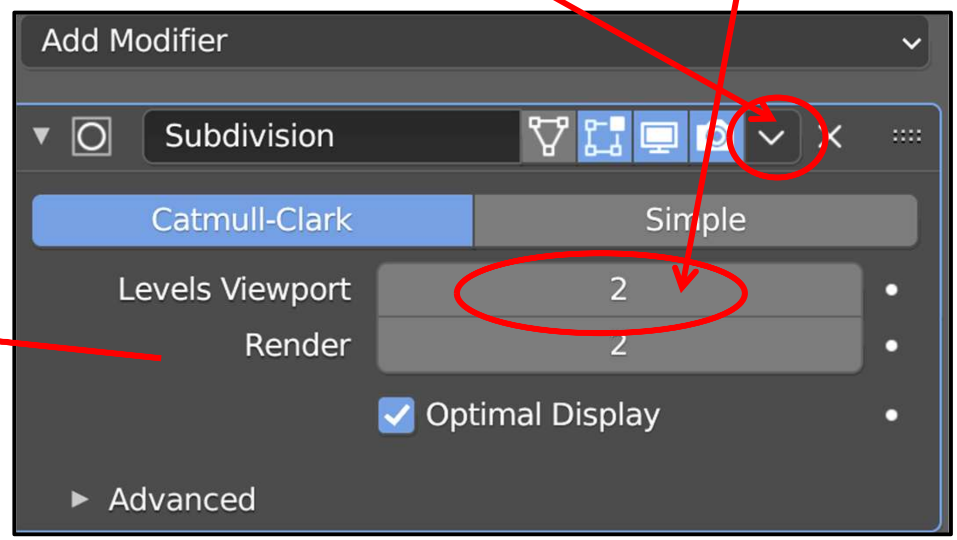


4. Back in Object Mode, select the grid, then select **Modifiers**.

5. Then click **Add Modifier** and select **Subdivision Surface.**

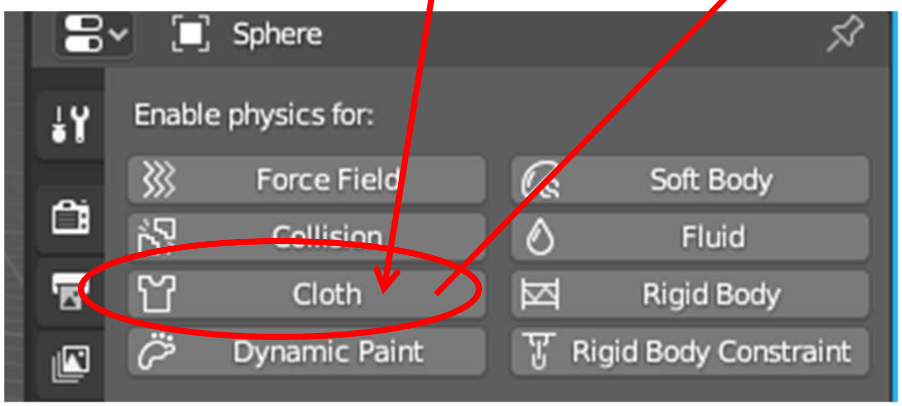
6. Change the **Viewport** parameter from 1 to 2

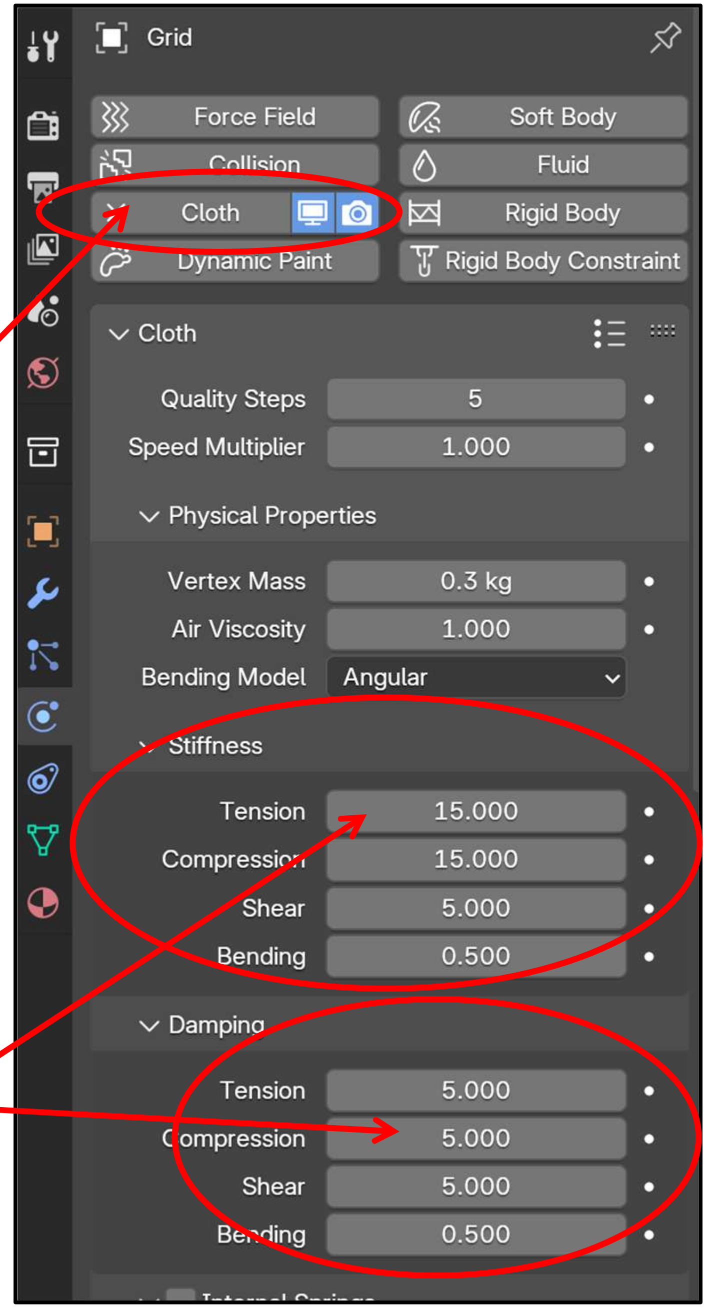
7. Click the **Apply** button.



Modeling Cloth – Tell the Grid that it is Really a Piece of Cloth

8. Select the grid.
Then go to the **Physics Property Button.**
Then click on **Cloth**.



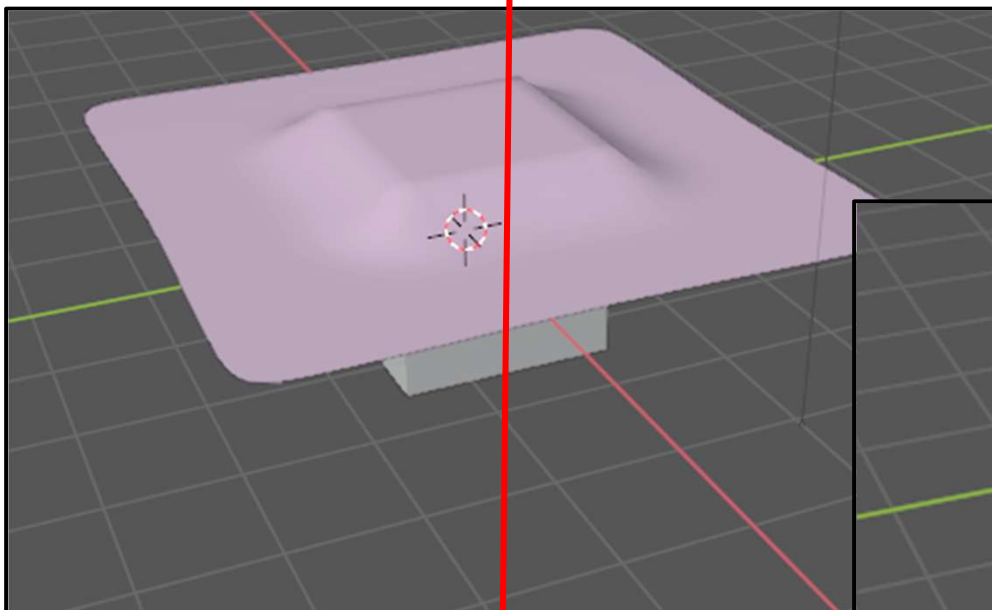


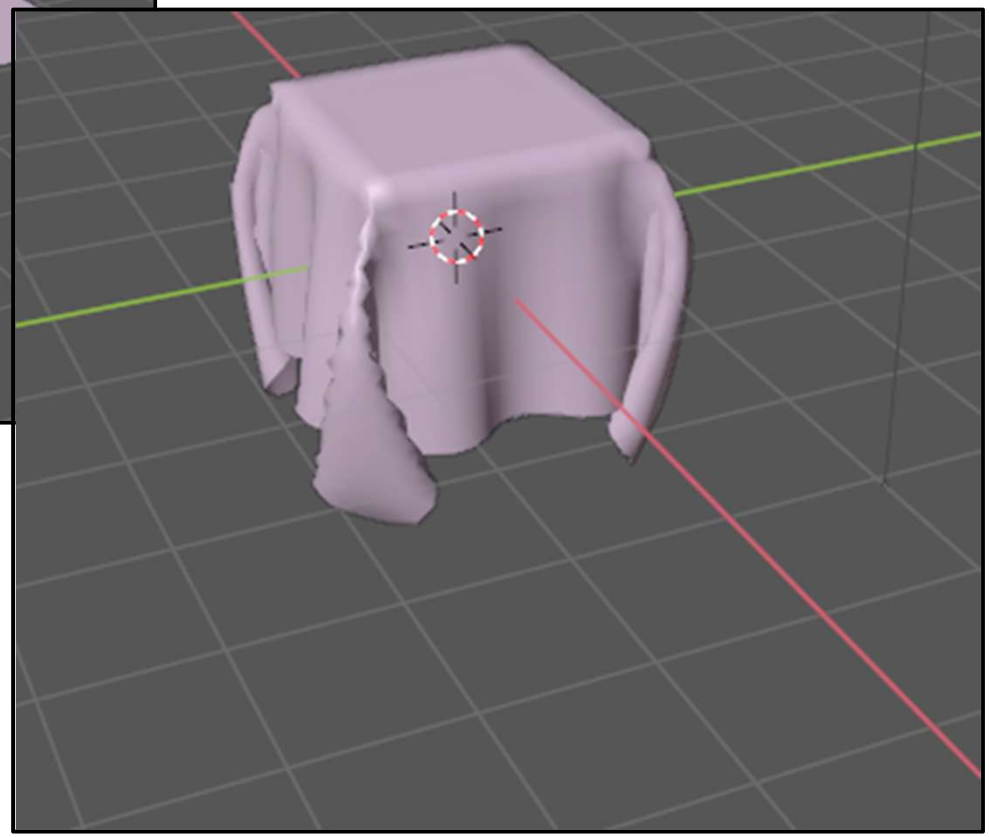
You can get away without changing any of these parameters, but, at some point, you will want to experiment with different values of **Stiffness** and **Damping.**

Modeling Cloth – Run the Animation

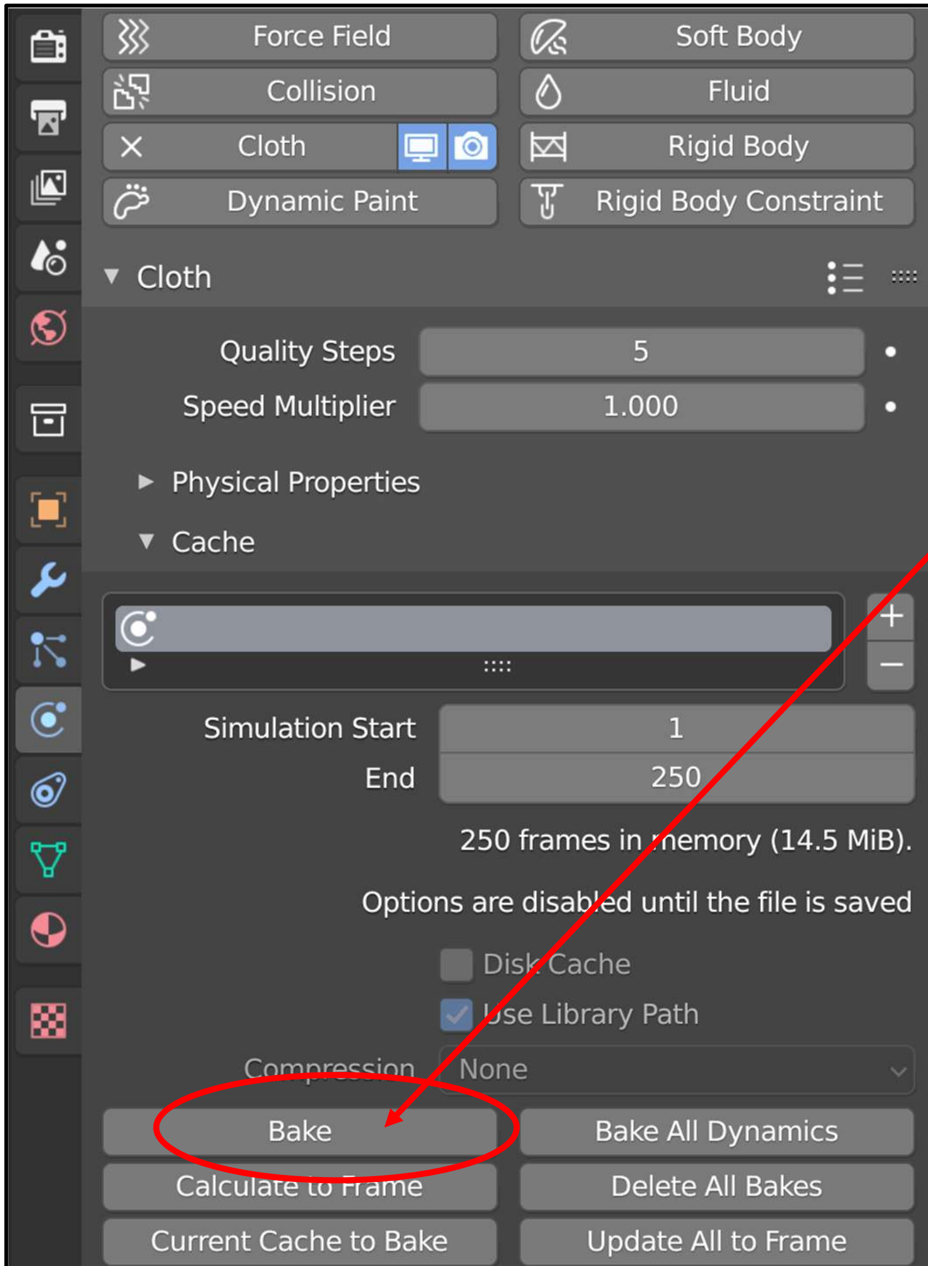
9. Select the grid, RMB, then select Shade Smooth.

10. Start the animation.





Baking the Cloth Animation

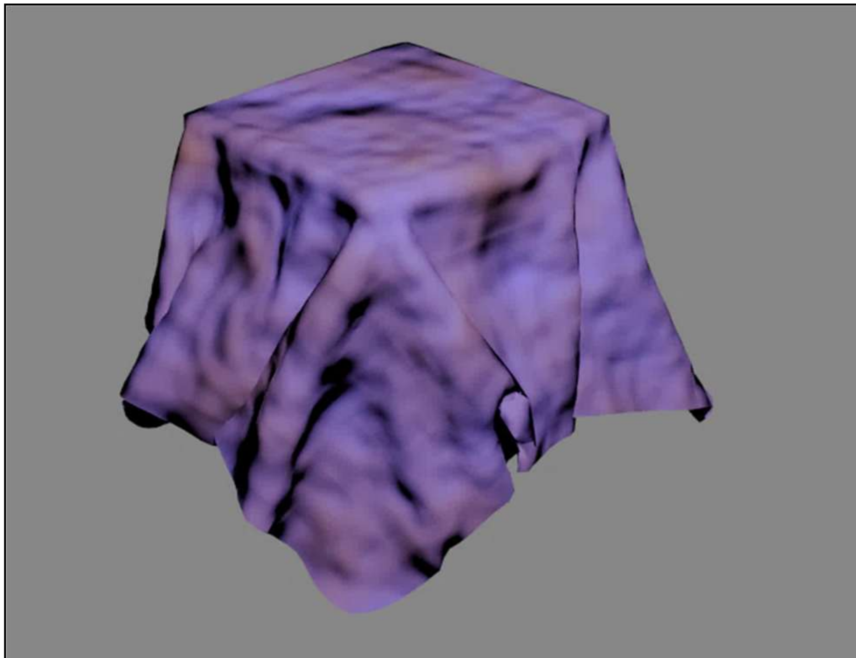


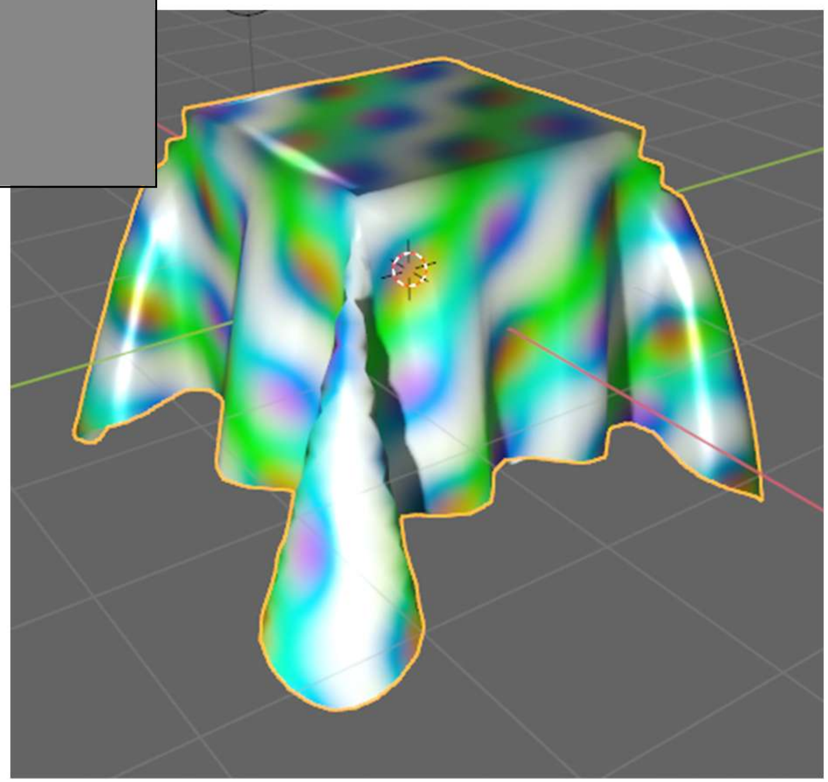
Why does the animation run so slowly? That is because it is computing the simulation while it is animating.

Instead, tell it to precompute the animation. You do this by selecting the **Bake** button (and waiting and waiting).

Now try animating.

Cloth Animation with Color, Texture, and Lighting



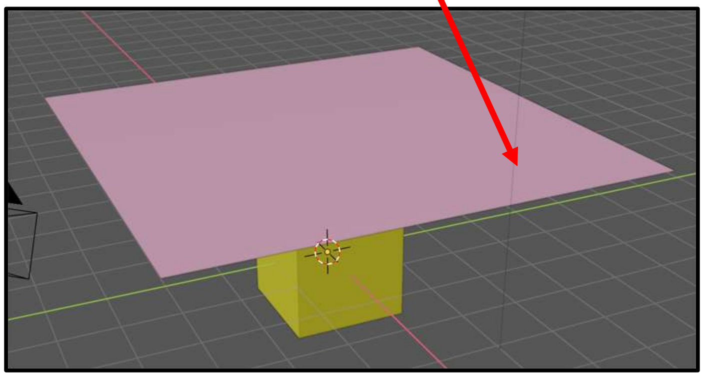


cloth.mp4

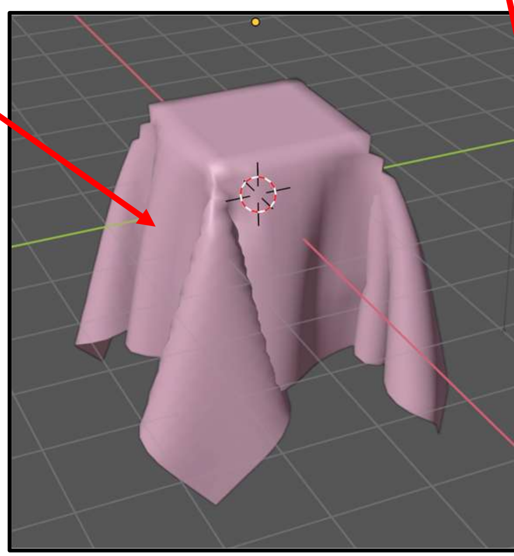
What if You Want the Cloth to Retain its Animated Shape Forever ?

That is, supposing you have used a cloth animation to drape a tablecloth over a table and now want to leave it that way.

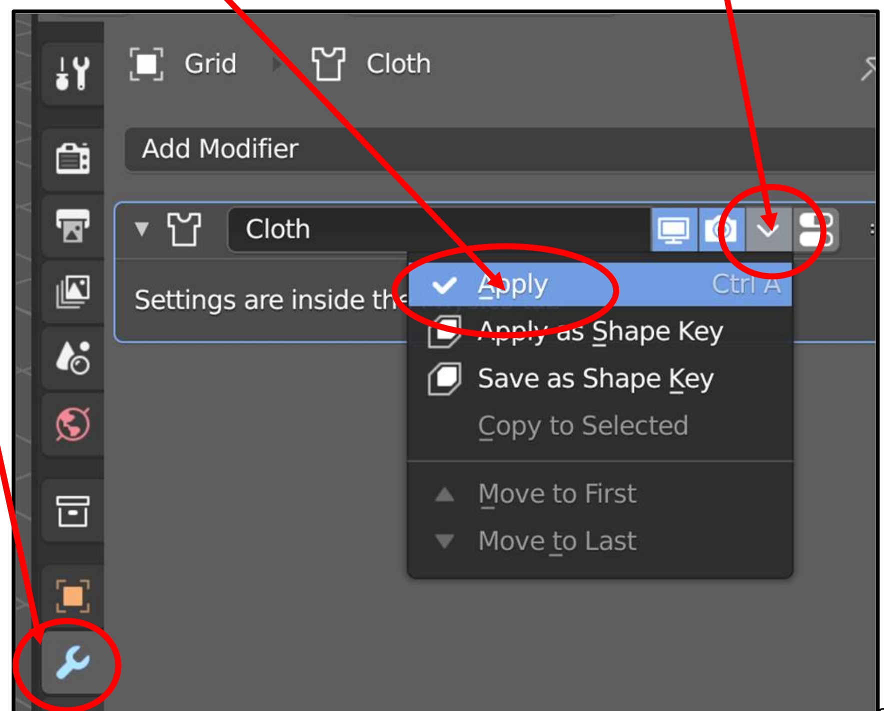
You start with this:



Animate to get this:



Then, with the cloth selected, go to the **Modifier** menu. You will see the **Cloth** modifier already magically there. Select the down arrow and click on **Apply**.

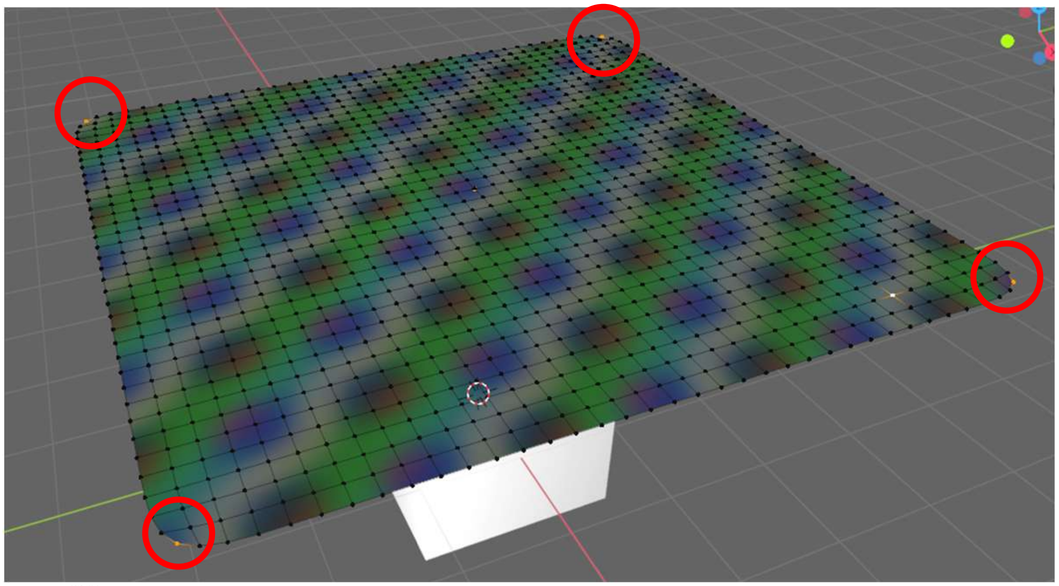


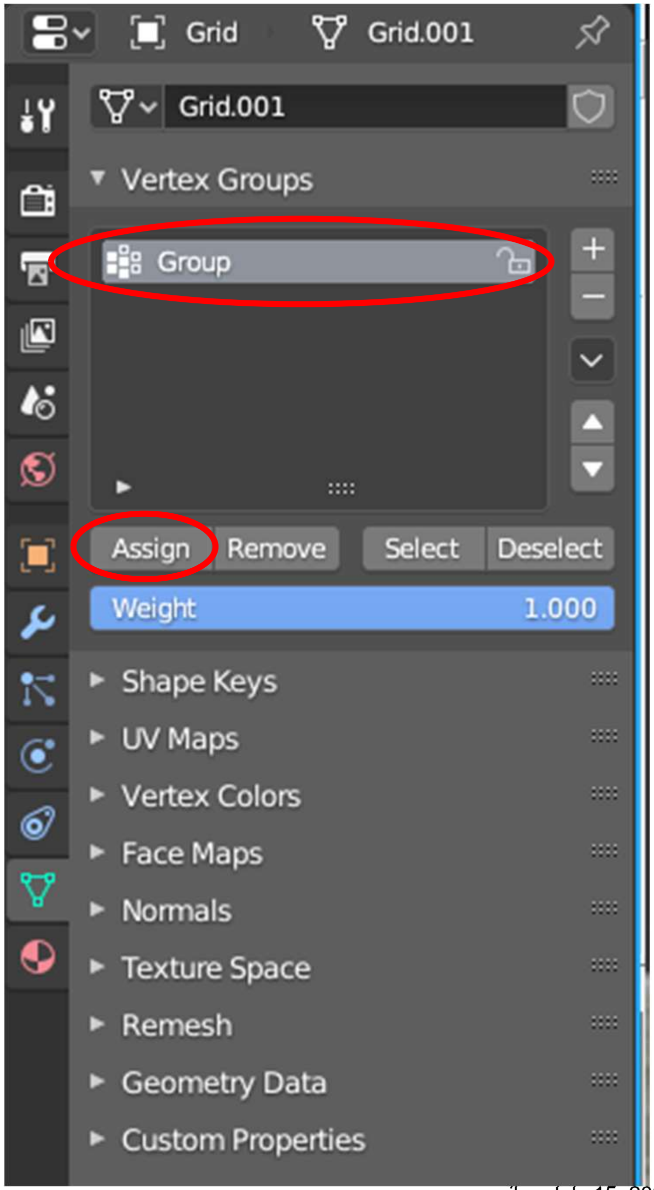
Oregon State University
Computer Graphics

Cloth Animation: Pinning Vertices

One of the many fun parts of cloth animation is pinning some of the vertices. There are lots of reasons to do this, such as to pin the edge of a flag to its flagpole, or to pin a cloth to a clothesline.

To do this, Tab into **Edit Mode**, **Shift-LMB** the vertices to be pinned, and create a **Vertex Group** from them. (This was described in more detail in the Modeling section of these notes).

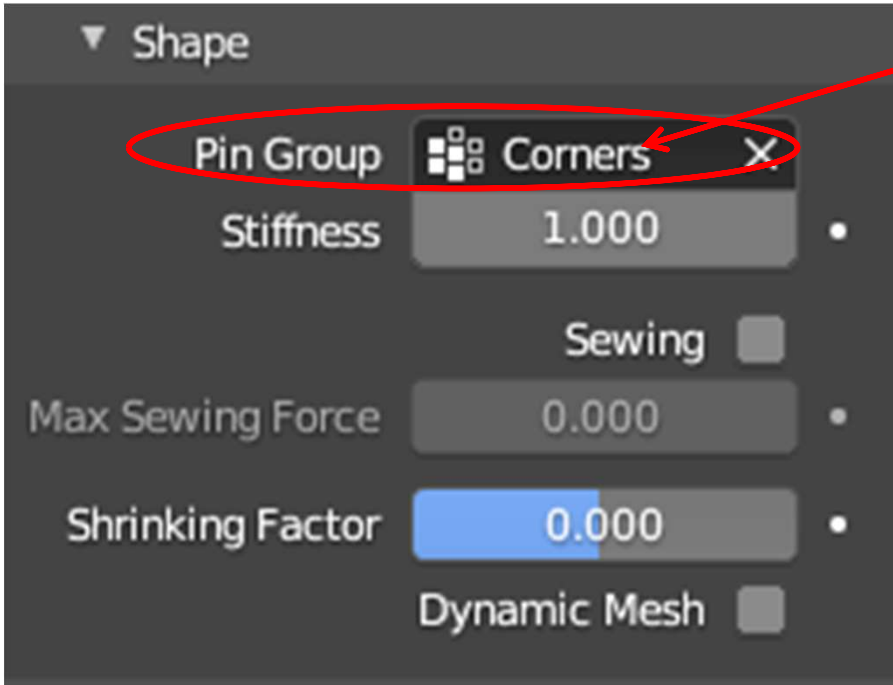


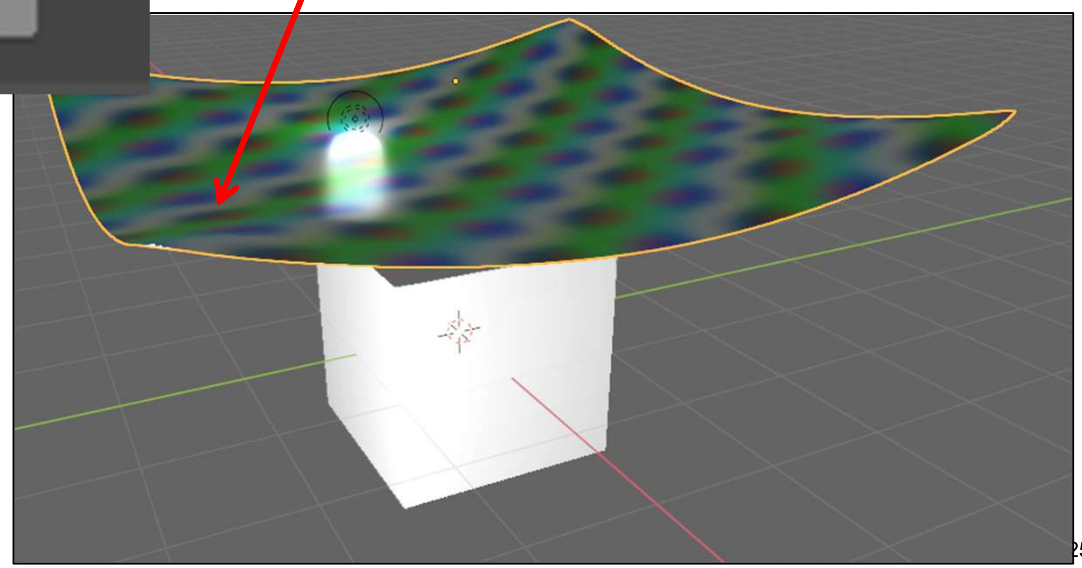


Cloth Animation: Pinning Vertices

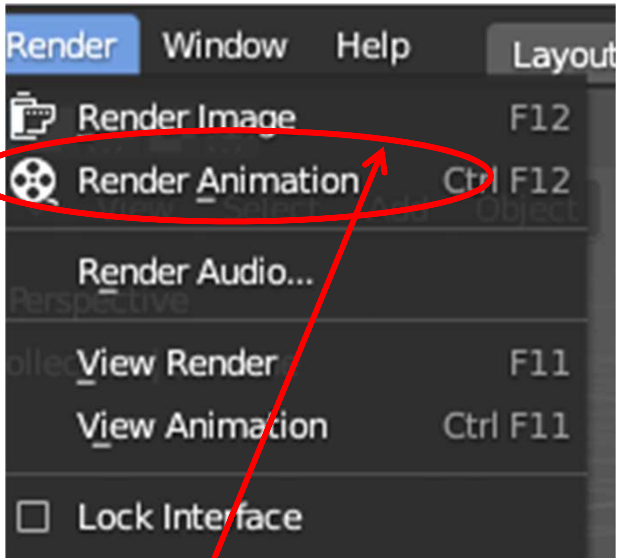
In the Cloth section of the grid's **Physics** menu, select the name of the Vertex Group to be pinned.

When you re-animate, those vertices will be stationary.

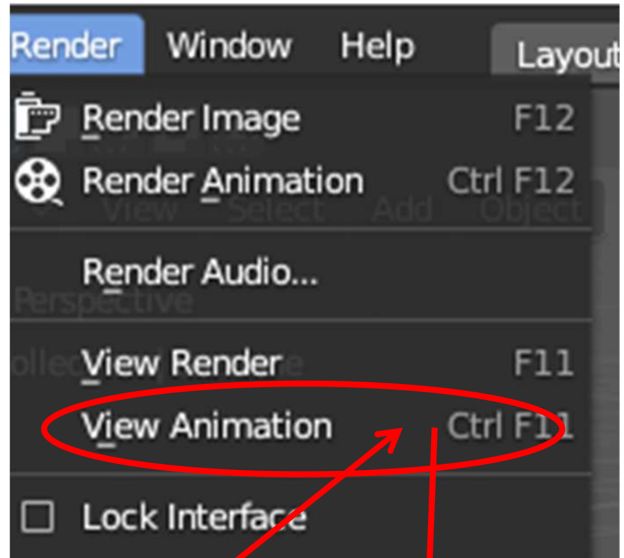




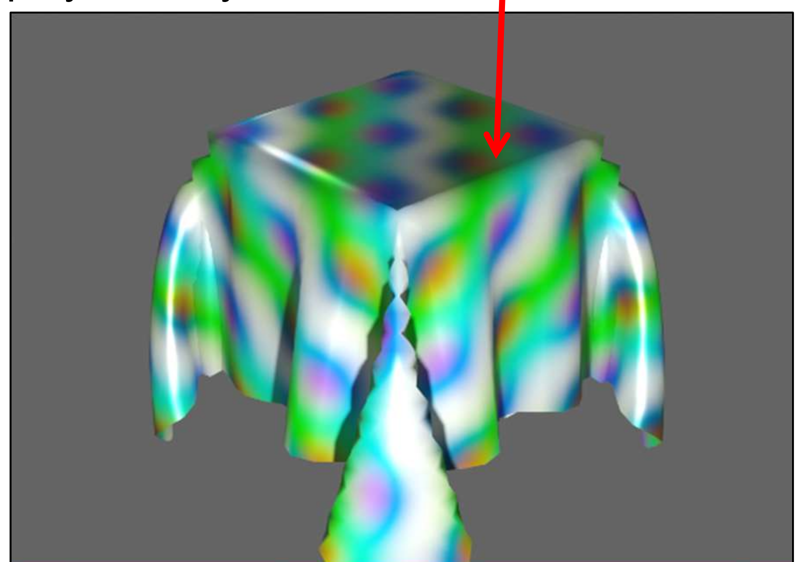
Rendering an Animation



Render Animation kicks off the rendering of all your animation frames in order



View Animation brings up a separate window and plays back your animation.

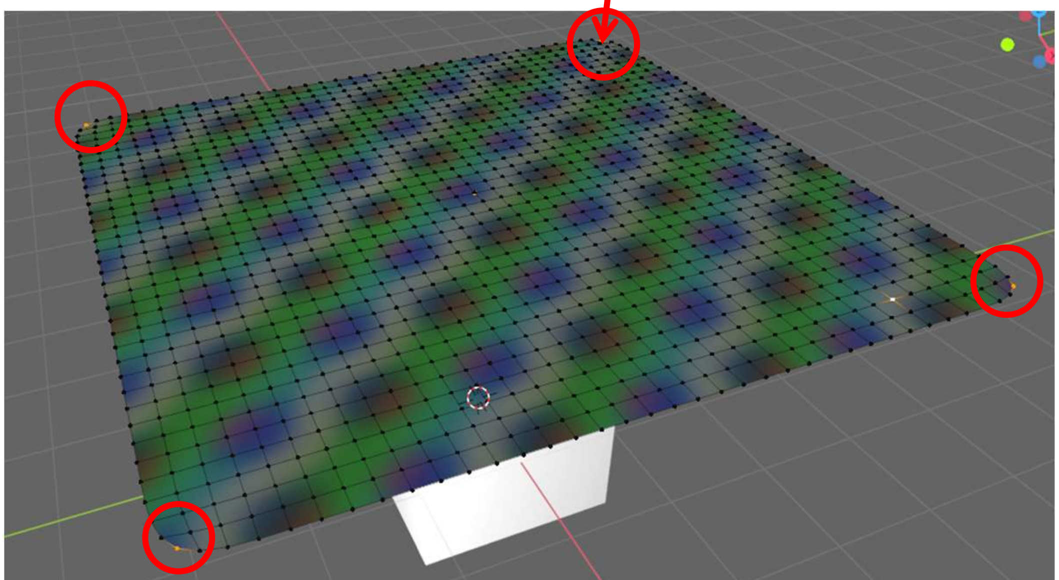


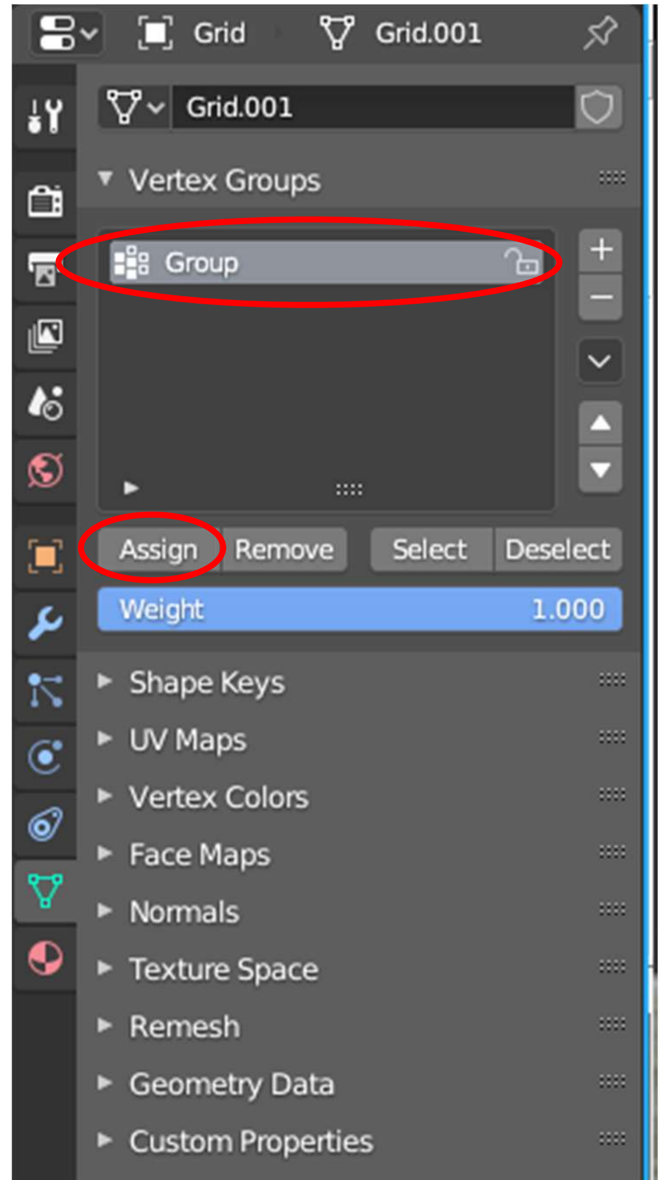
Hint: if this is just a test render, and you have lots of time-consuming visual effects going on, you might cut down the resolution and/or the number of rendered frames to speed things up.

Cloth Flag Animation: Pinning Vertices

We previously had this note-slide in which we looked at creating a vertex group that would become pinned in place*.* ***This slide shows what we did before for pinning the cloth horizontally. Starting after the Vertex Groups, we will pin a column of vertices to create a flag waving.***

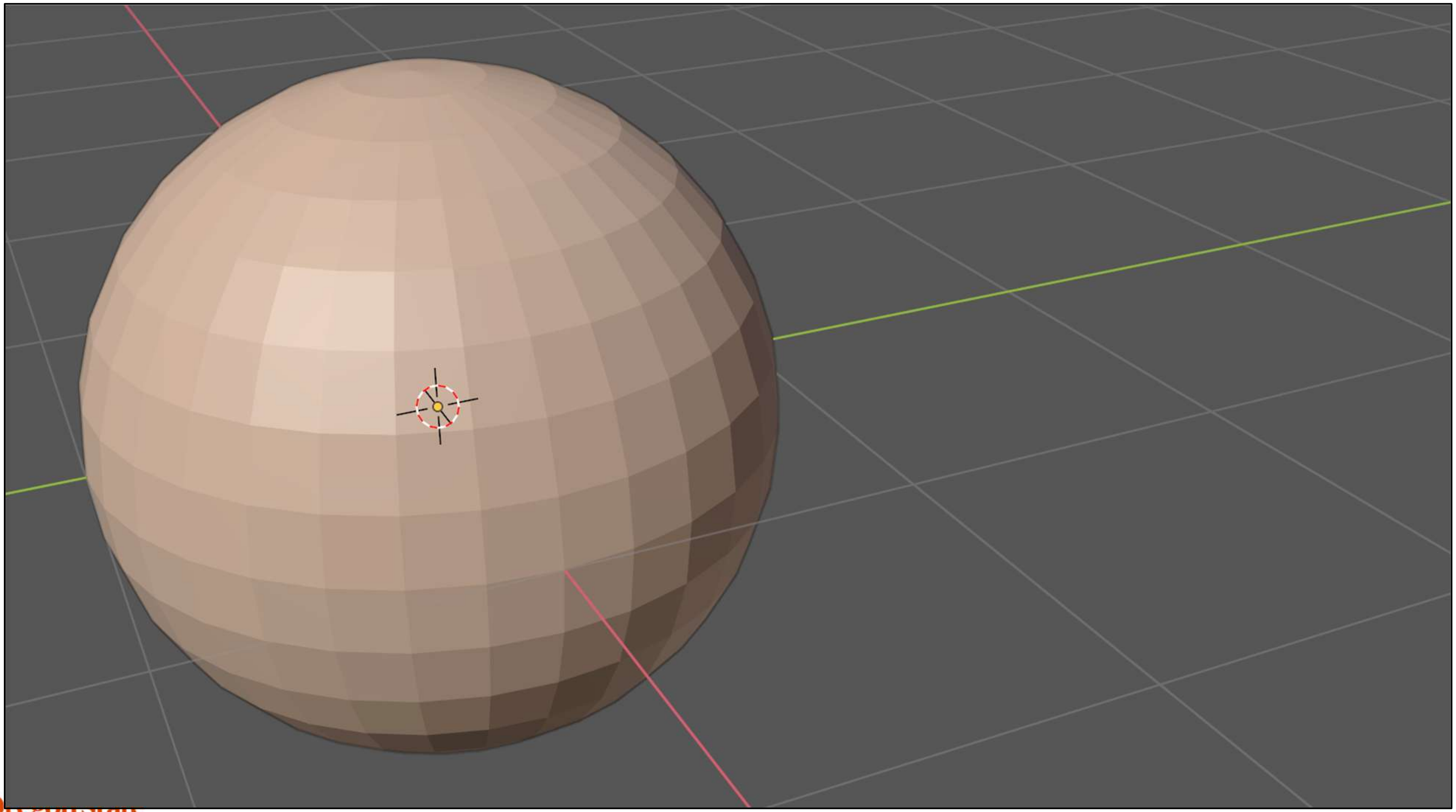
To do this, Tab into **Edit Mode**, **Shift-LMB** the vertices to be pinned, and create a **Vertex Group** from them. Vertex Groups were described earlier in these notes, but I am repeating them right after here so you don't have to go find them.





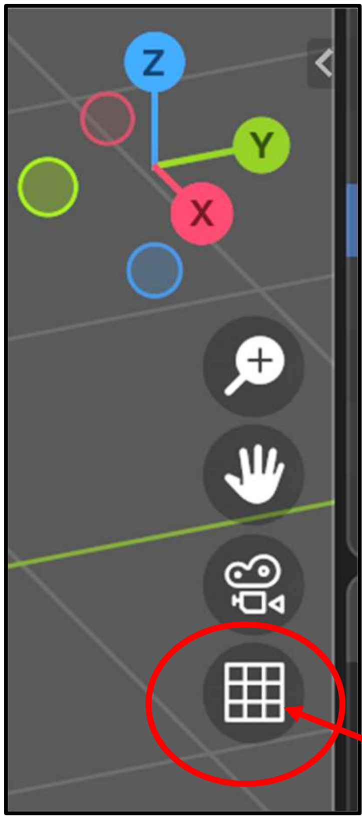
Vertex Groups

Add a **UV Sphere**



Vertex Groups

Select a group of sphere vertices to turn into a **Vertex Group.**

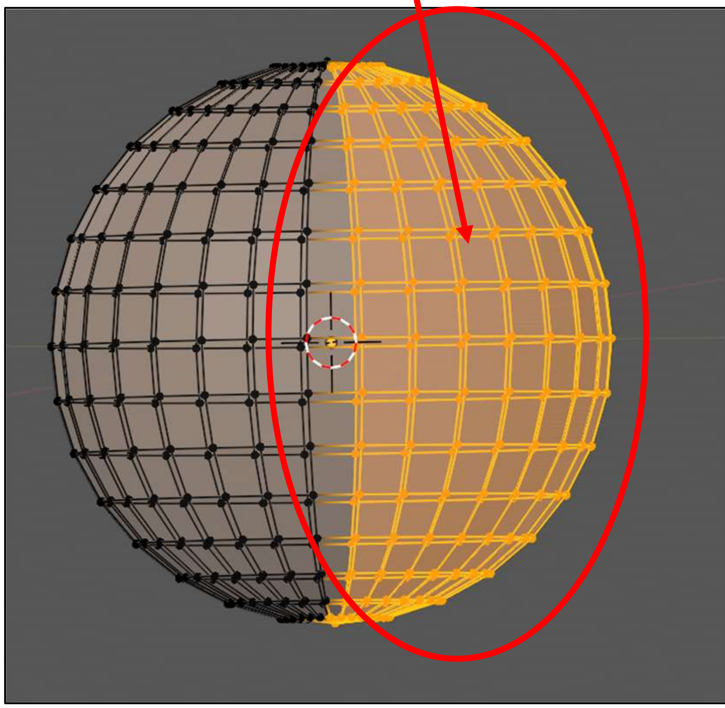


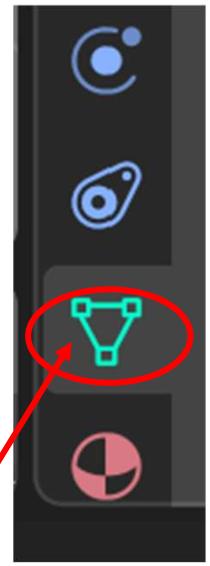
In **Object Mode**, turn on **X-ray**

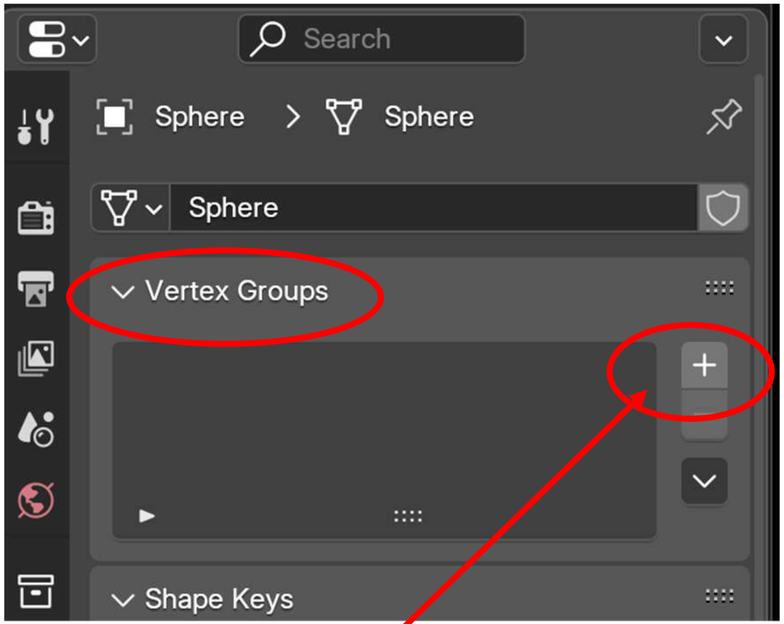
In **Object Mode**, turn on **Orthographic**

Vertex Groups

In **Edit Mode**, sweep over a group of sphere vertices





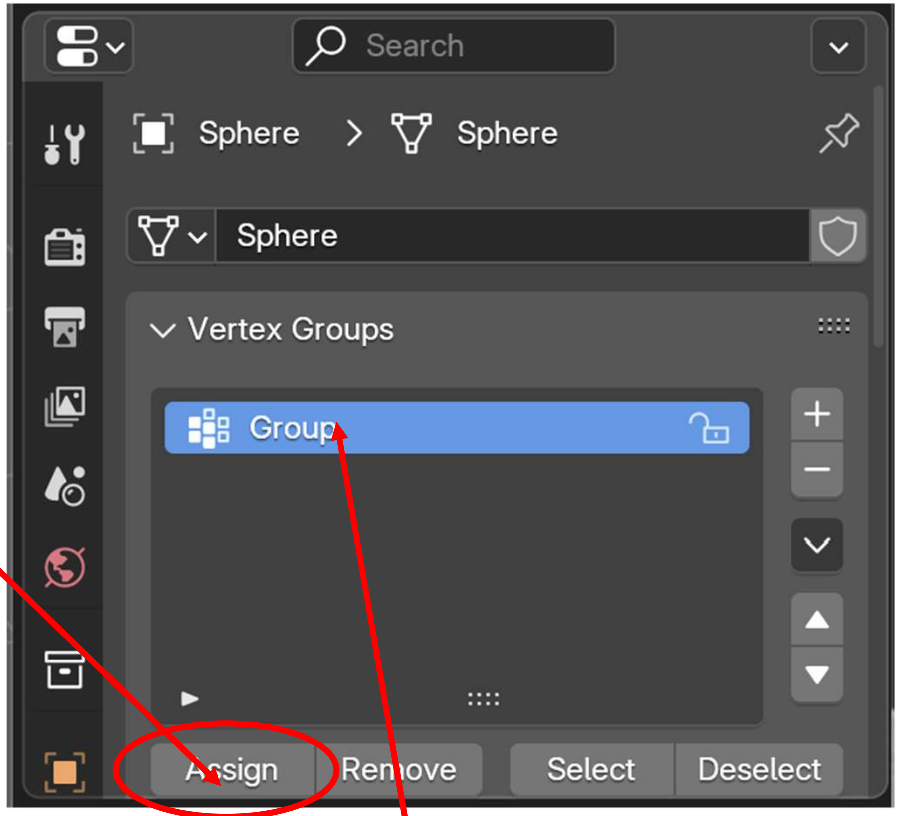


Click on the **Object Data Properties** icon

In **Vertex Groups**, click on the **+**
This creates a new Vertex Group

Vertex Groups

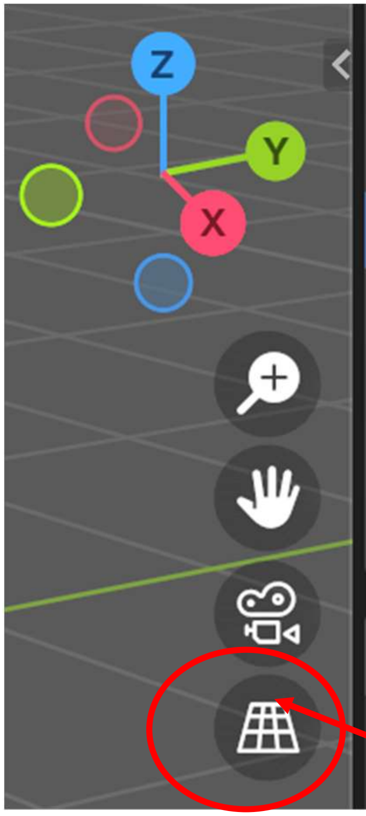
Now click on **Assign** to assign the vertices you picked to vertex group **Group**.



Double-click on **Group** and give that Vertex Group a more descriptive name

I named mine “Right” because these vertices are on the right side of the sphere.

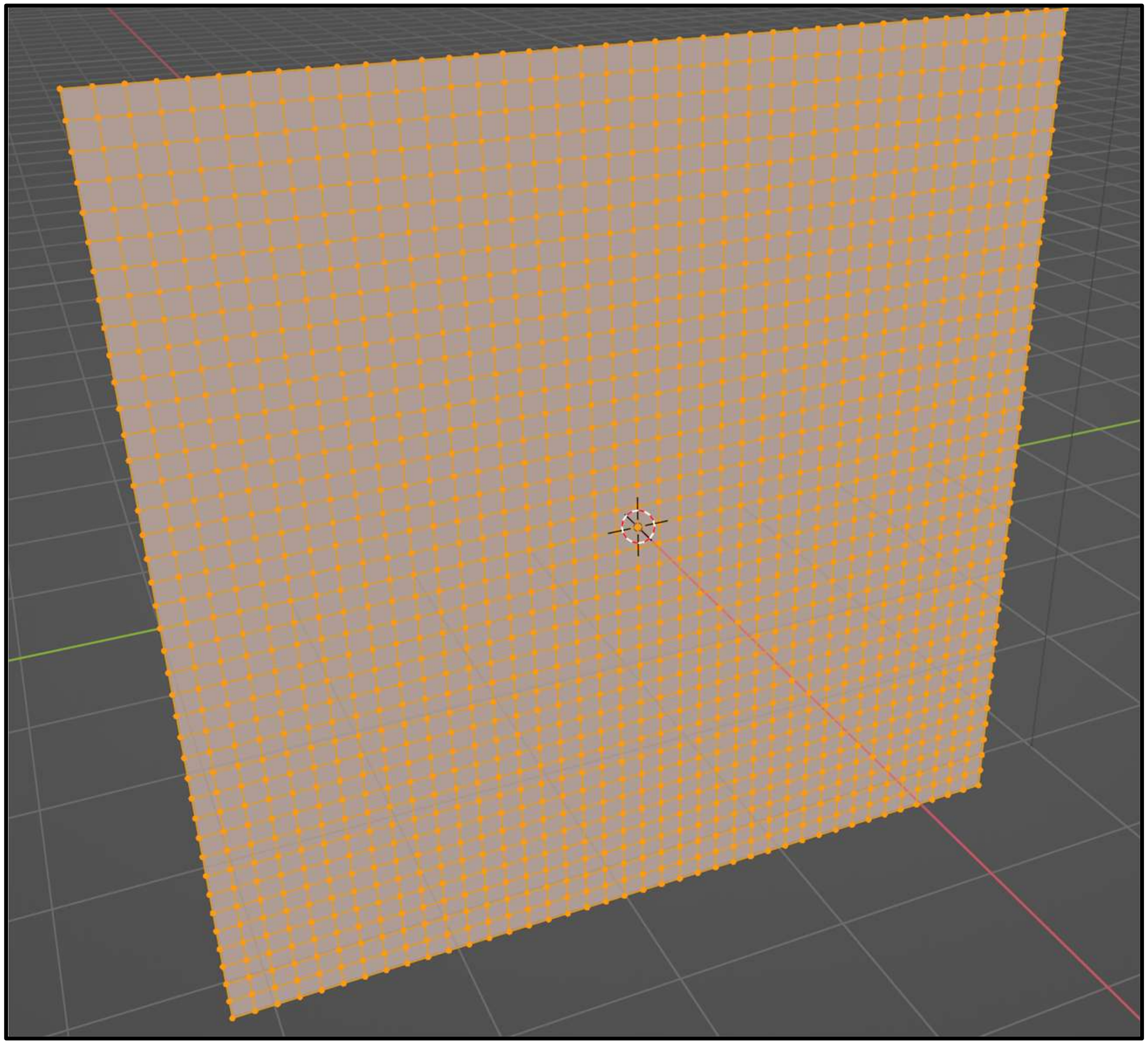
Vertex Groups



In **Object Mode**, turn off **X-ray**

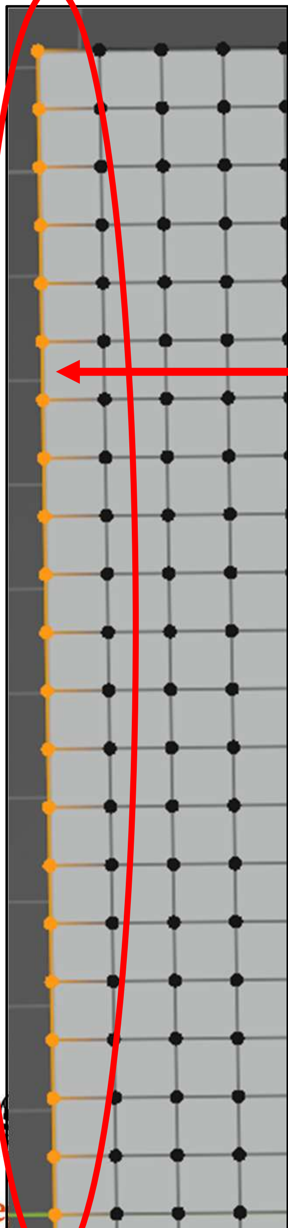
In **Object Mode**, turn on **Perspective**

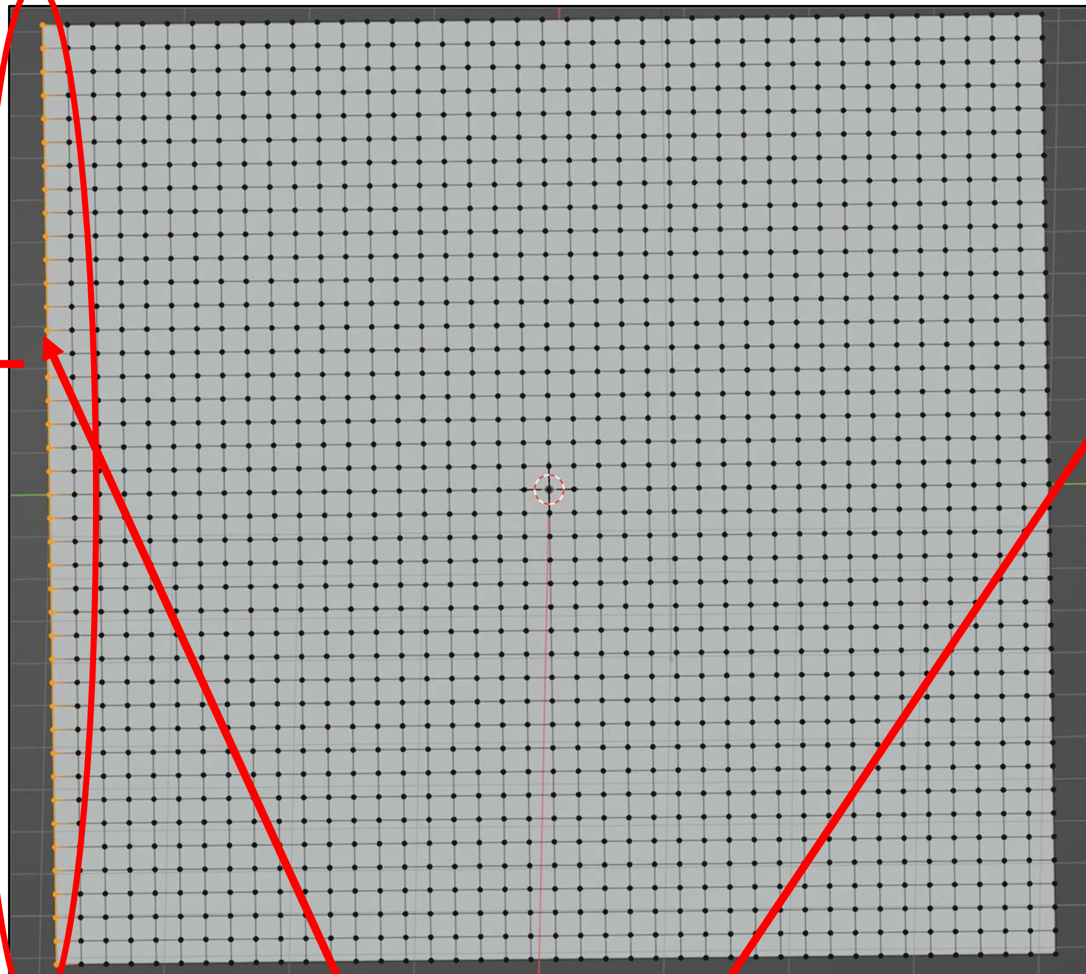
Cloth Flag Animation: Pinning Vertices

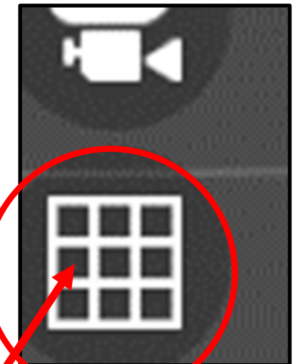


Create a grid, scale it up, rotate in to be vertical, and subdivide it in Edit mode.

Cloth Flag Animation: Pinning Vertices



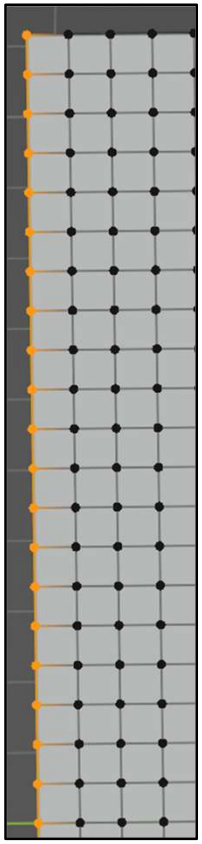


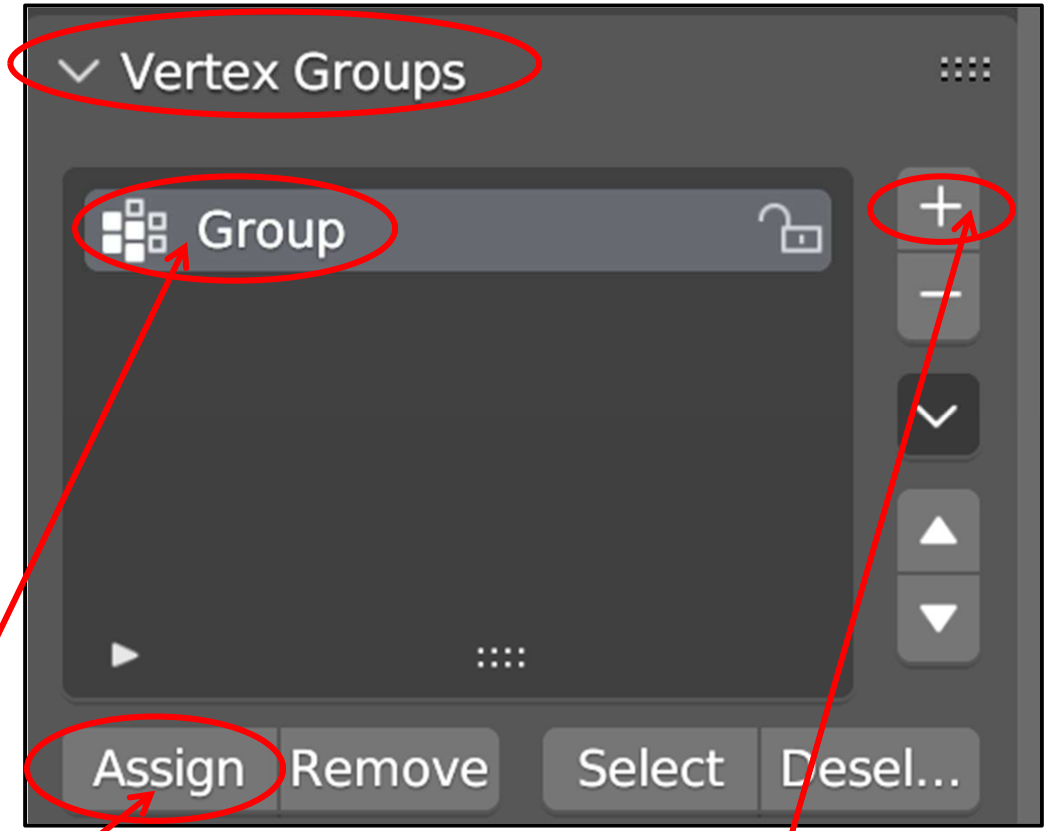


Still in Edit mode, switch to **Orthographic** mode and rotate so the cloth is perpendicularly facing you. Unselect everything (click in empty space) then box-select one column of vertices.

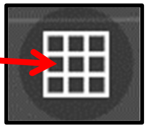
Cloth Flag Animation: Pinning Vertices

Click on this icon.

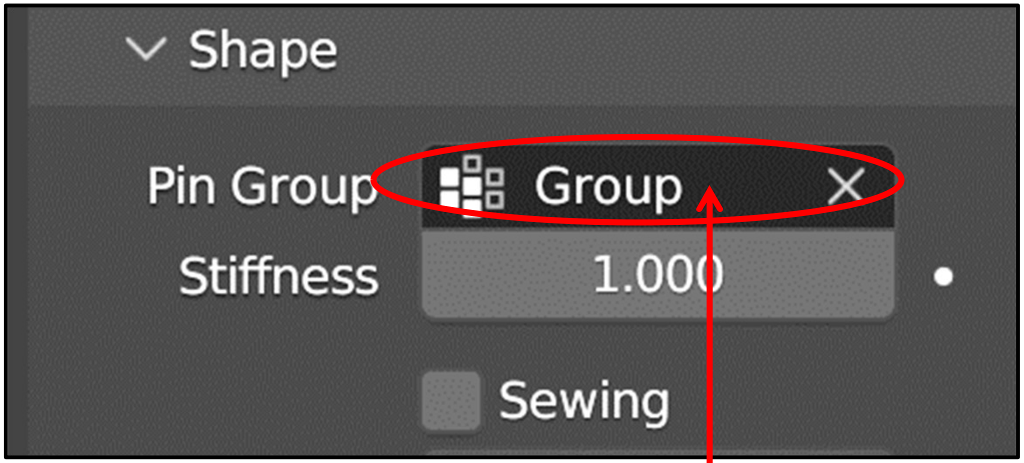




Find the **Vertex Groups** area. Click on the plus sign (**+**) then click on **Assign**. You can leave these vertices labeled as **Group**, or give them something more descriptive, like **Column**. Tab back to **Object Mode.** Go back to **Perspective Projection.**

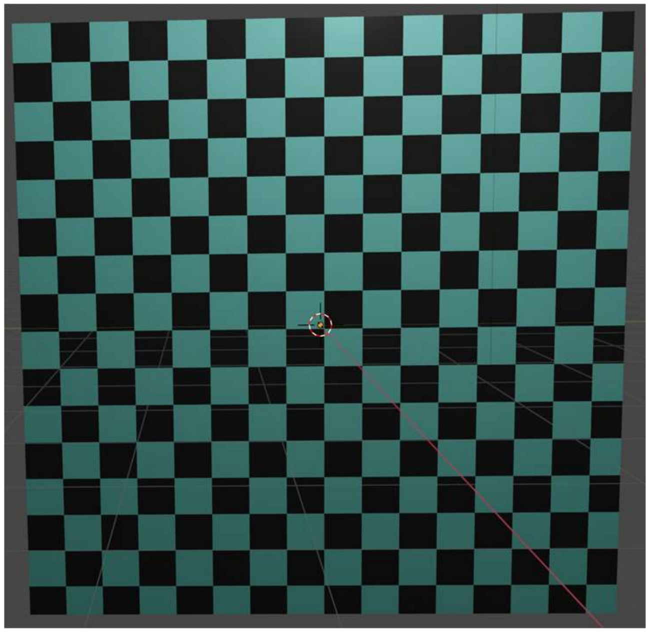


Cloth Flag Animation: Pinning Vertices

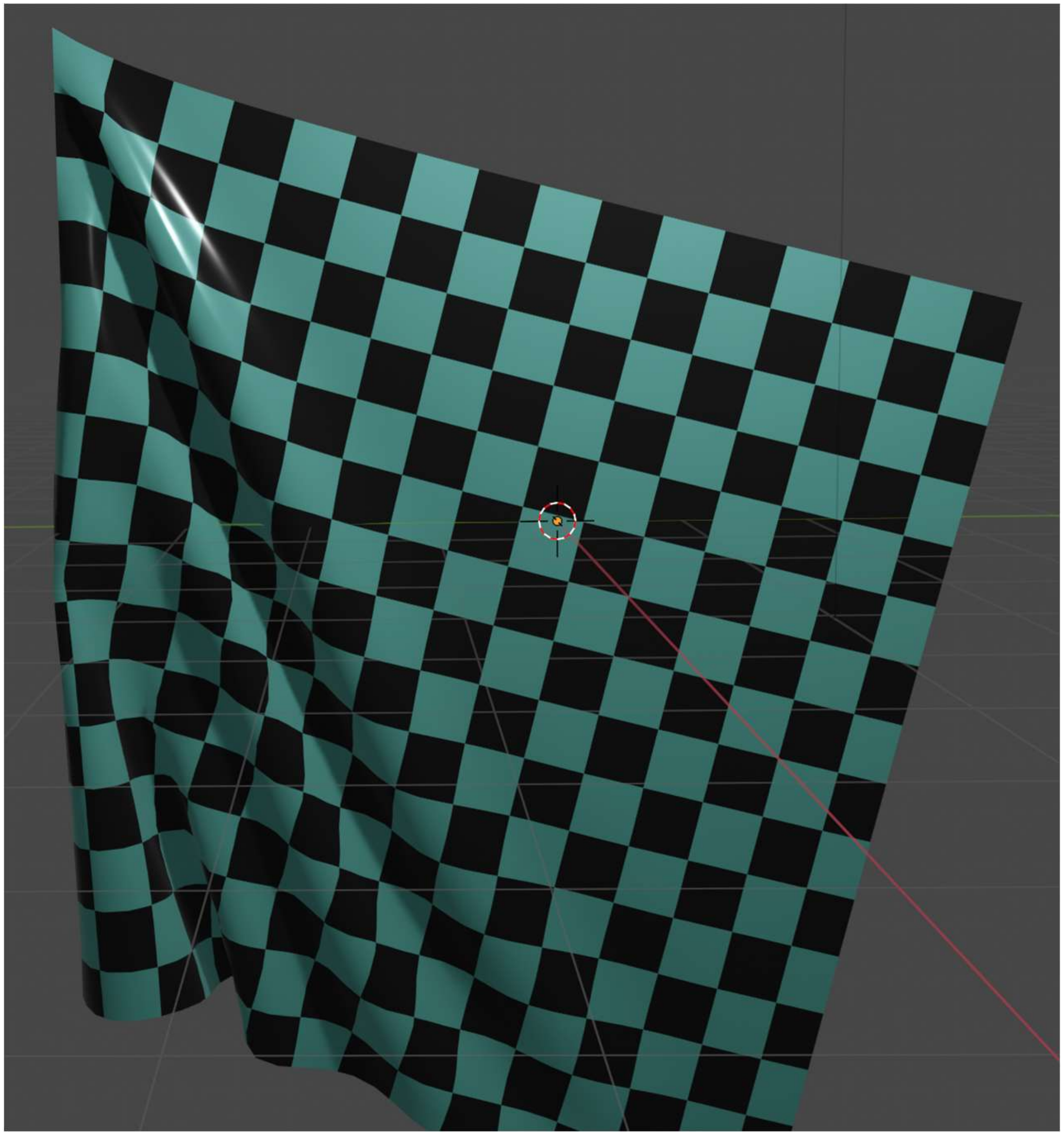


With the cloth selected, go to the **Physics icon** and select **Cloth**. Scroll down to the Shape tab and set the Pin Group to whatever name you gave your column of points (**Group**, here).

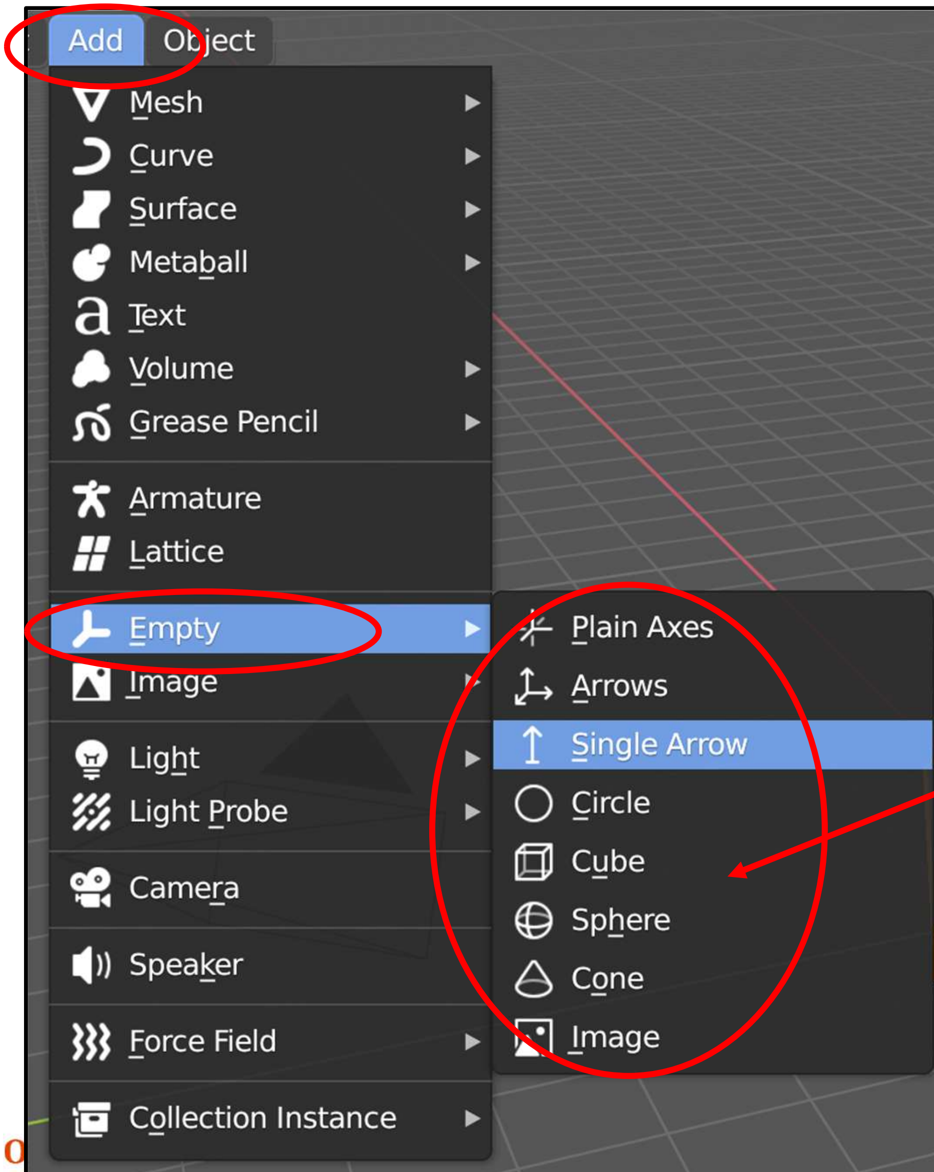
Cloth Flag Animation



Color and texture the cloth any way you'd like, and turn on the **Animation**.



To Blow Cloth, We need a Force Field – Attach it to an Empty Object

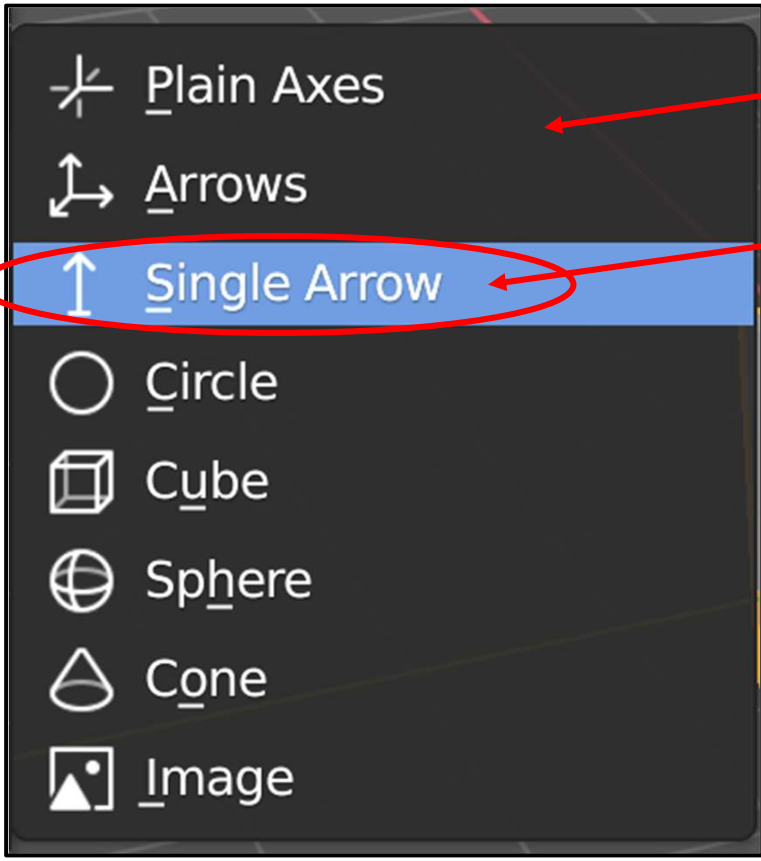


Ironically, one of the most useful objects is the one you can't see. Blender calls this an **Empty**.

It's invisible on the screen, but you can treat it like a real object, and can attach forces to it. These forces will influence the behavior of other objects.

Find the **Empty** under the **Add** tab at the top of the screen. When you click on it, this sub-menu pops up.

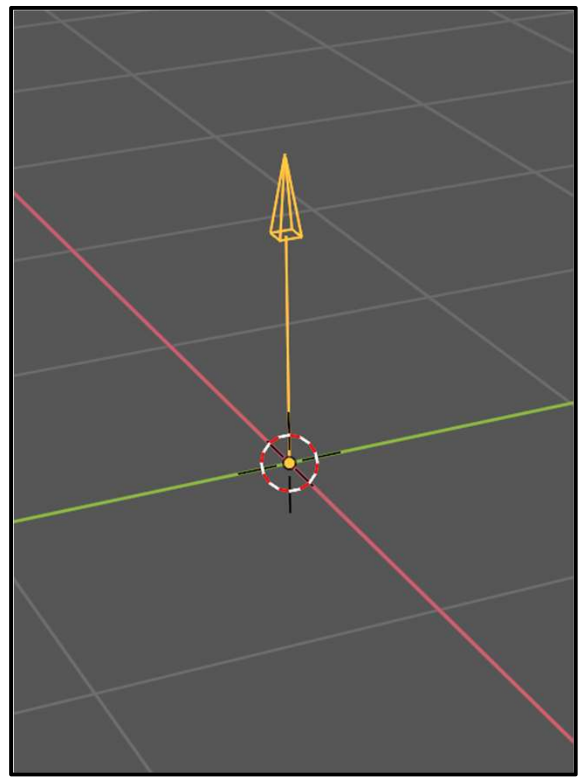
We need a Force Field – Attach it to an Empty Object



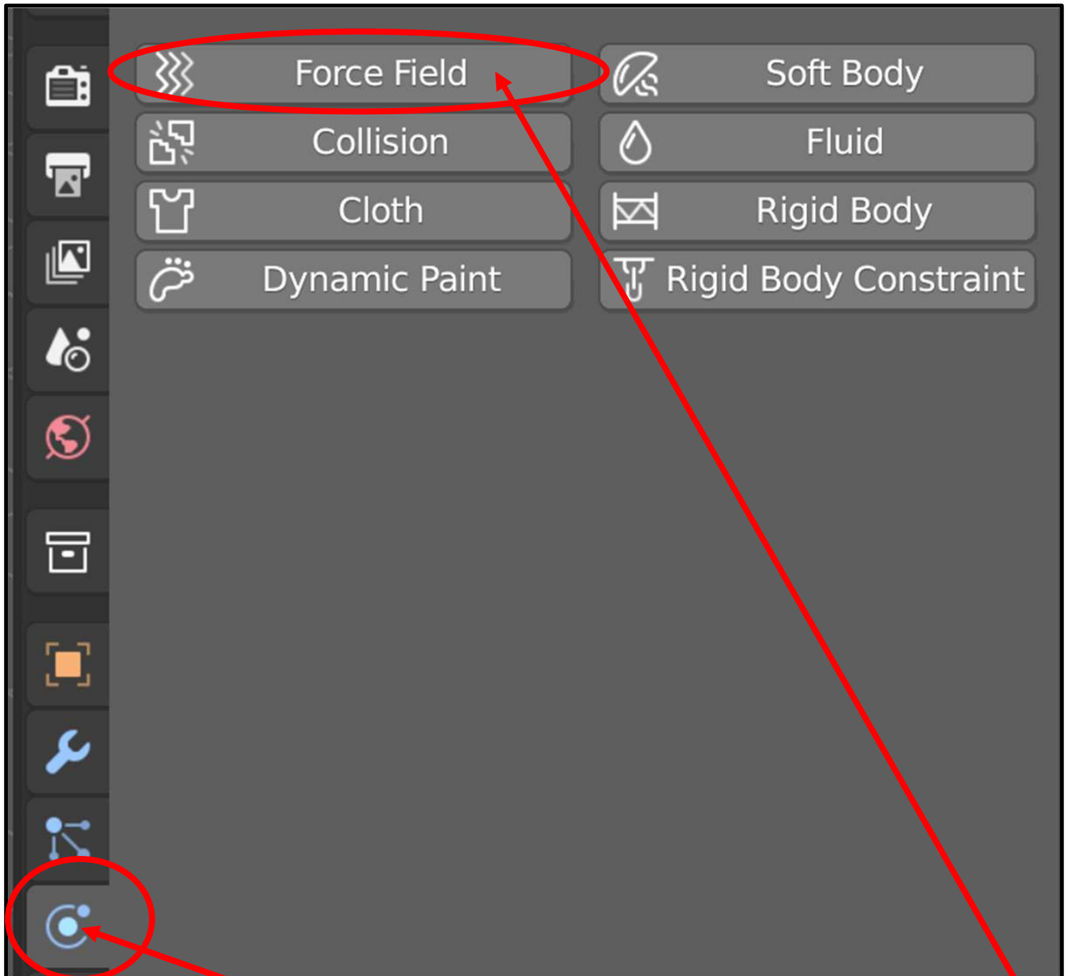
Surprise! Even though it is invisible, an **Empty** has a shape!

For this exercise, pick the **Single Arrow**

On the screen, it will look like this:.



Blowing the Cloth -- Force Fields



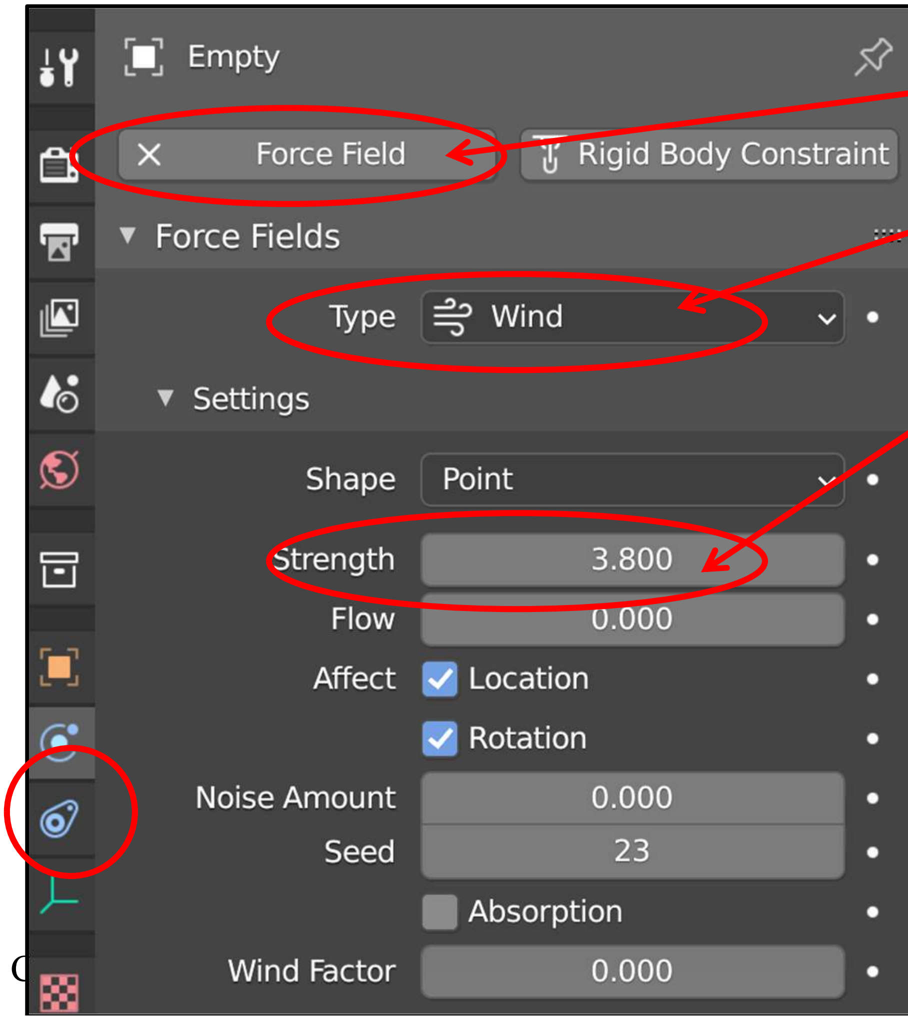
A really good use for **Force Fields** is to blow particles and cloth around

With the **Empty** Object selected, click on the Physics icon and then click on **Force Field**

Position and Orient the Empty

Using the usual object-rotate commands, orient the **Empty** so that it is pointing at the particles.

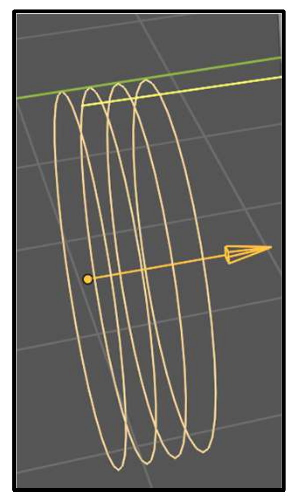
Hint: it is easiest to *position* it in Global Coordinates **(g → x)** and easiest to *rotate* it in Local Coordinates **(r → x → x)** .



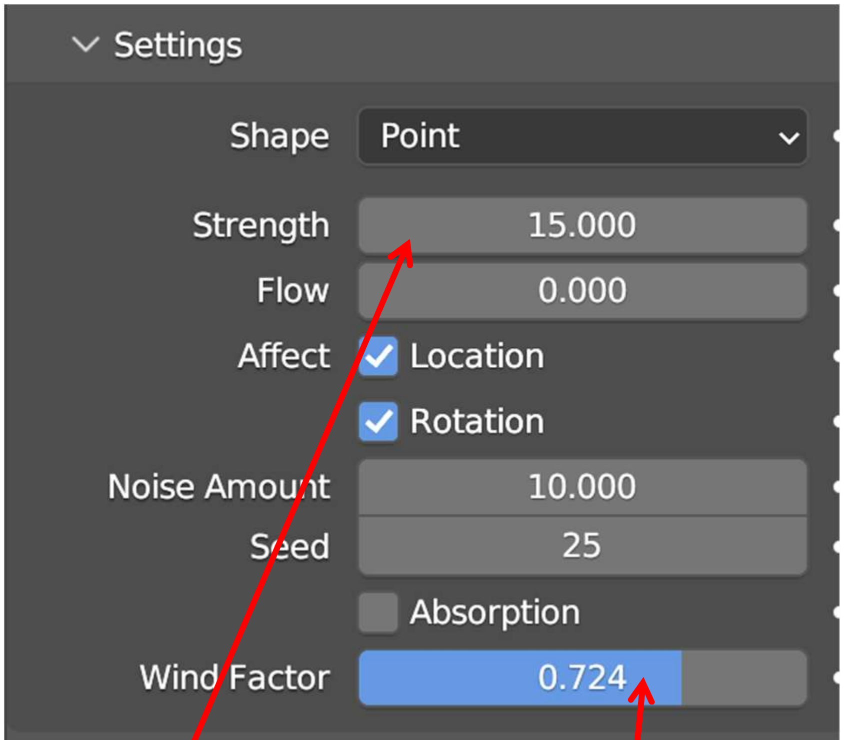
And, under **Force Field Type**, select **Wind**

You will use this to change the **Strength** of the wind

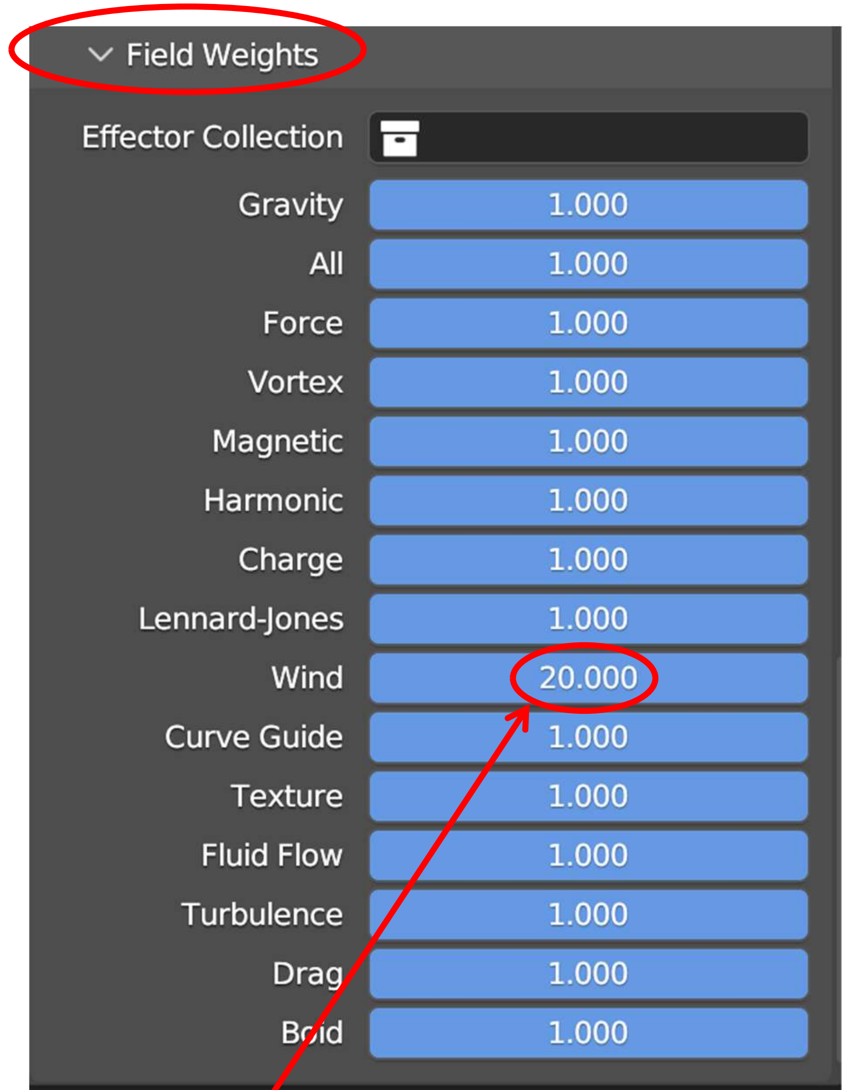
It will look like this on the screen:



Cloth Flag Animation: Adjusting the Amount of Fluttering

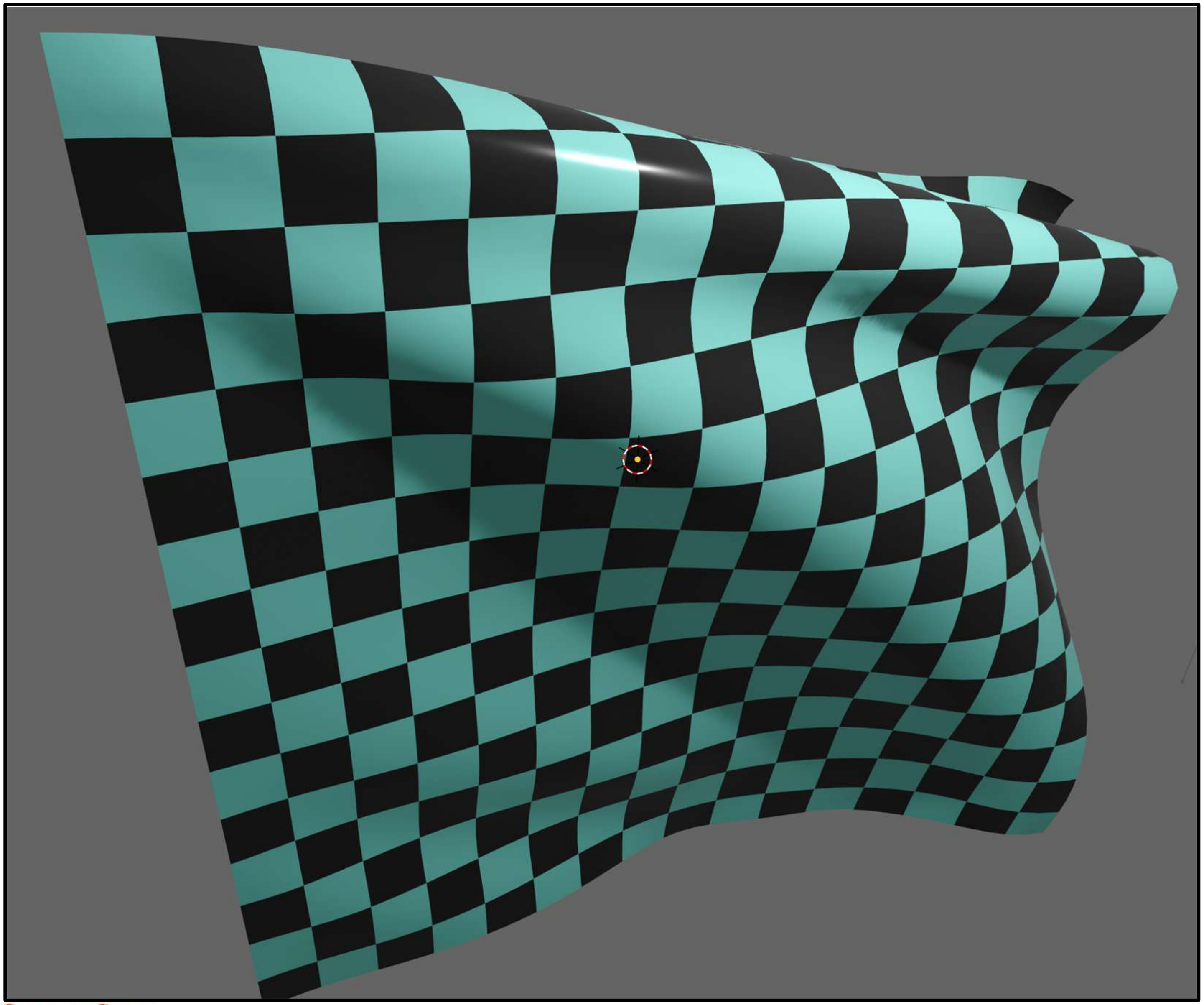


In the **Empty** object, increase the **Strength** and the **Wind Factor**.

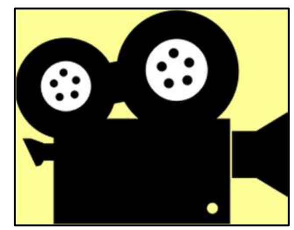


In the **Cloth** object, scroll down to the **Field Weights** and increase the **Wind**.

Cloth Fluttering Flag Animation



fluttering.blend



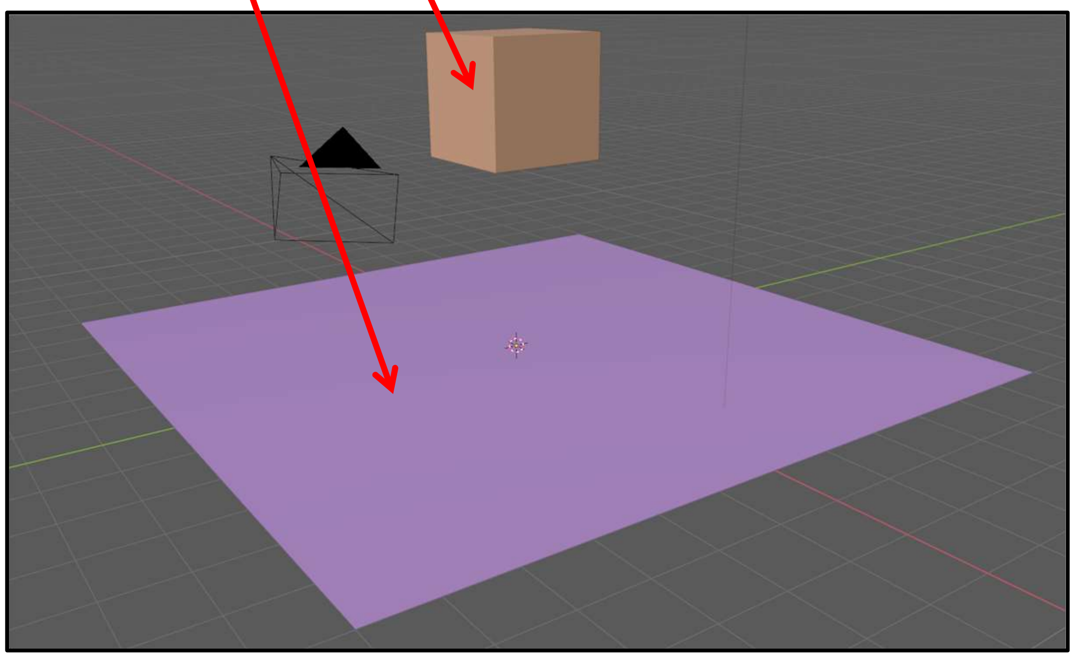
fluttering.mkv

Cloth Fluttering Flag Animation ☺

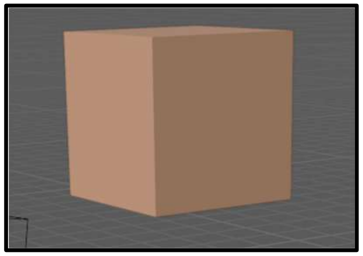
Dropping an Object on the Cloth

Setup this scenario:

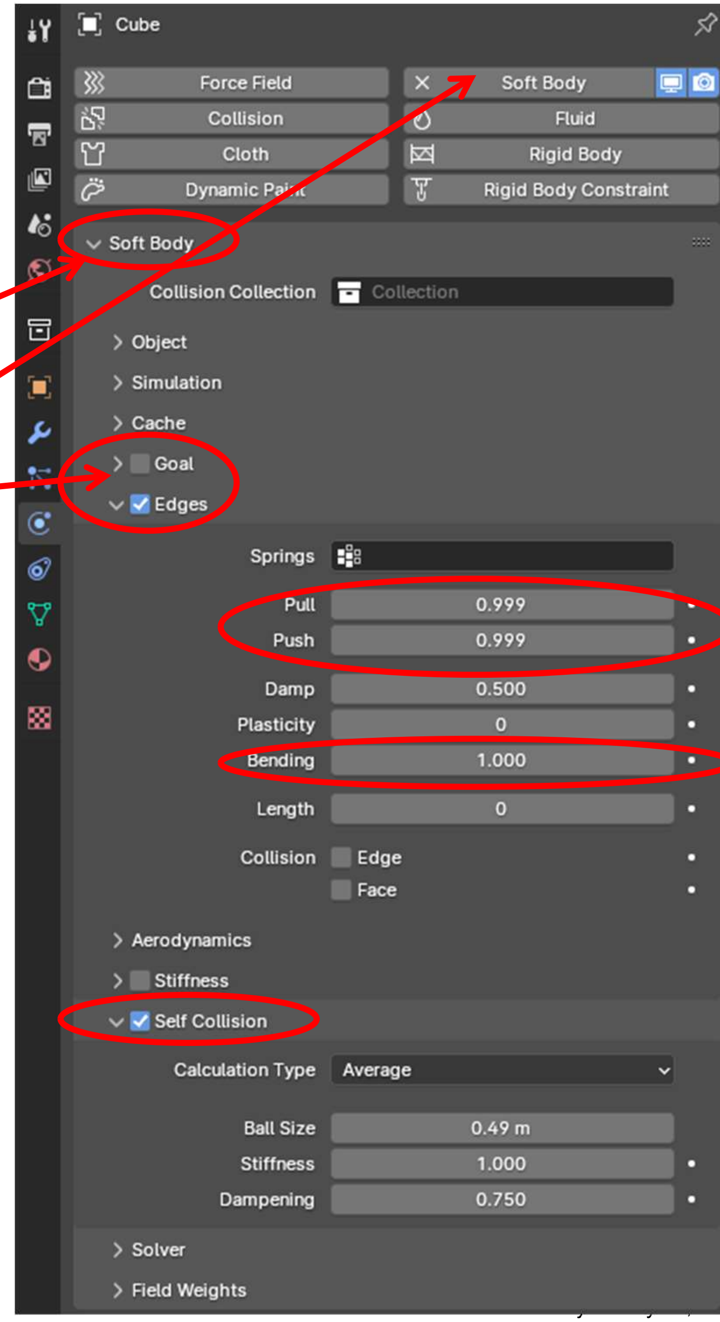
1. Have an object hovering up in the air (‘gz’)
2. Add a Grid object and scale it up
3. In Edit Mode, **Subdivide** the Grid a few times
4. In Edit Mode, select the 4 corner vertices of the grid and place them into a Vertex Group called **Corners** (see how to do this a few slides back)
5. Back in Object Mode, select the grid and hit **RMB→Shade Smooth**



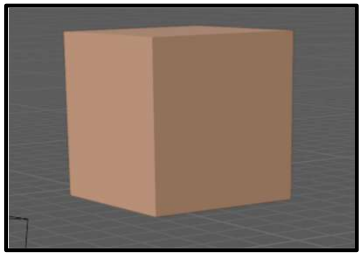
Dropping an Object on the Cloth

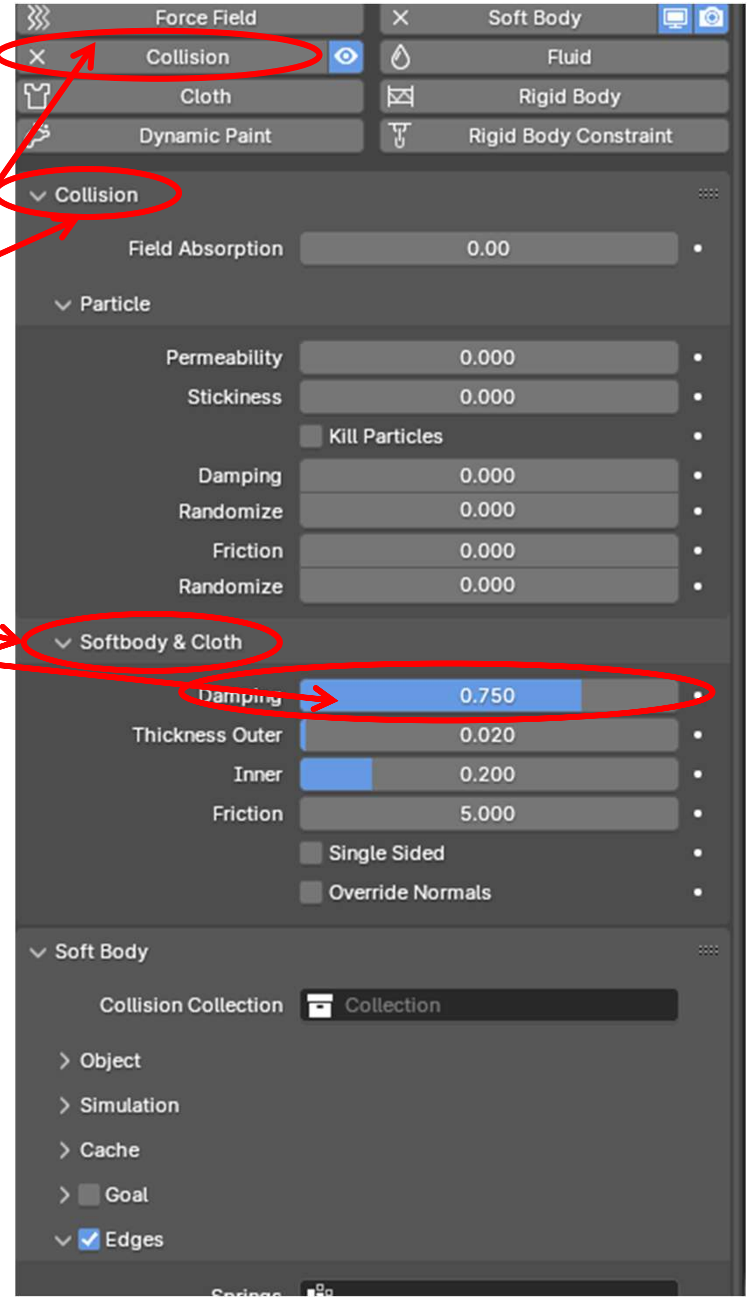


Select the object hovering up in the air:
Go to the **Physics** menu and select **Soft Body**
In the **Soft Body** sub-menu:
1. Uncheck **Goal**
2. In the **Edges** sub-menu:
- Set the **Pull** and **Push** each to 0.999
- Set **Bending** to **1.00**
3. In the **Self Collision** sub-menu
- Check **Self Collision**



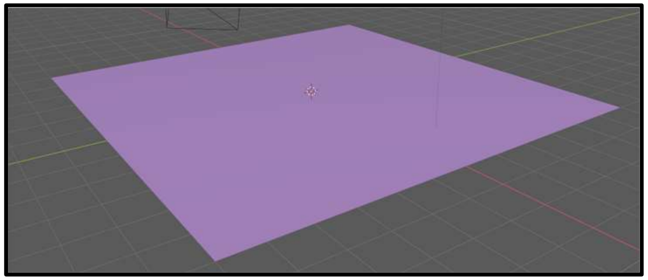
Dropping an Object on the Cloth





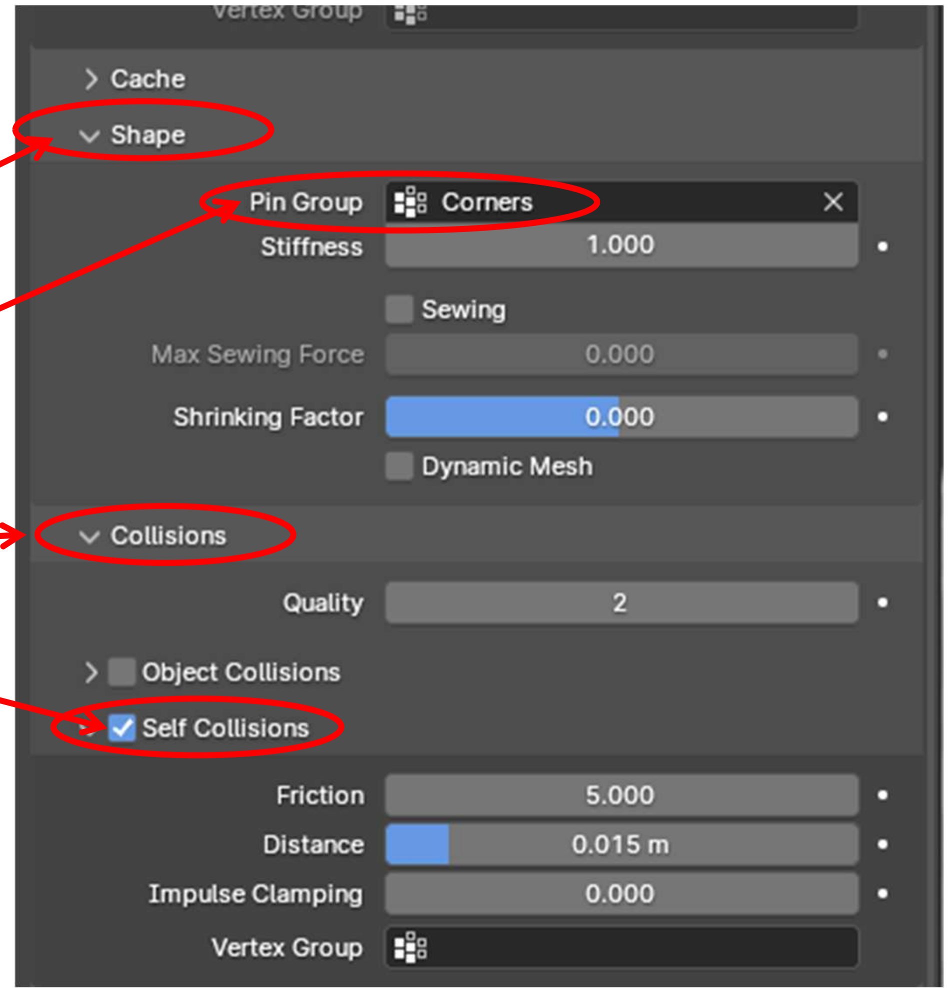
With the hovering object still selected:
Go to the **Physics** menu and select **Collision**
In the **Collision** menu:
1. In the **Softbody & Cloth** sub-menu
- Set the **Damping to 0.75**

Dropping an Object on the Cloth

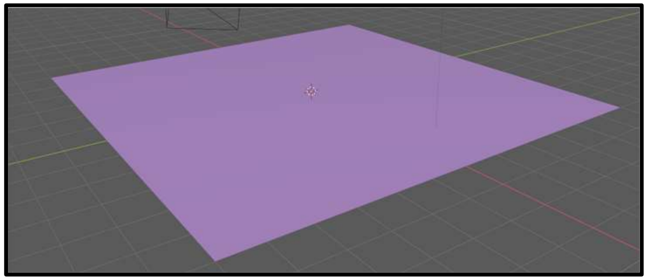


Select the cloth grid, then:
Go to the **Physics** menu and select **Cloth**
In the **Cloth** menu:

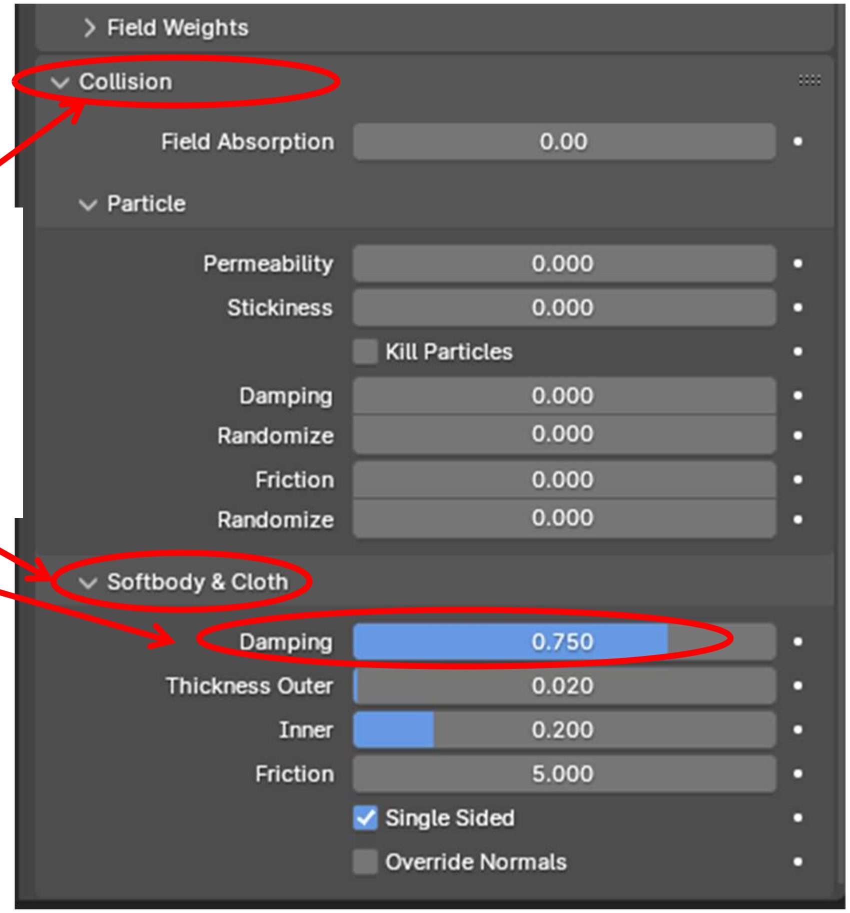
1. Open the **Shape** sub-menu and select the **Corners** Pin Group
2. Open the **Collisions** sub-menu and check **Self Collisions**



Dropping an Object on the Cloth



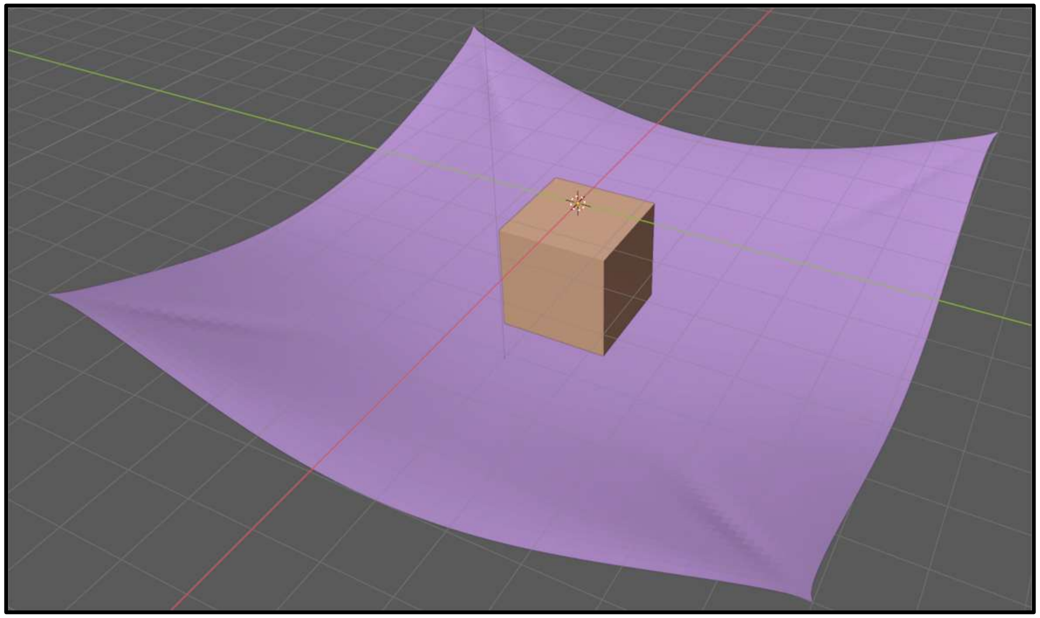
With the cloth still selected:
Go to the **Physics** menu and select **Collision**
Then, in the **Collision** sub-menu:
1. In the **Softbody & Cloth** sub-menu
• Set the **Damping to 0.75**



Dropping an Object on the Cloth

Click on the **Play** button in the animate controls

The cloth sags and the object plops into it

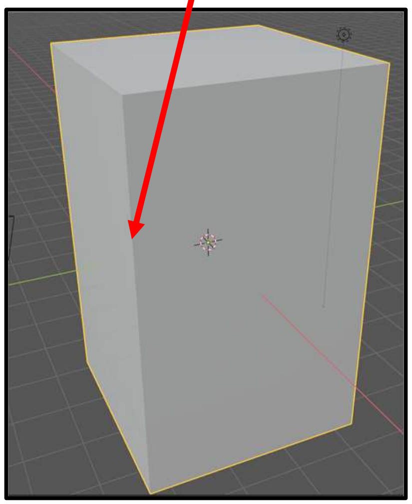


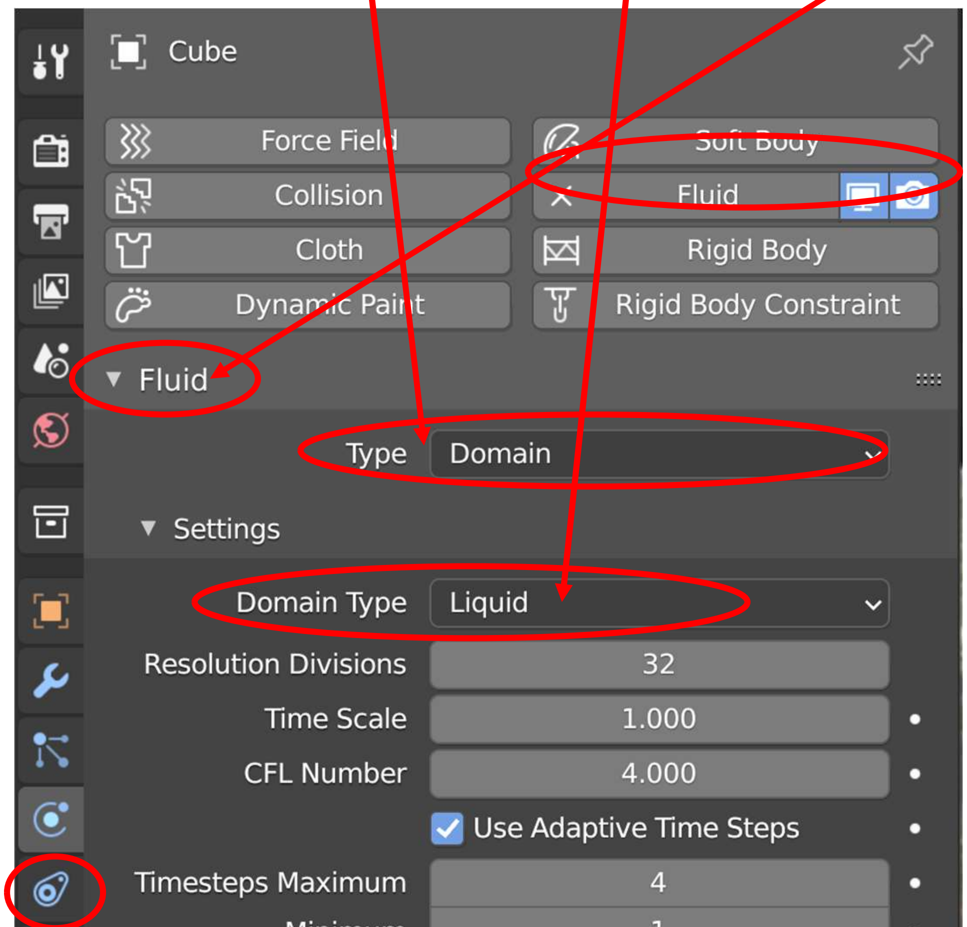
Setting up a Fluids Simulation – Create the Domain Object

Step #1: Create the **Domain**, the volume in which the fluid will be simulated. Here, I scaled the default cube by 3 in X, 3 in Y, and 5 in Z: ‘sx3<ret>sy3<ret>sz5<ret>’

Step #2: With the cube selected, go to the **Physics** tab and select **Fluid**

Step #3: Under that **Fluid** tab, select **Domain** and **Liquid**

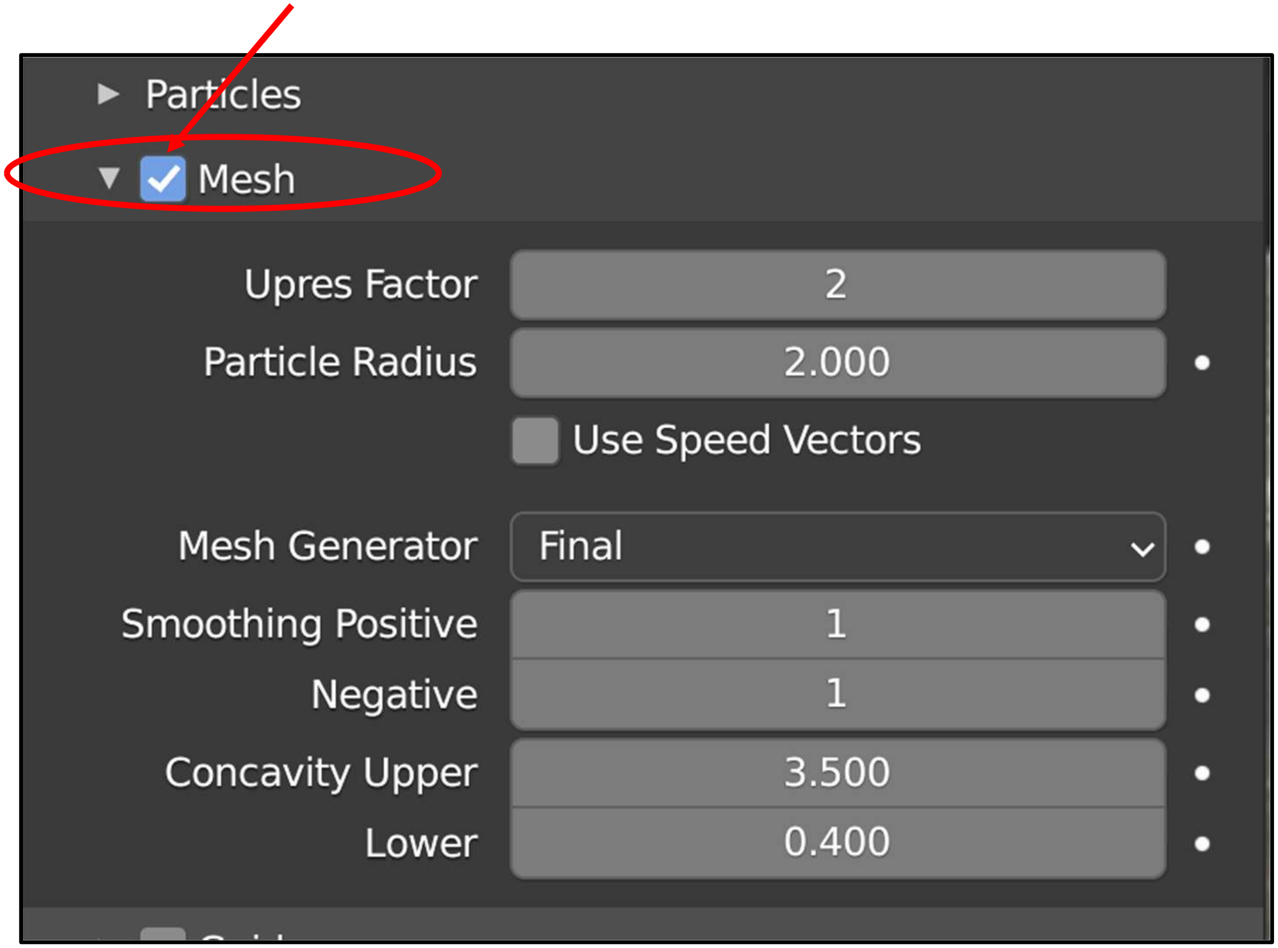




fluidmonkeycone.blend

Setting up a Fluids Simulation – Create the Domain Object

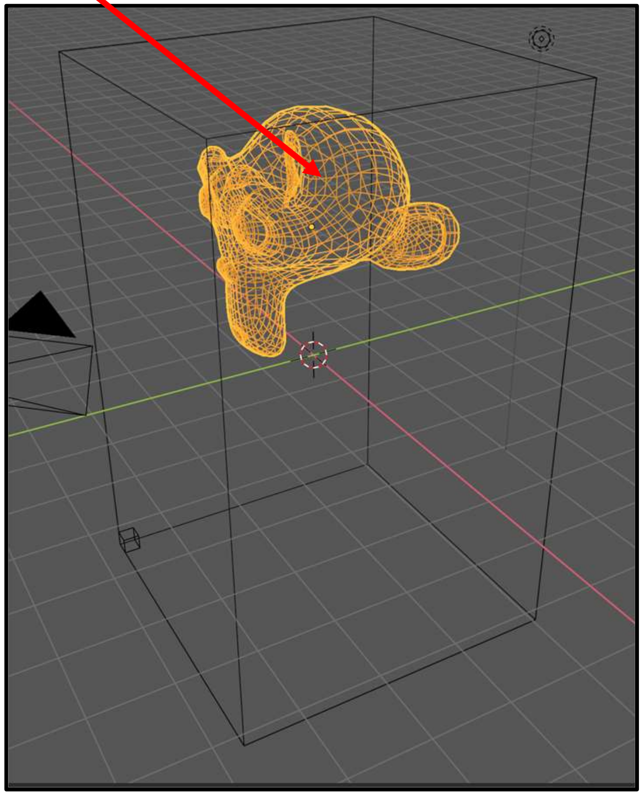
Step #3: Scroll down in the **Physics-Fluid** menu until you find the **Mesh** tab.. Be sure it is turned on.



Setting up a Fluids Simulation – Create the Flow Object

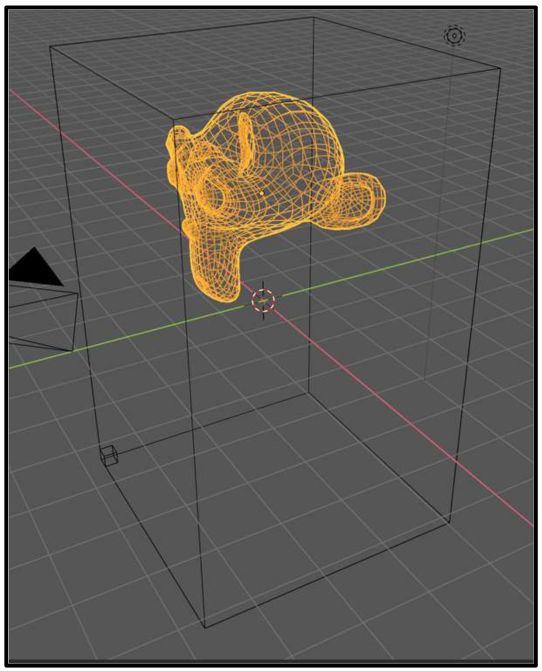
Step #4: Create a mesh object that will be the original location and shape of the fluid. A UV-Sphere works well. A monkey works even better! ☺ This object must lie totally within the Domain. You should probably toggle into **Wireframe** or **X-ray** mode so you can see inside the Domain.

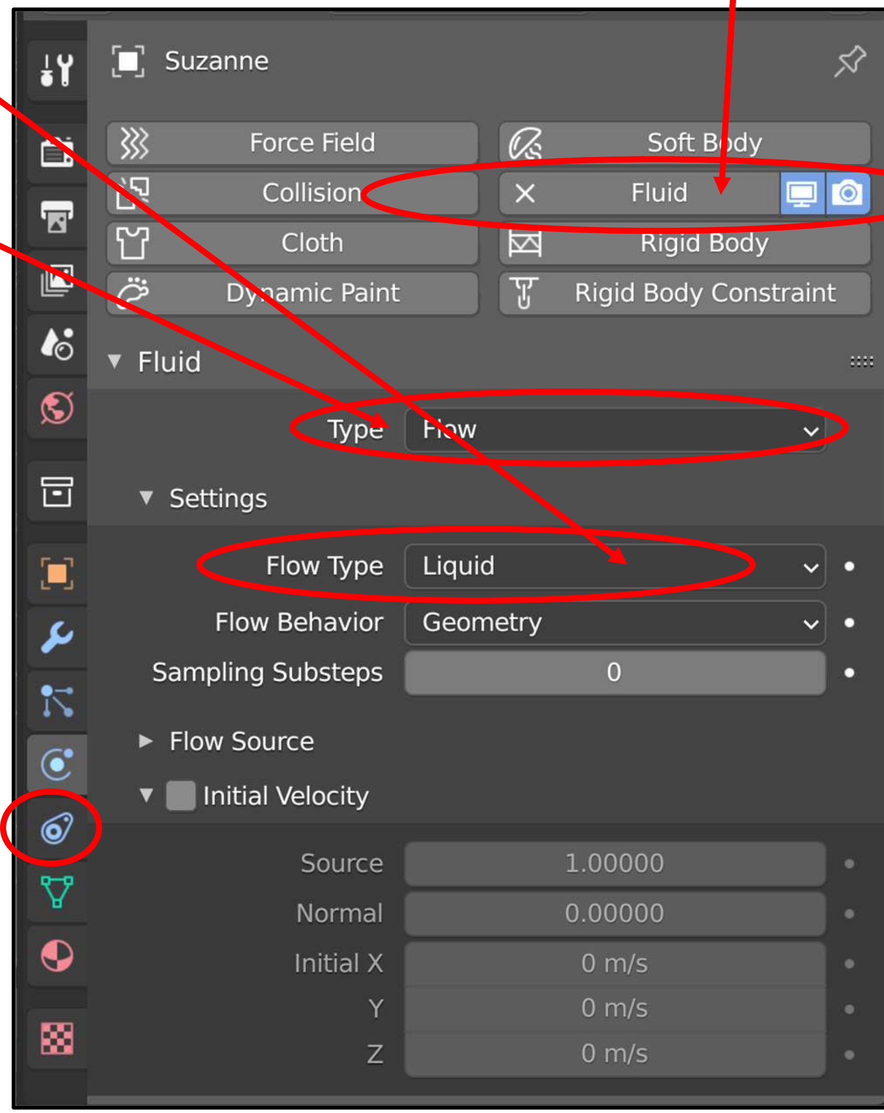
Position this object near the *top of the Domain*.



Setting up a Fluids Simulation – Create the Flow Object

Step #5: With this object selected, go to the **Physics** menu, click on **Fluid**, select **Flow**, and select **Liquid**





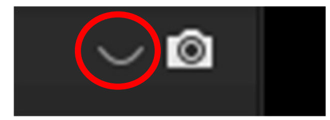
Setting up a Fluids Simulation – Miscellaneous

Step #6: Miscellaneous Things:

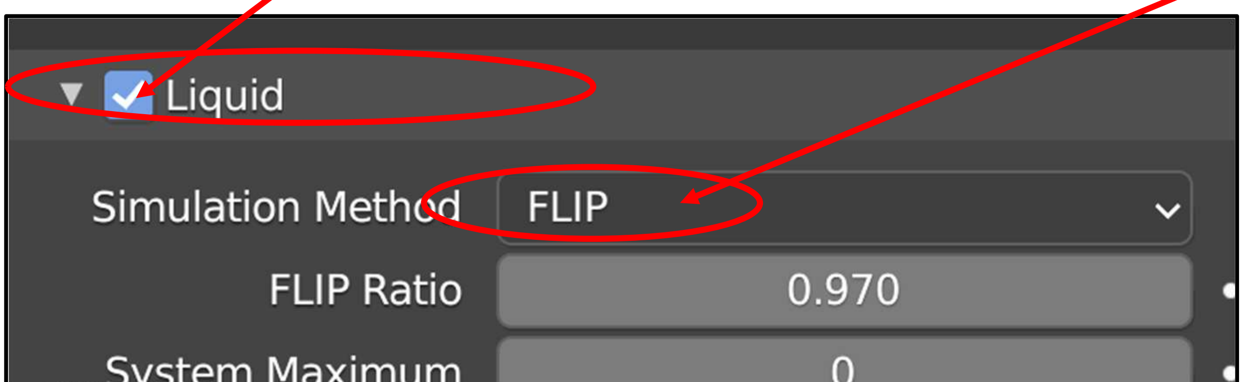
- Change the color of the Domain object (cube) to the color you want the fluid to be. Feel free to change the **Metallic** and **Roughness** parameters as well.

- Change the shading type of the Domain object (cube) to **Shade Smooth**

- Hide the Flow object (monkey?) by clicking off its eyeballs in the Outliner

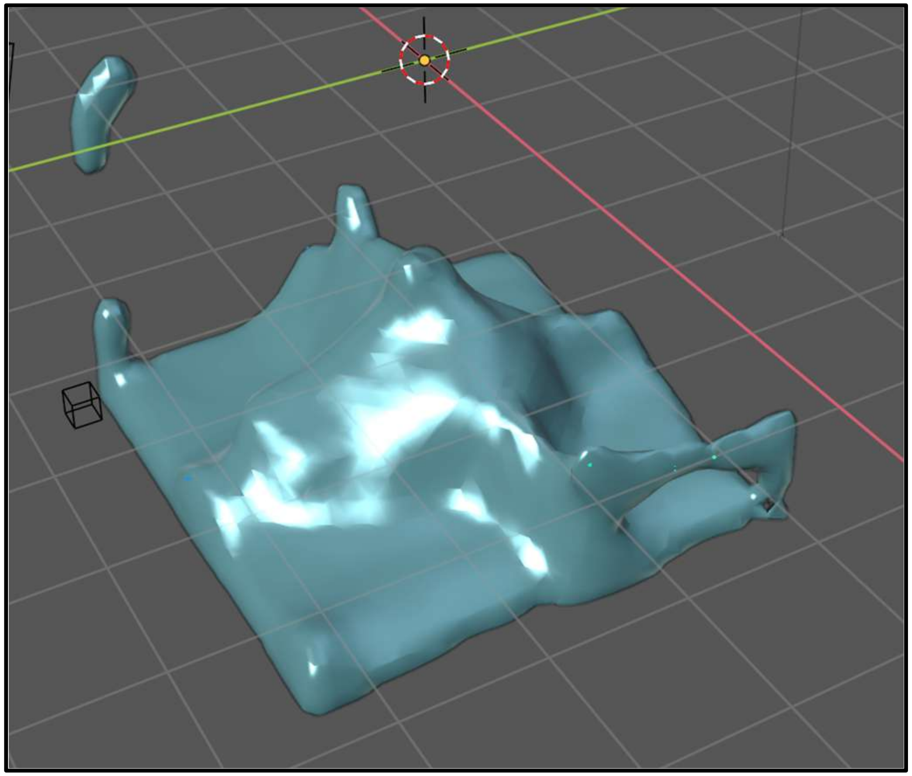


- Select the Domain object (cube), go to the **Physics** menu, scroll down until you see this: Be sure **Liquid** is turned on. Now, go here and select the *other option*. It doesn't make a huge difference which one you pick, but changing the option resets the fluid simulation.



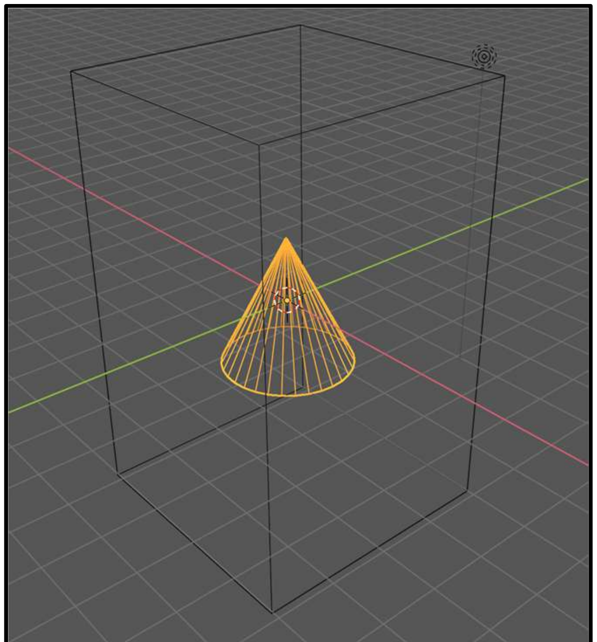
Running the Fluids Simulation

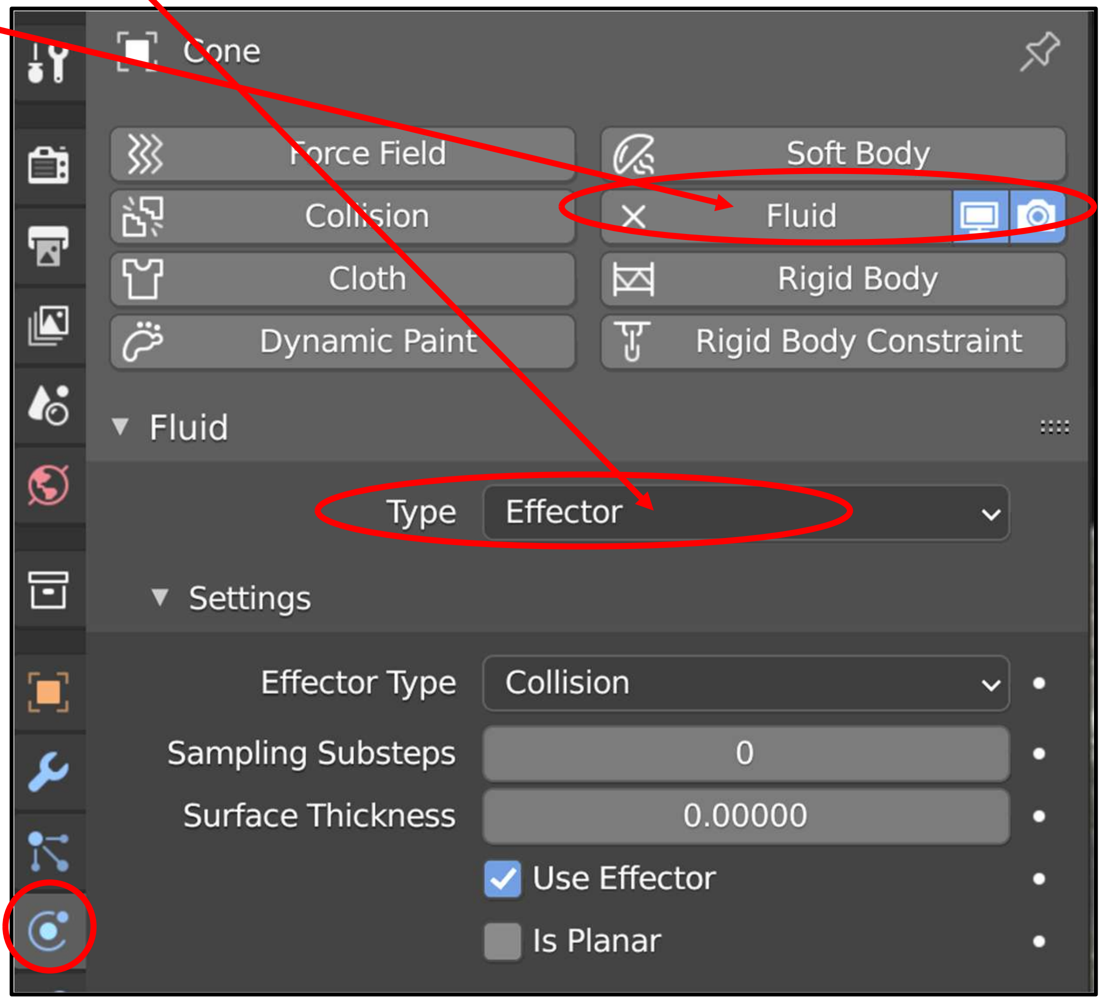
Step #7: Run the animation! Go to **Viewport Shading mode** and hit **Play**. The first time through will seem slow because it is computing the frames and storing them. After that, the animation will be much smoother because Blender is playing back your frames.



Adding a Barrier

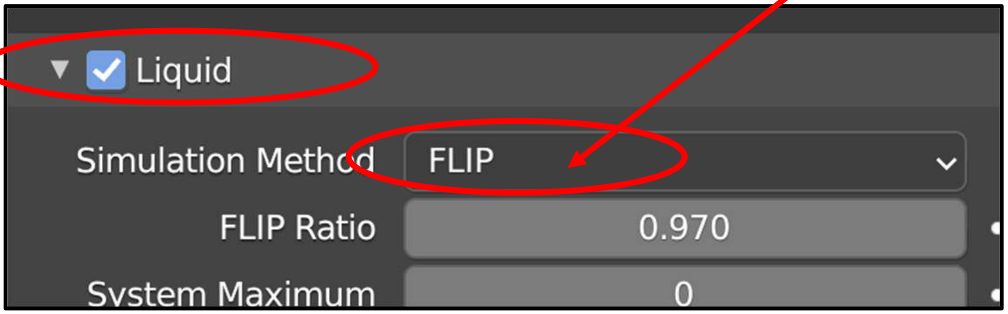
Step #8: Add some shape (a cone perhaps) into the middle of the Domain. Give it a color and the proper shading type. Then, go to the **Physics** menu, click on **Fluid**, and select **Effector.**



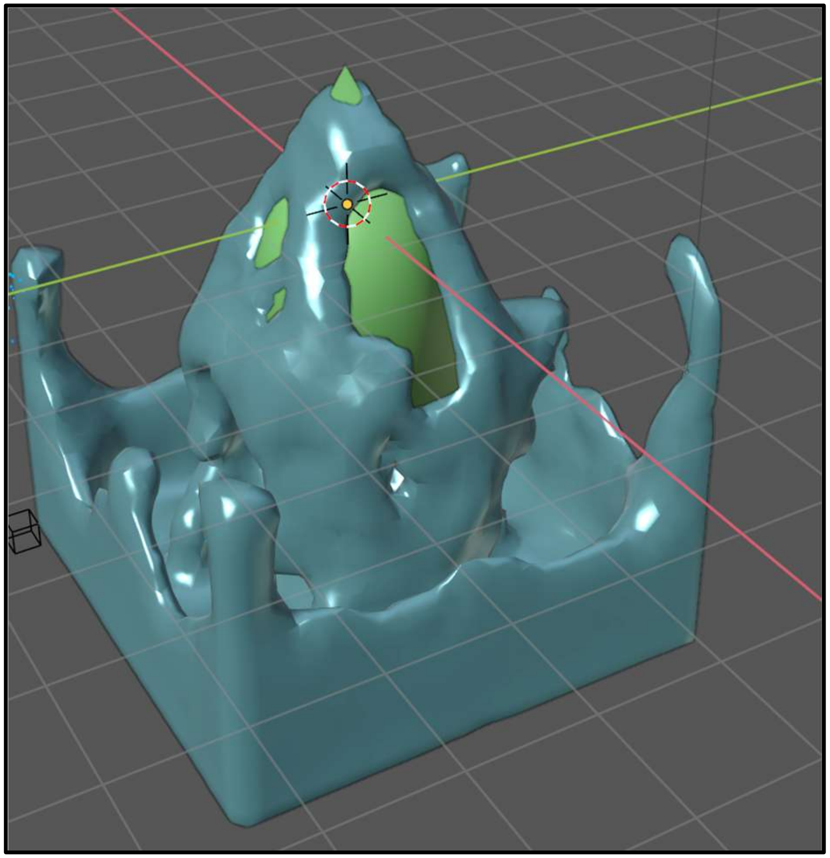


Adding a Barrier

Step 9: Select the Domain object, go to the **Physics** menu, scroll down until you see this again: Go here and select the *other option*. It doesn't make a huge difference which one you pick, but changing the option resets the fluid simulation.

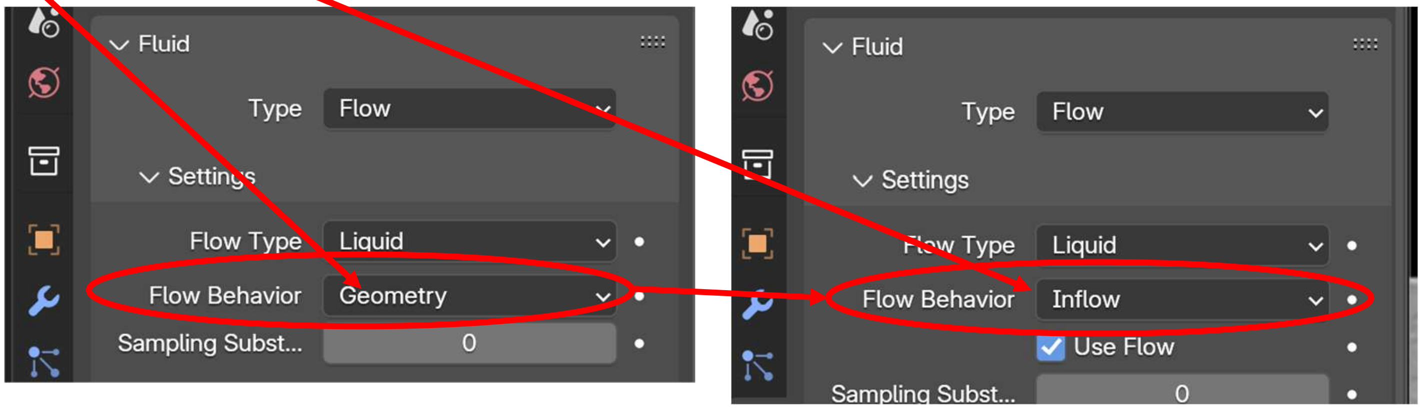


Step 10: Hit Play!

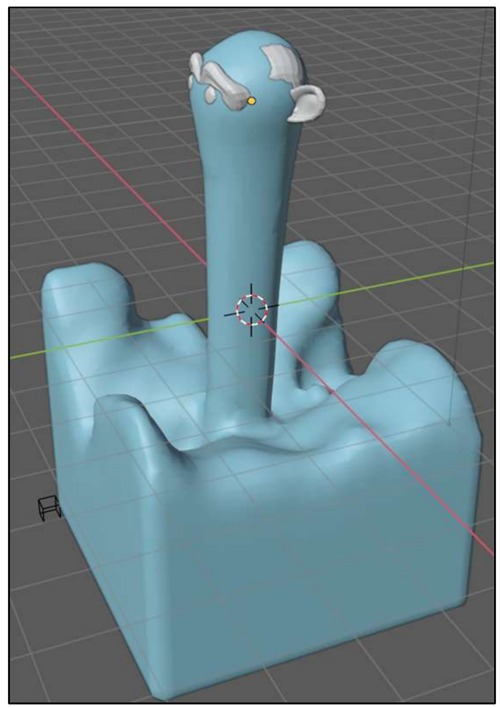


Inflow

Select the **Flow** object (Suzanne in this case), and try changing the flow behavior from **Geometry** to **Inflow**.

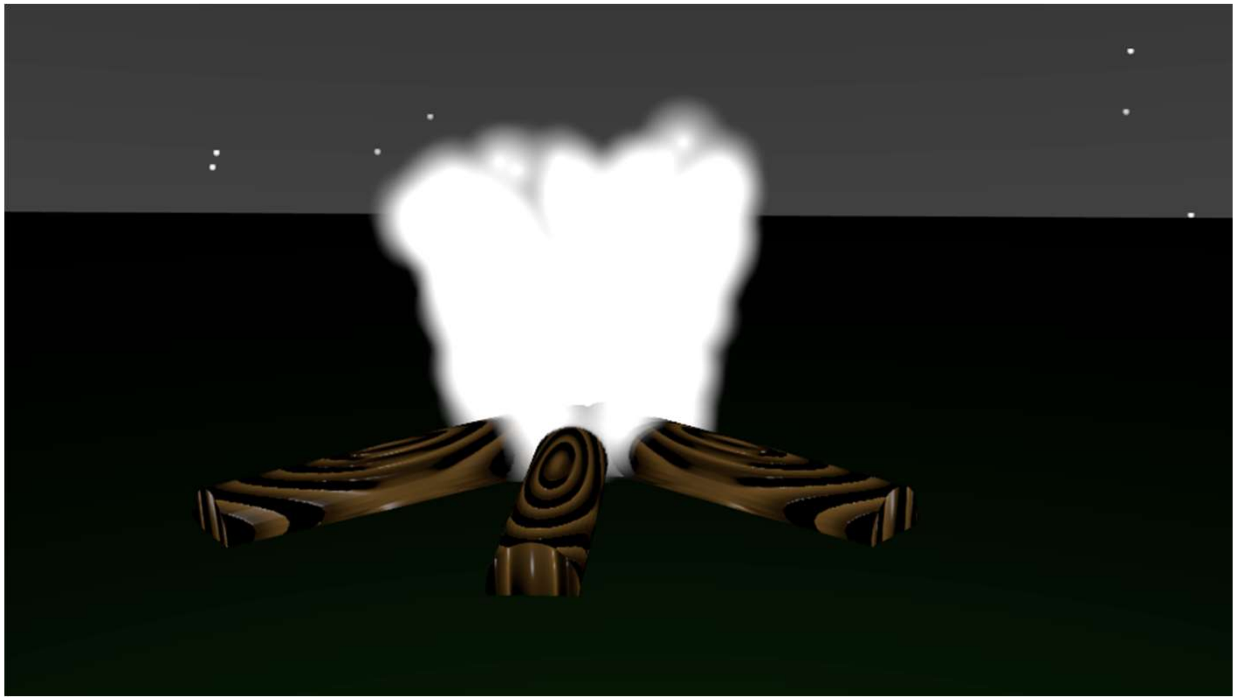


Inflow means that we want the fluid to keep flowing into the domain:

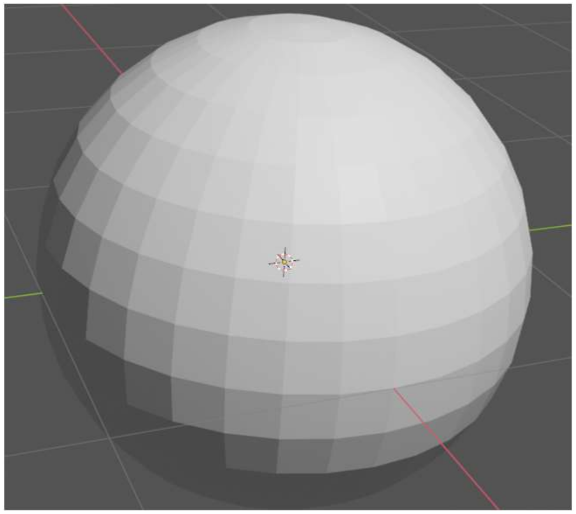


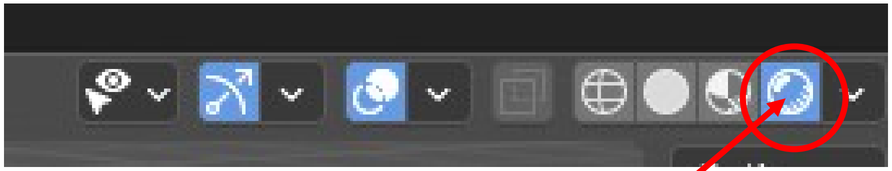
Oregon State
University
Computer Graphics

10. Appearance, II



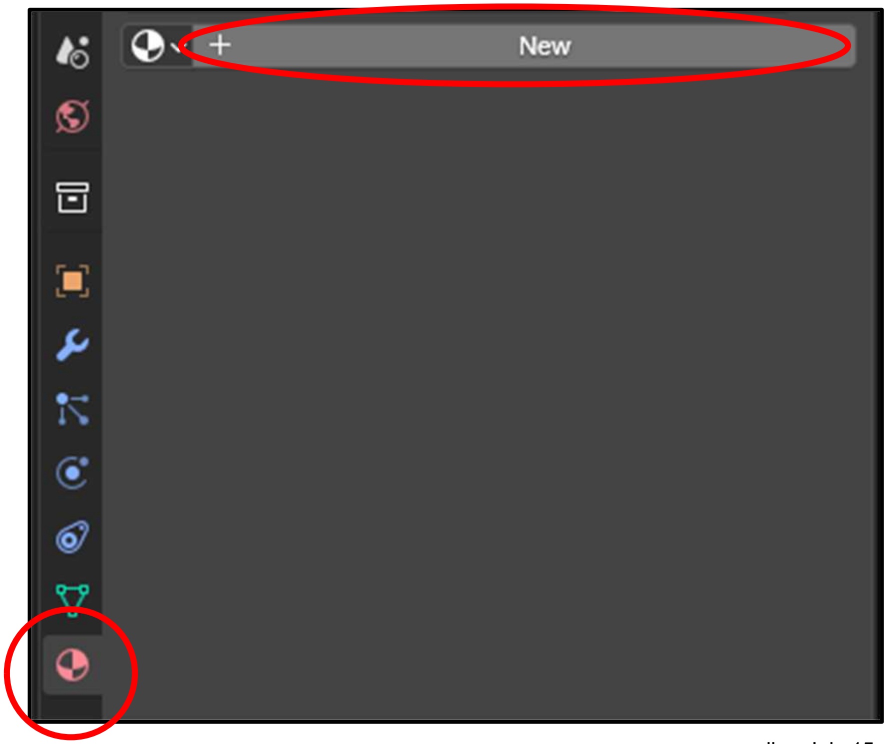
Procedural Texturing





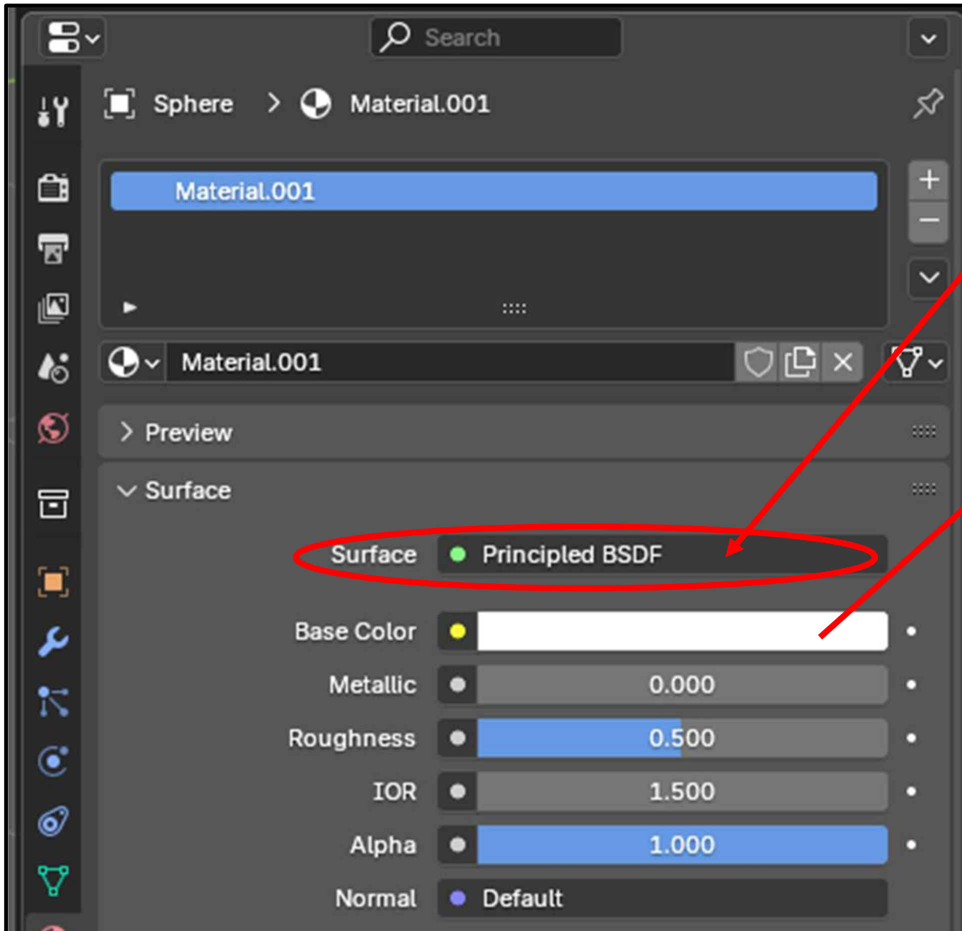
Put the display in **Render Preview** mode

Select an object, click on the **Material Properties** icon, and then click on **New**



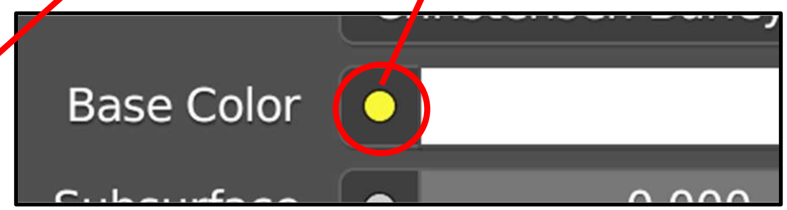
Procedural Texturing

This time we're *not* going to go down to **Viewport Display**.
We are going to use the color settings at the top.



1. Select **Principled BSDF** (probably already selected)

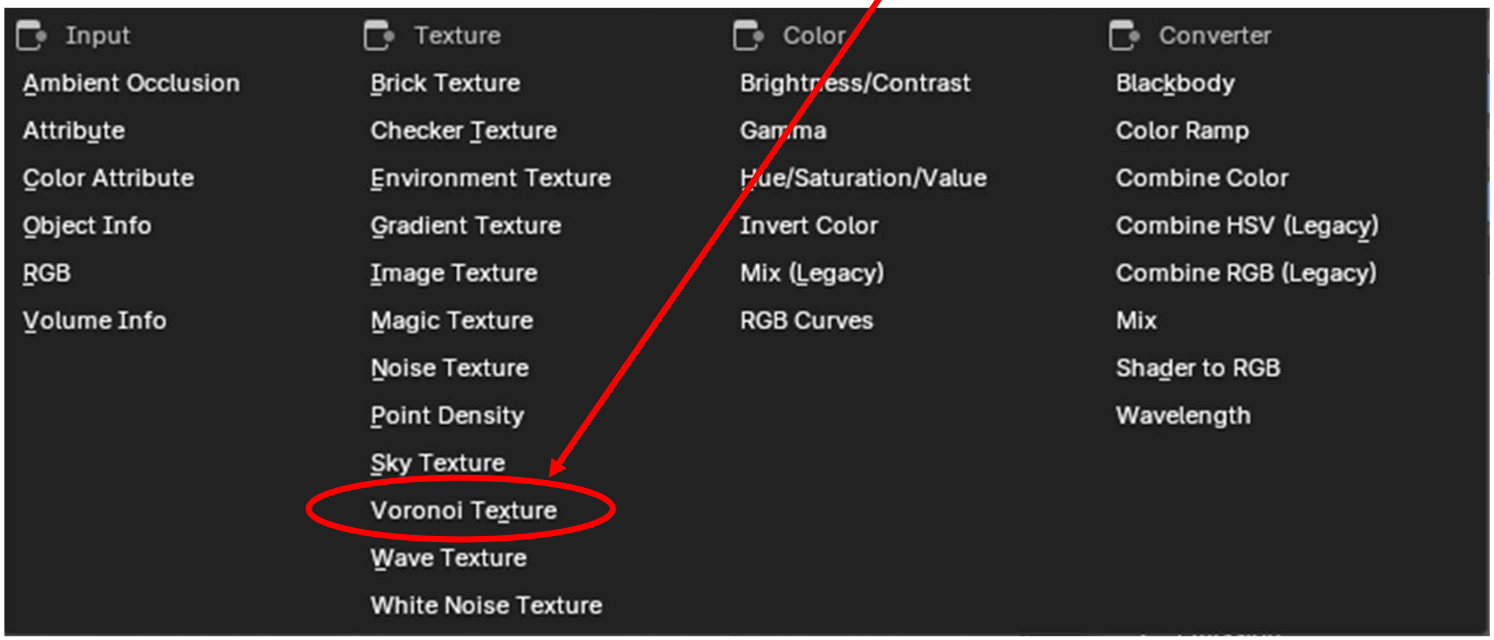
2. Here, where you would normally select a color, click on this little circle instead



3. From that pop-up menu, select **Voronoi Texture** (or one of the others)

Procedural Texturing

3. From that pop-up menu, select **Voronoi Texture** (or one of the others)



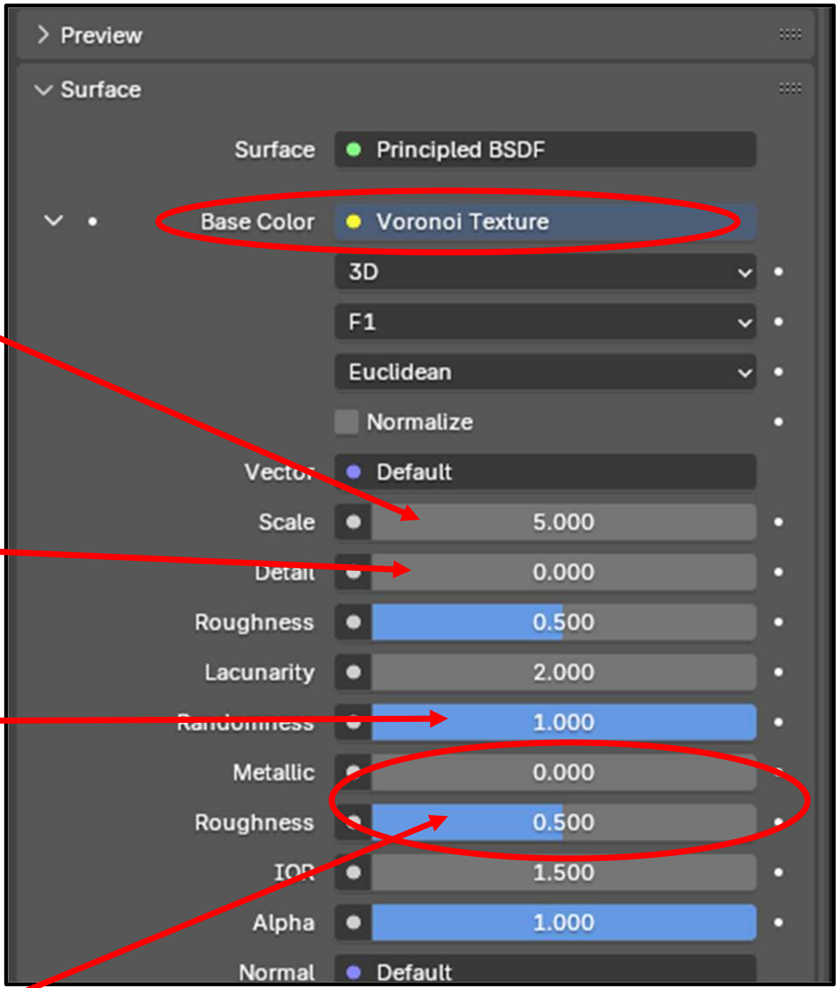
Procedural Texturing

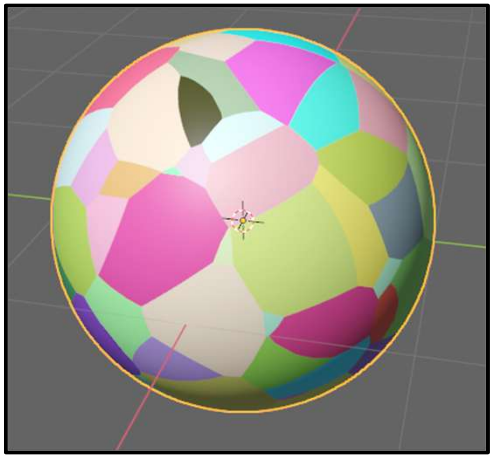
4. Change the **Scale** to change the size of the Voronoi cells

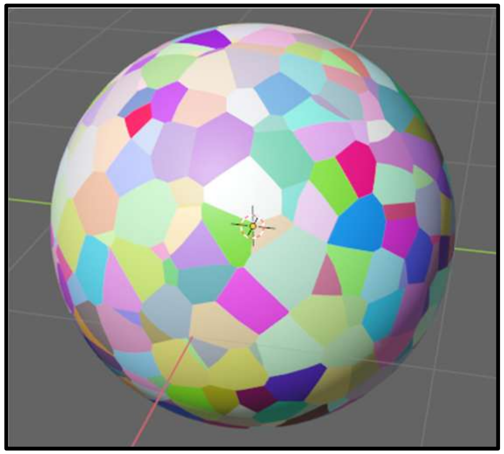
5. Try changing the **Detail**!

6. Try changing the **Randomness**!

7. As before, changing **Metallic** and **Roughness** affects the shininess.



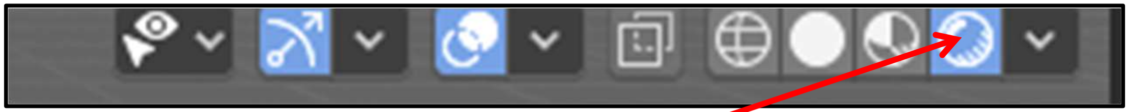




Blender has these Built-in Procedural Textures

Input	Texture	Color	Converter
Ambient Occlusion	Brick Texture	Brightness/Contrast	Blackbody
Attribute	Checker Texture	Gamma	Color Ramp
Color Attribute	Environment Texture	Hue/Saturation/Value	Combine Color
Object Info	Gradient Texture	Invert Color	Combine HSV (Legacy)
RGB	Image Texture	Mix (Legacy)	Combine RGB (Legacy)
Volume Info	Magic Texture	RGB Curves	Mix
	Noise Texture		Shader to RGB
	Point Density		Wavelength
	Sky Texture		
	Voronoi Texture		
	Wave Texture		
	White Noise Texture		

Image Texturing



Start with a **UV Sphere** being shown in **Render Preview** mode

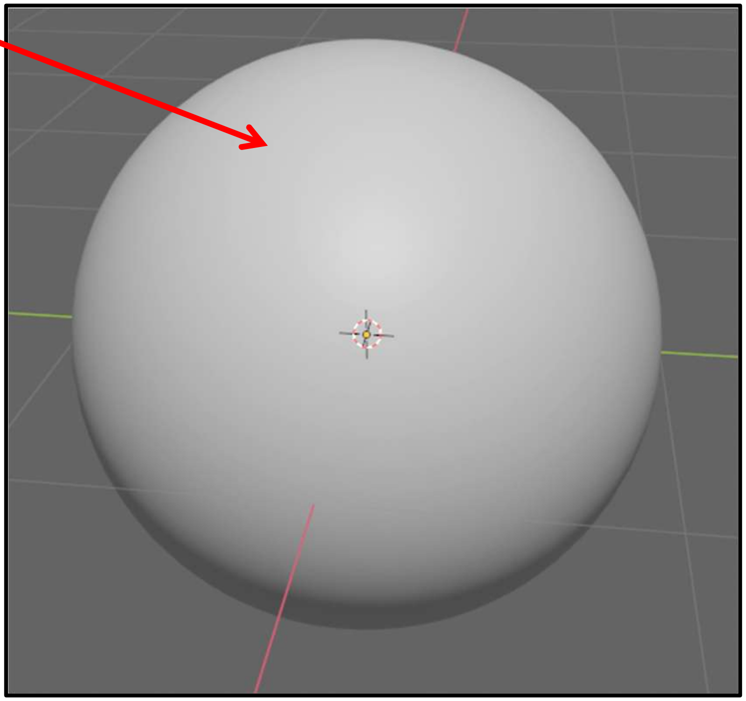
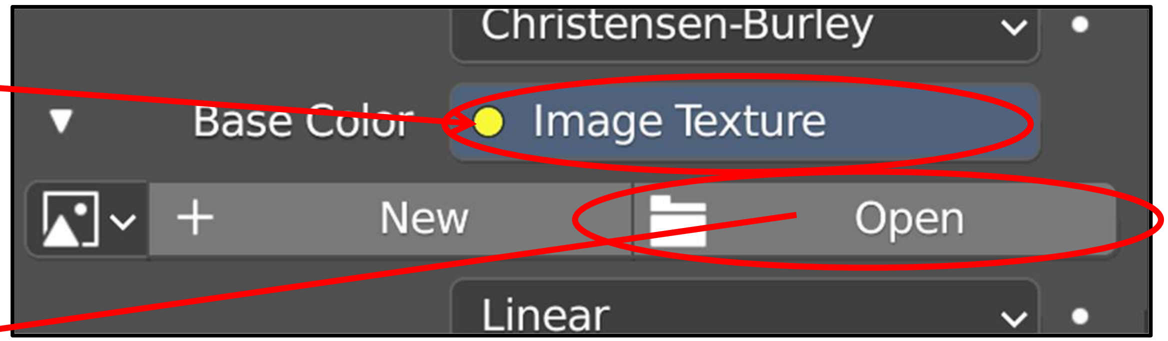


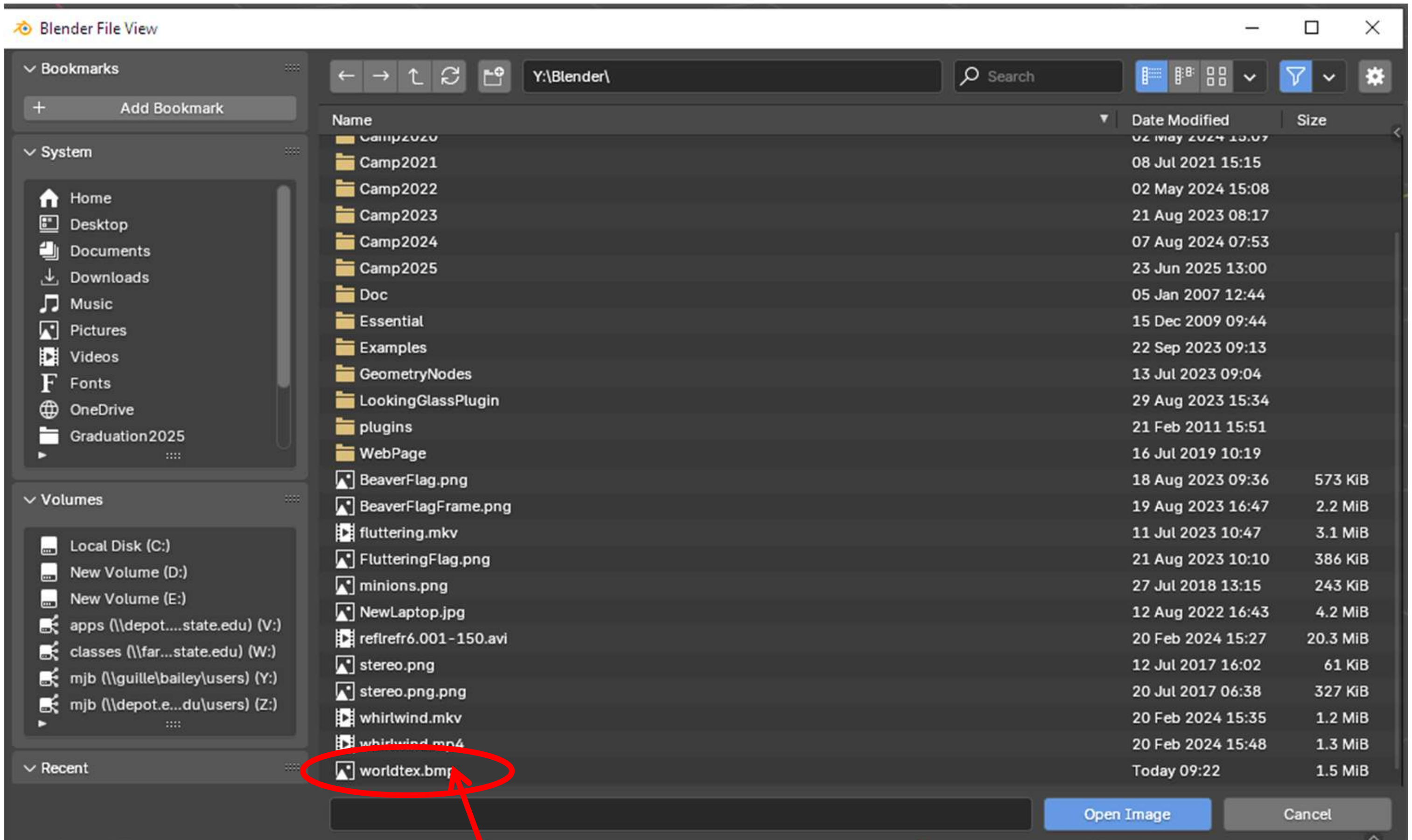
Image Texturing

Says that you want to read
a texture image from a file



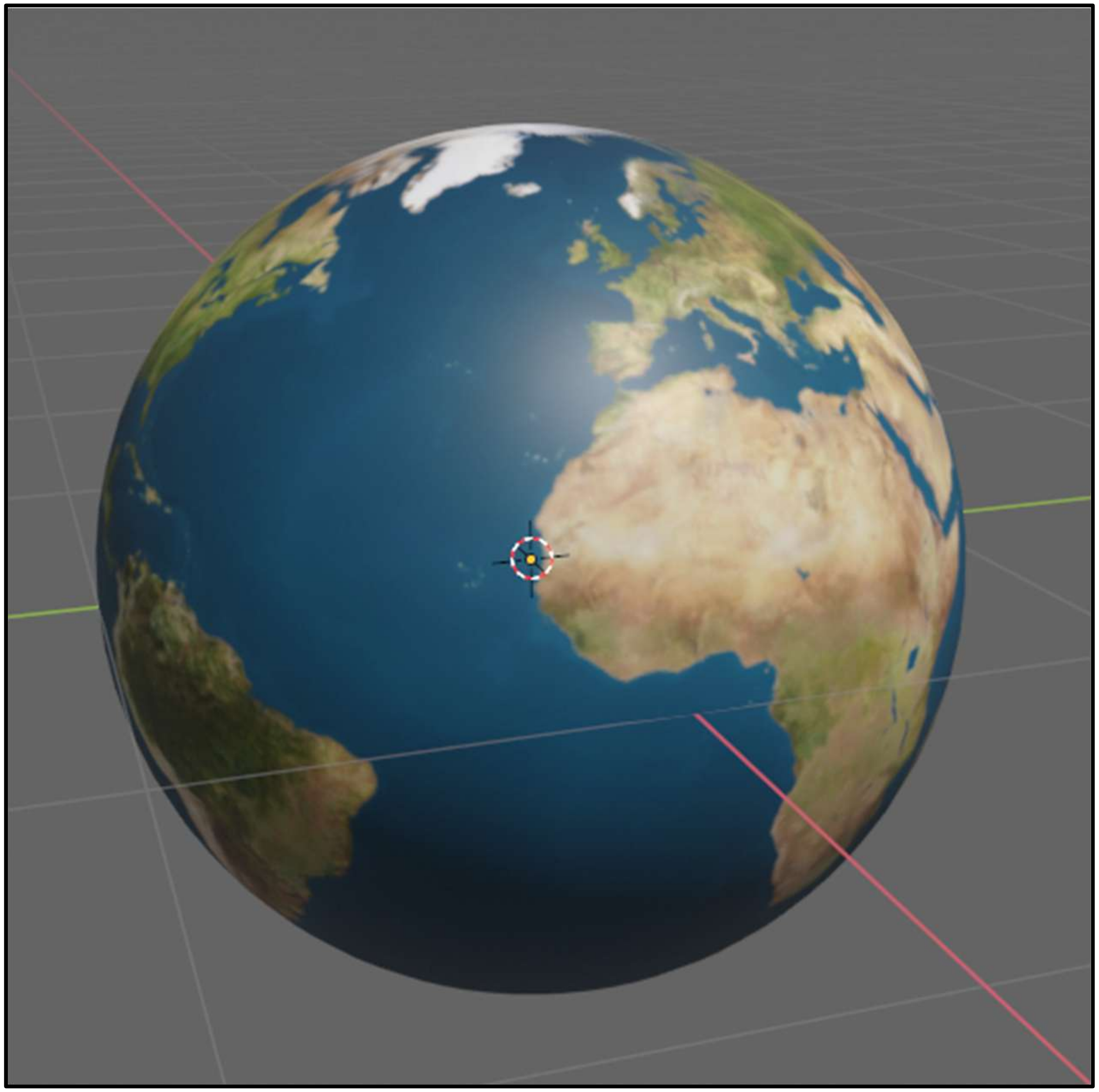
Click here to open an image file

Image Texturing



worldtex.bmp is a good texture to try!

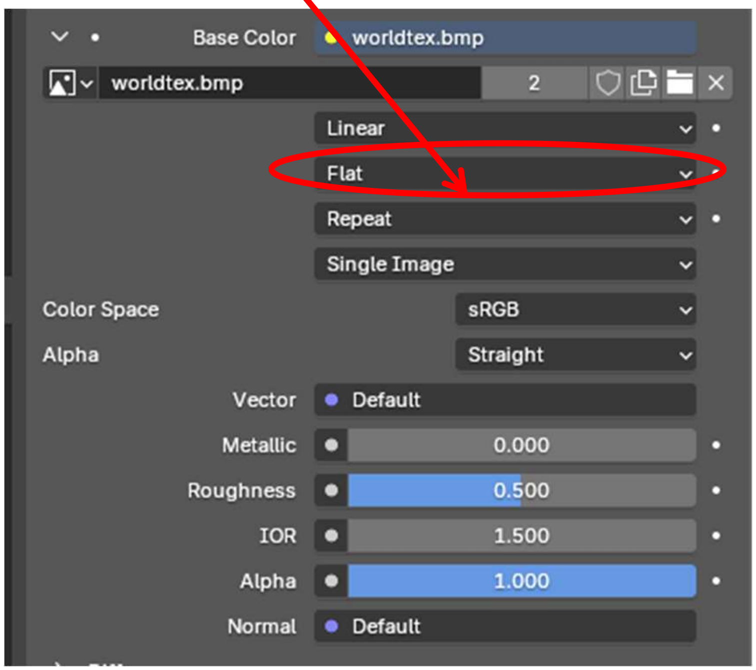
Image Texturing



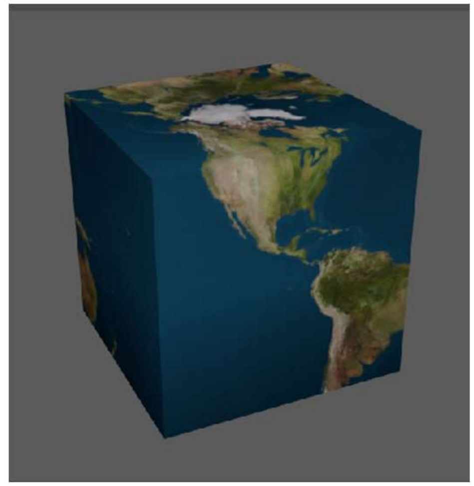
worldtex.bmp is a good texture to try!

Image Texturing

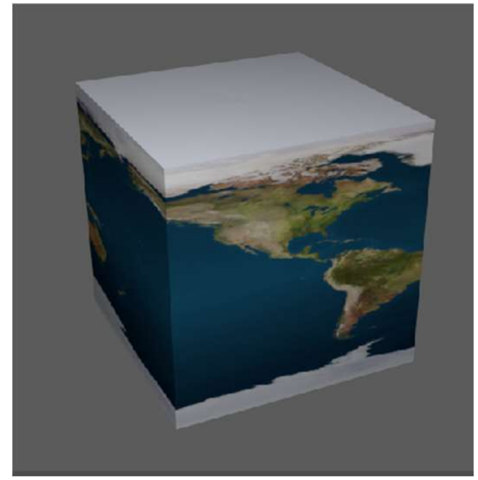
You can change the **Flat** parameter to one of the others depending on what your object is most like

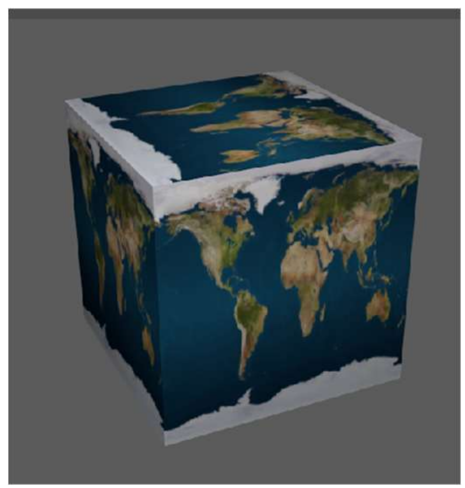


Sphere

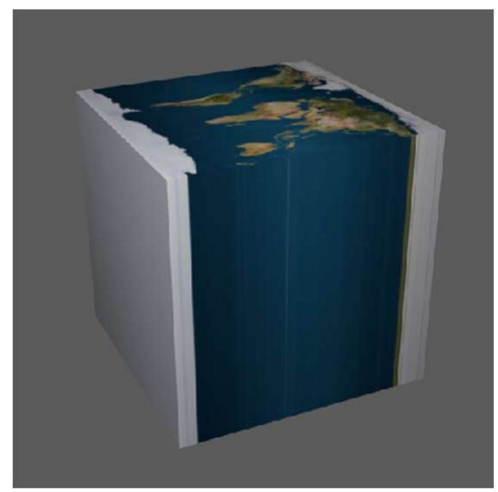


Tube





Box



Flat

Places to Find Good Texture Images

https://www.shutterstock.com/search/texture

https://ambientcg.com/list?sort=Popular

https://www.freepik.com/photos/texture

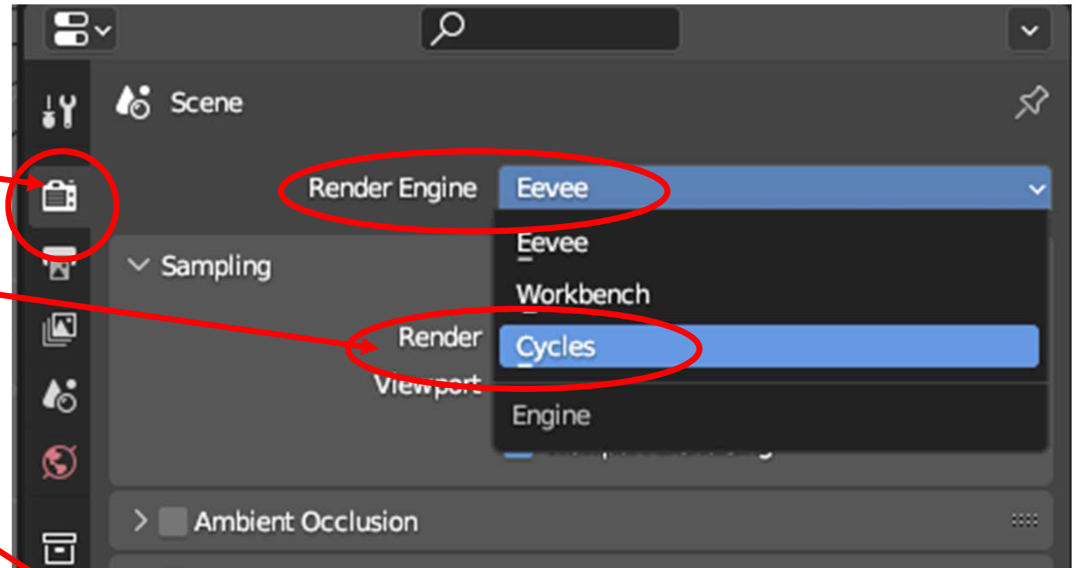
Links checked: June 26, 2025

Your own photos should work well too!

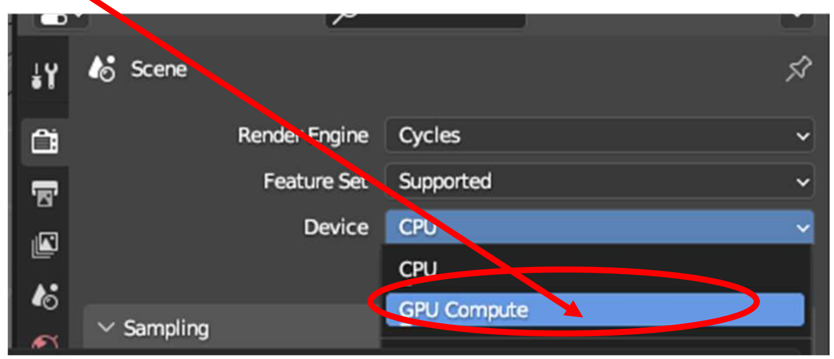
Turning on the Cycles Renderer

We have been using the **Eevee** renderer and have gotten some very nice results. But we can do even better with the **Cycles** renderer.

In the **Rendering Properties** menu, select **Cycles** instead of **Eevee**.

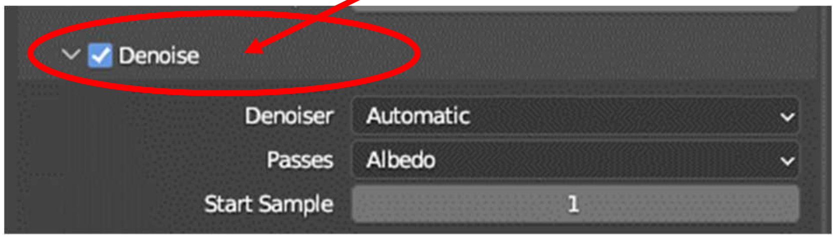


And then select **GPU Compute** instead of **CPU** (it's faster!).



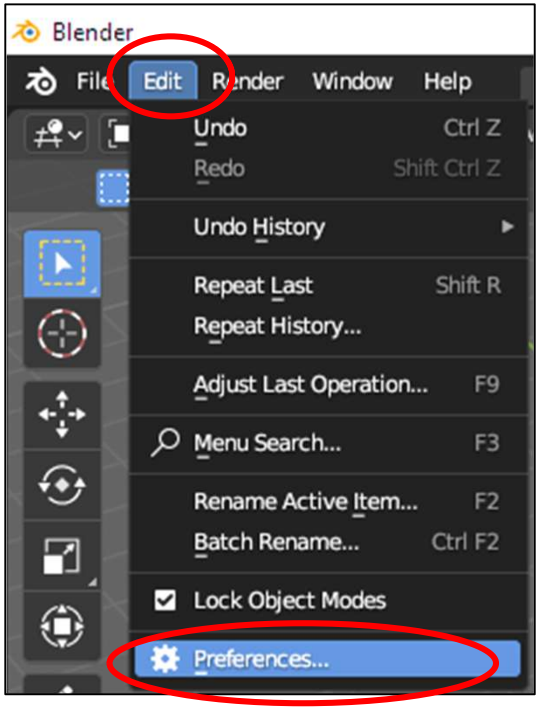
Turning on the Cycles Renderer

Then, right below that, turn on **Denoise** if it's not turned on already

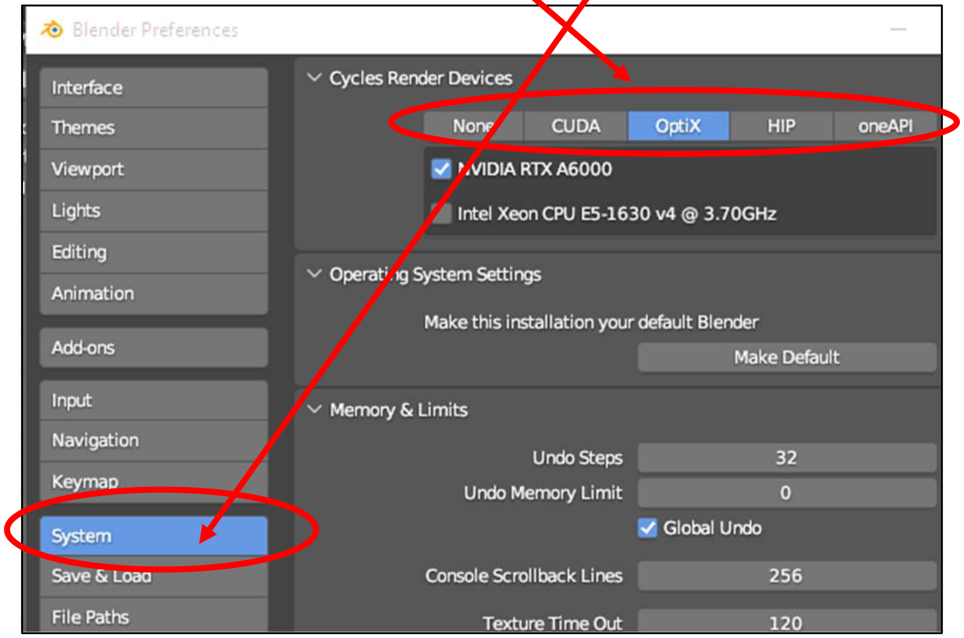


Selecting the GPU Options

Select **Edit→Preferences**



In the **Preferences** menu, select **System**. These are your GPU options. All might work on your system, or none might work on your system. Depends on what graphics hardware you have.



Try them all to see which you have and which give the fastest Cycles render. On my system, **OptiX** is fastest, followed by CUDA. On my system, HIP and oneAPI aren't available.

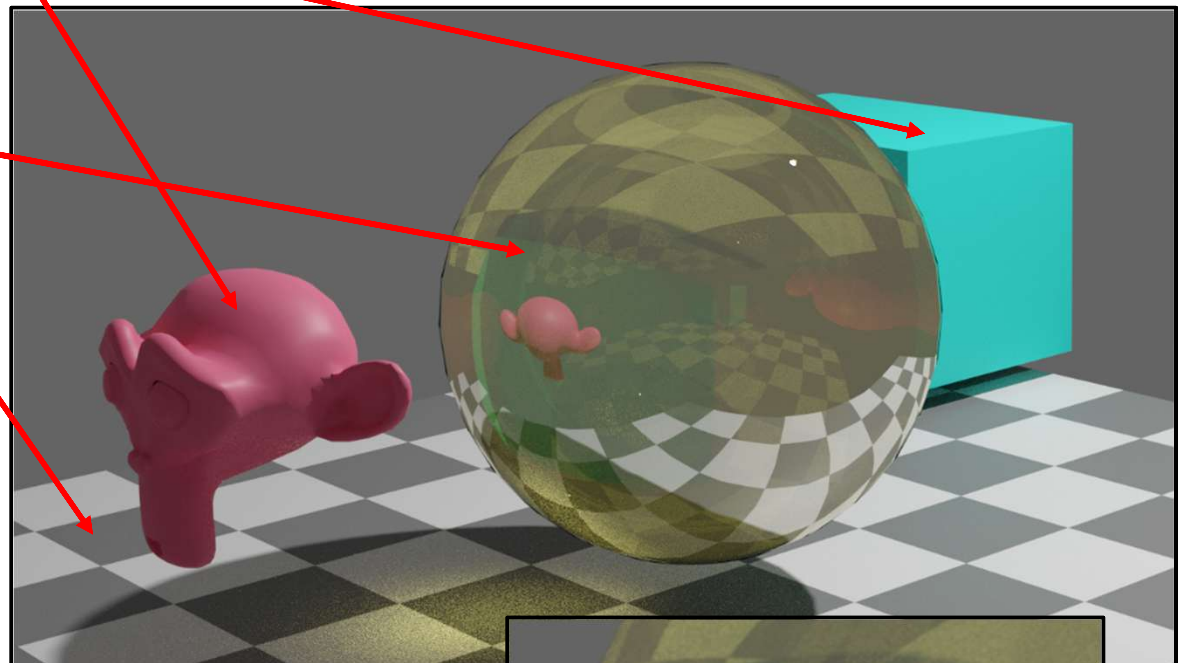
Back to Cycles: Let's Say That We Want to Render This Scene

Cube and Monkey are opaque

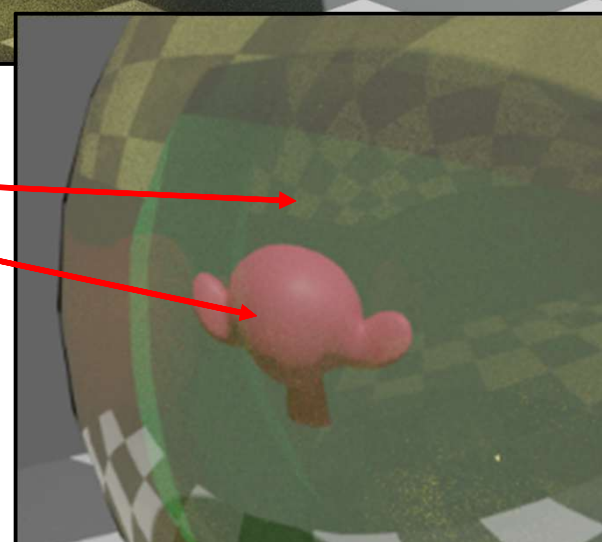
Sphere is both reflective and refractive

Plane has a checkerboard texture on it

Scene has lighting and shadows



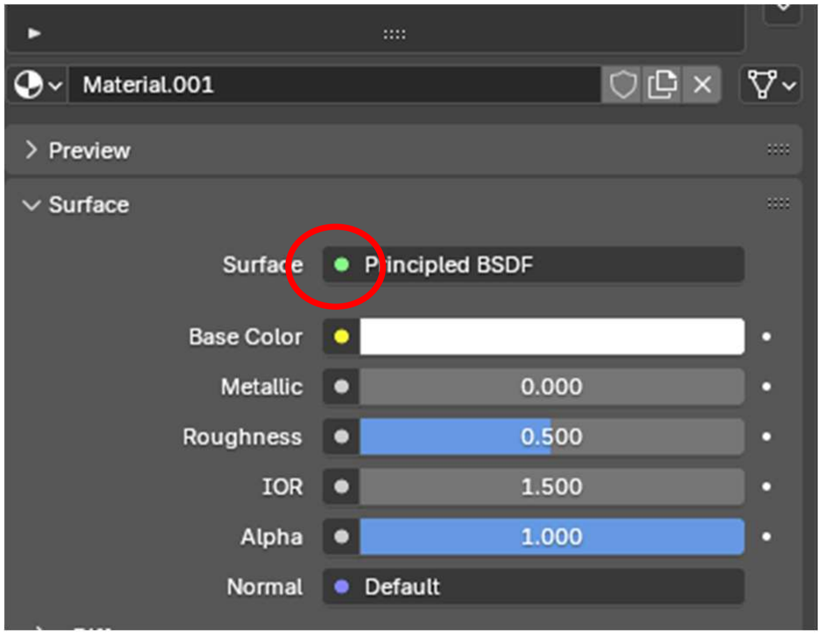
Sphere is both reflective and refractive

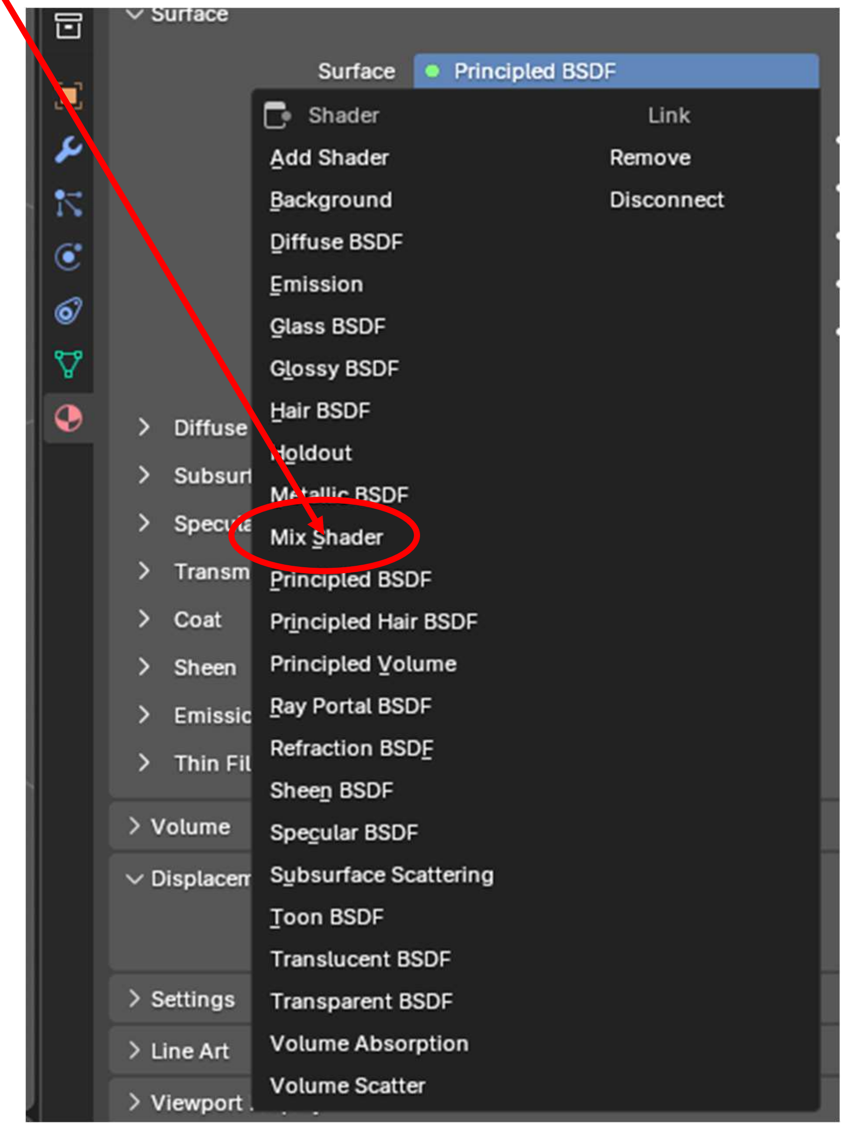


reflrefr.blend

Making the Sphere Reflective and Refractive

Click on this small green circle. Instead of making the surface shader Principled BSDF select **Mix Shader**:





Making the Sphere Reflective and Refractive

Combine refraction and reflection effects together with the **Mix Shader**

How much to mix each shader

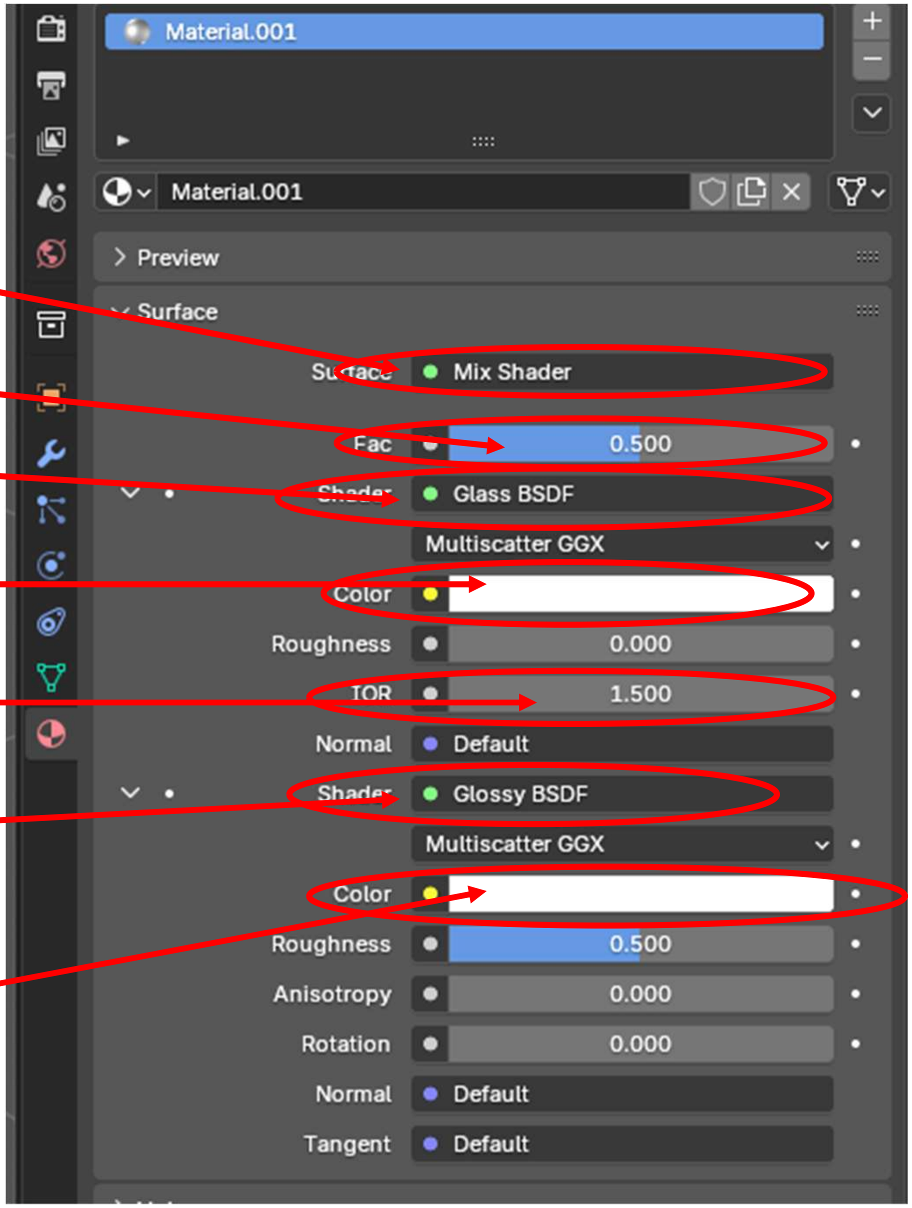
The first shader is **Glass BSDF** to get the refraction

Transmission color

Index of Refraction

The second shader is **Glossy BSDF** to get the reflection

Reflection color

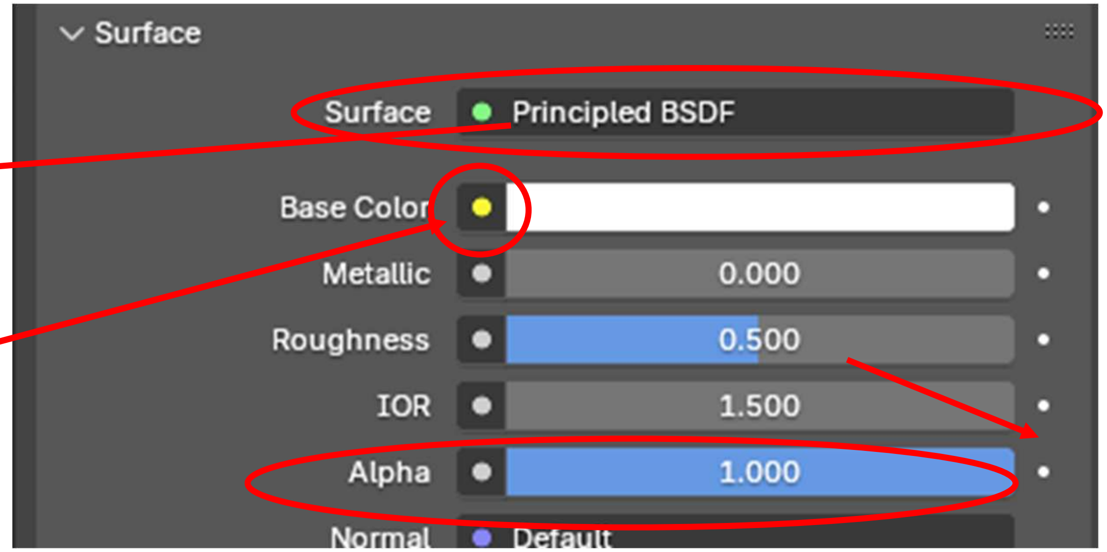


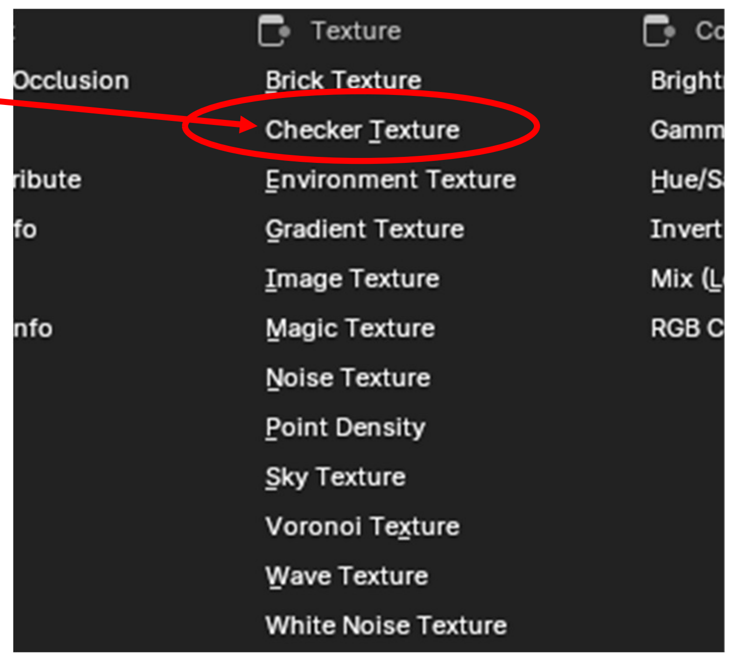
Putting a Checkboard Pattern on the Plane

1. Select **Principled BSDF** (probably already selected)

2. Here, where you would normally select a color, click on this little yellow circle

3. From that pop-up menu, select **Checker Texture** (or one of the others)

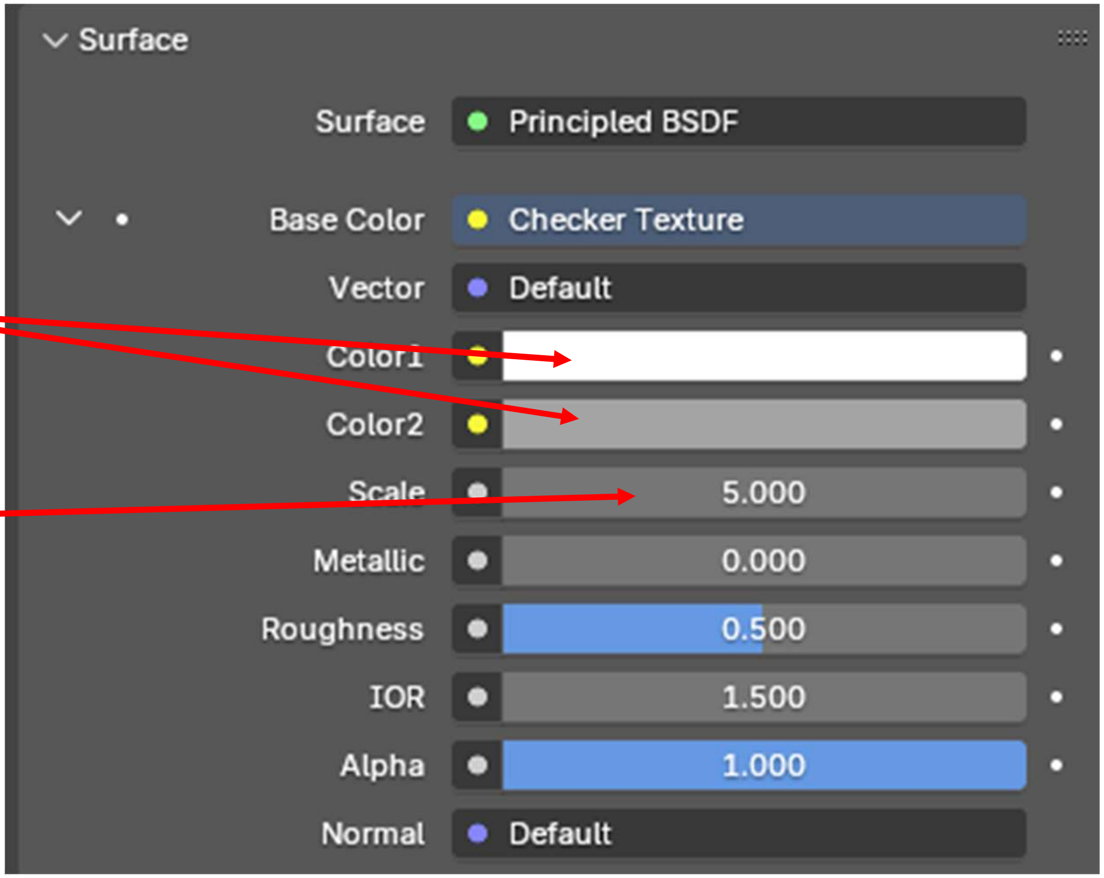




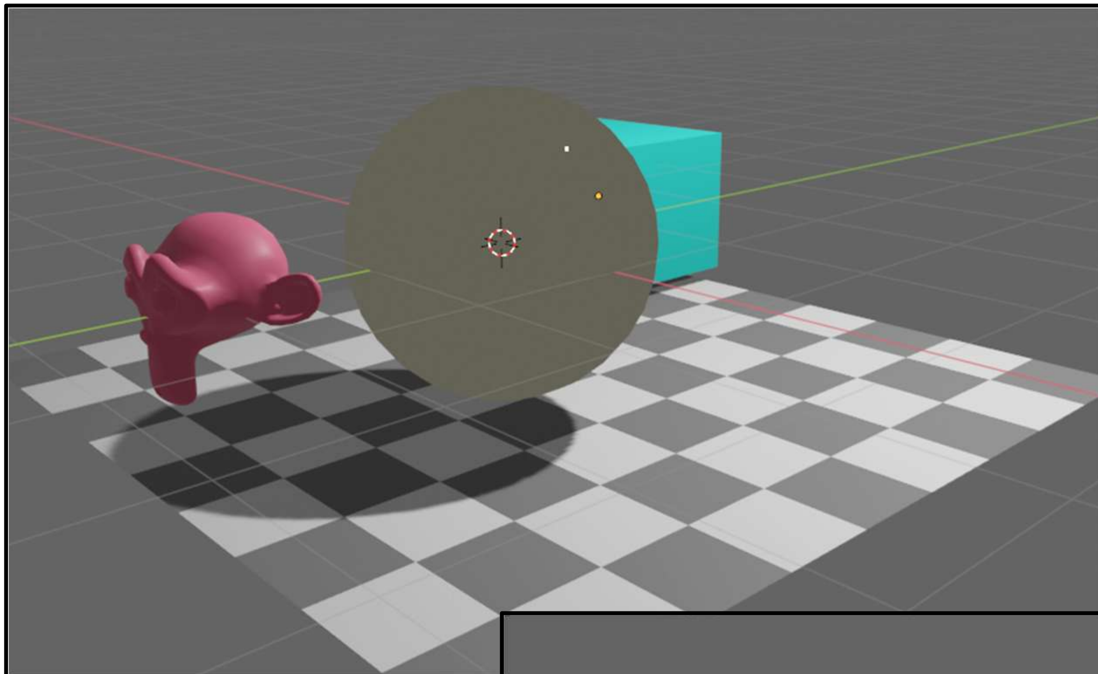
Putting a Checkerboard Pattern on the Plane

5. Here you can select the two colors making up the checkerboard

6. Change the **Scale** to change the size of the checkerboard squares

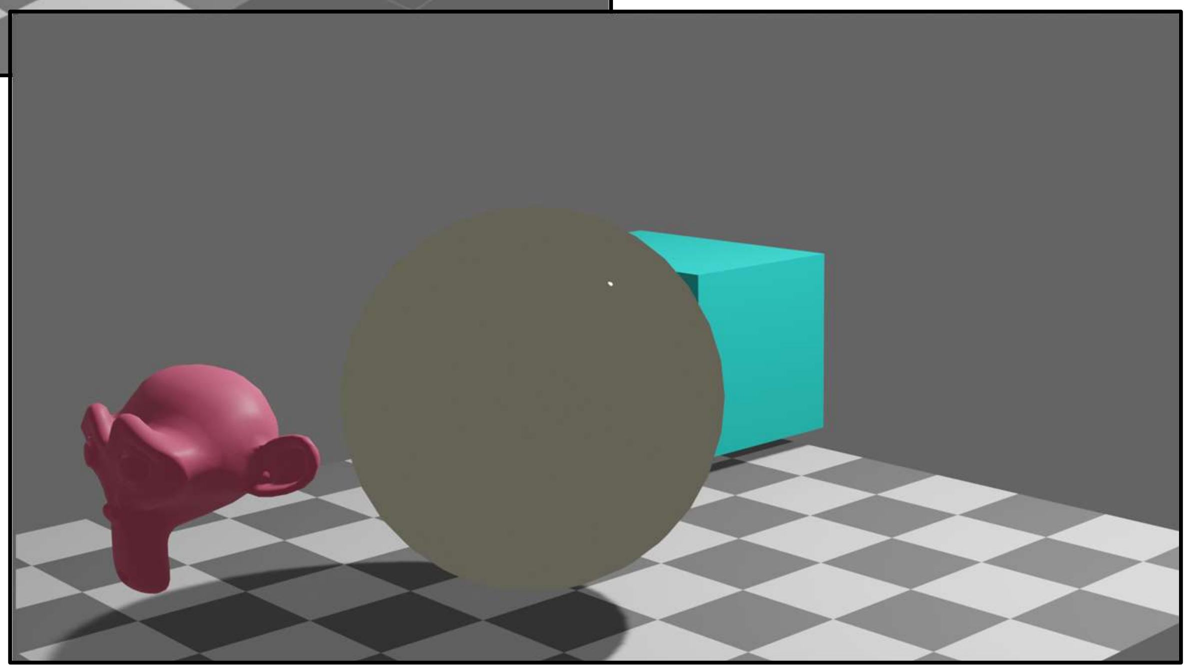


Onscreen and Rendered Results with *Eevee*



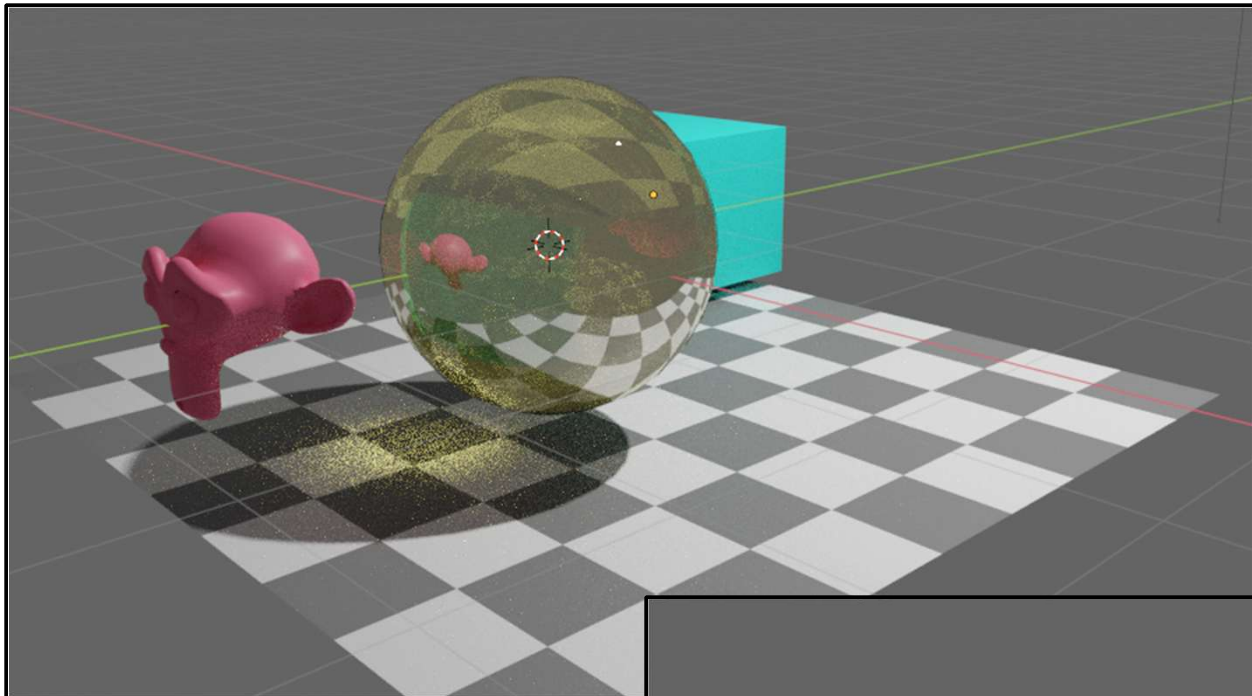
On-screen

Rendered

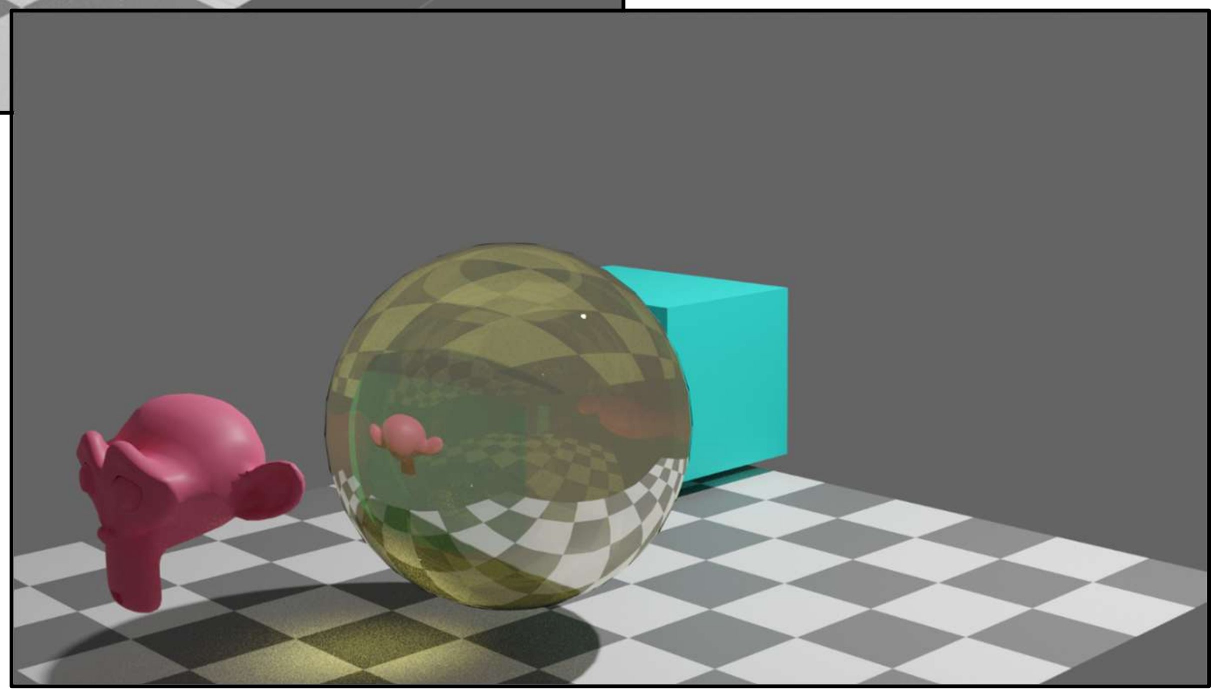


Onscreen and Rendered Results with ***Cycles***

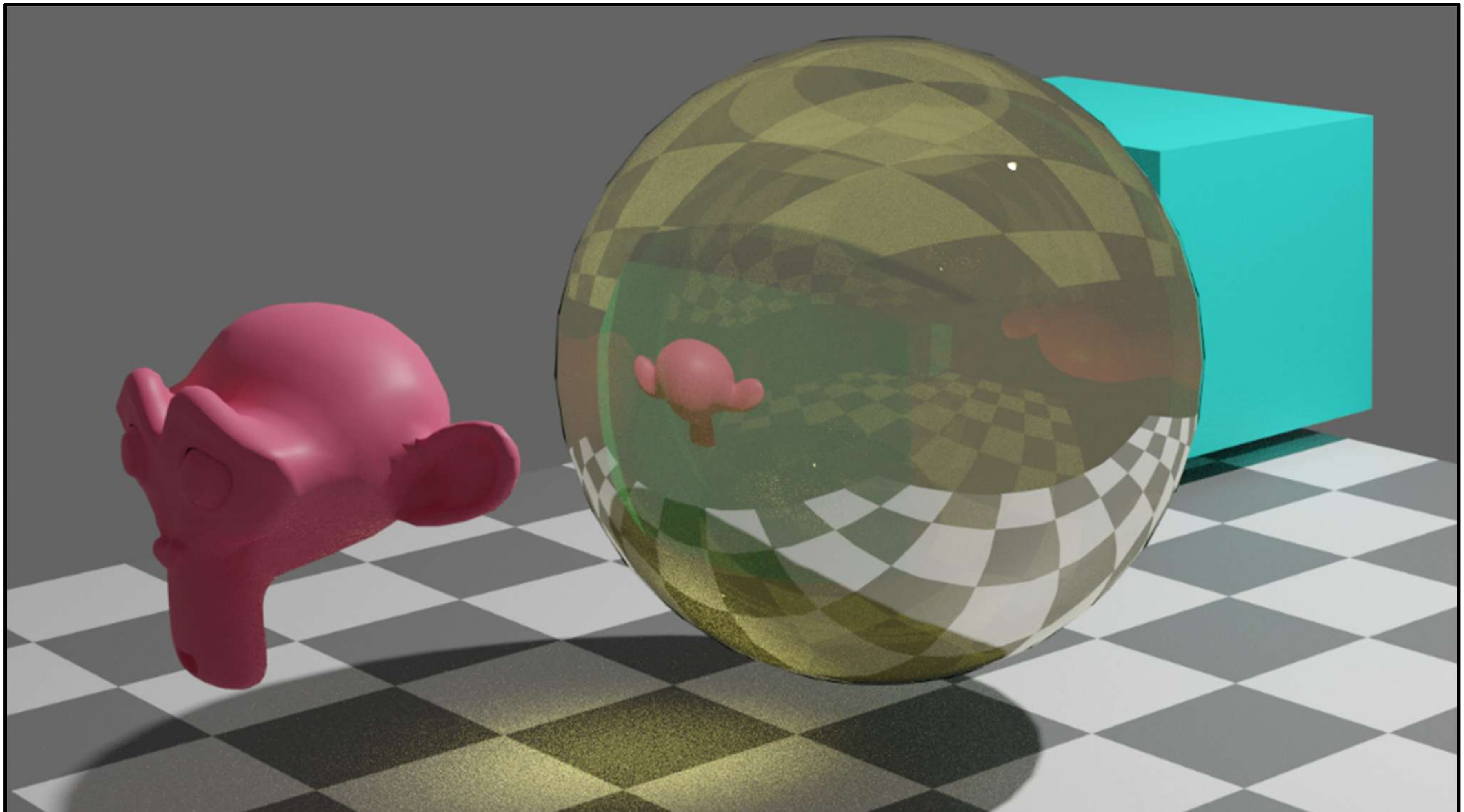
On-screen



Rendered

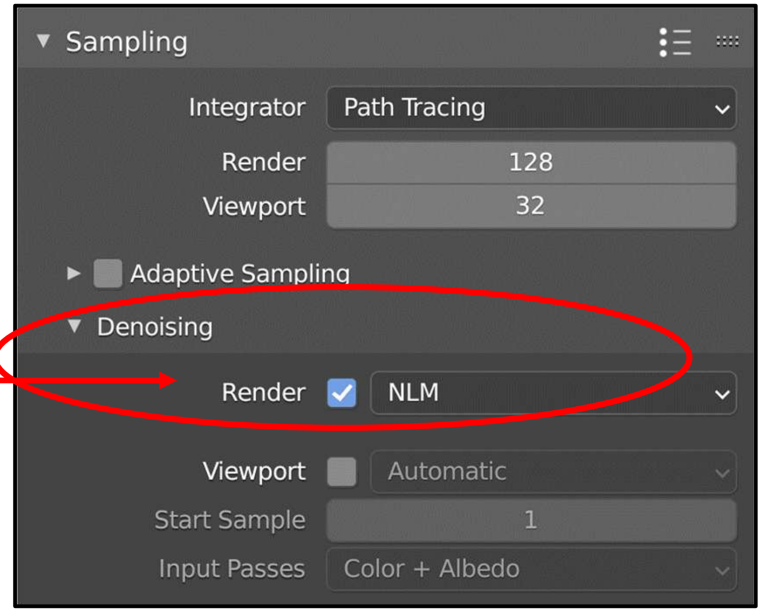


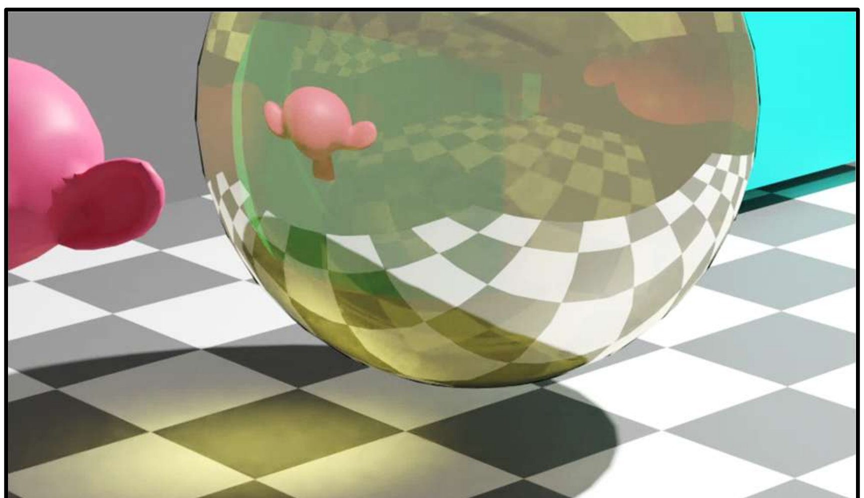
Rendered Results with Cycles



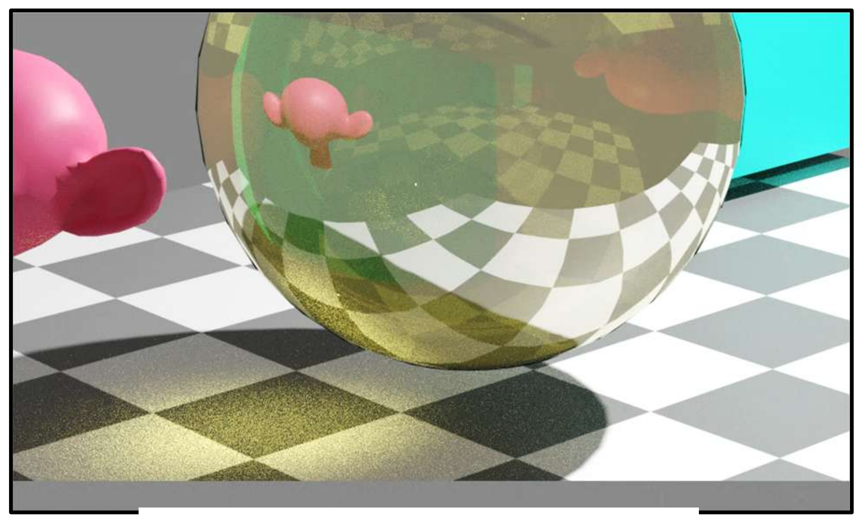
Rendered Results with Cycles

You may have noticed some “sparkling” in the rendered image on the previous slide. That is a natural artifact of the path-tracing algorithm that Cycles uses. In computer graphics, this is called “render noise”. Blender has a denoising feature. All you have to do is turn it on in the **Denoising** tab of the **Render Properties** menu.



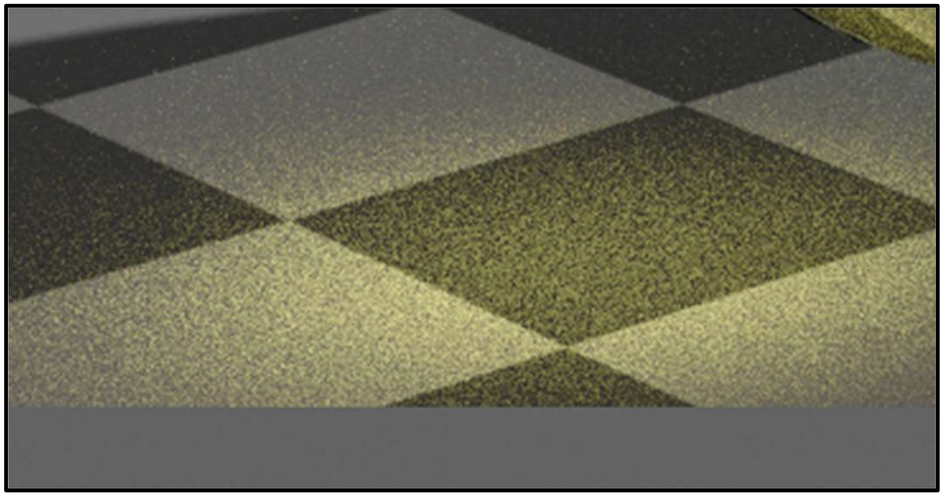


No Denoising
1 minute, 39 seconds

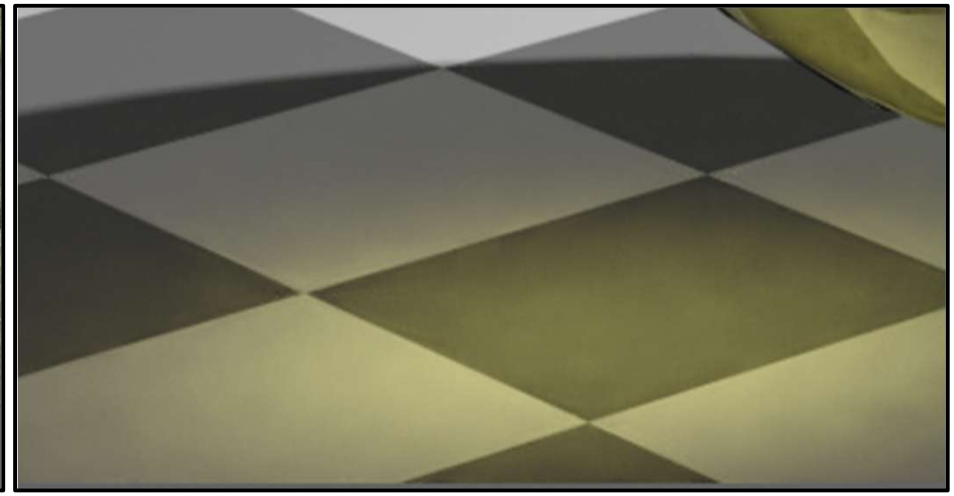


Denoising
2 minutes, 14 seconds

Rendered Results with Cycles

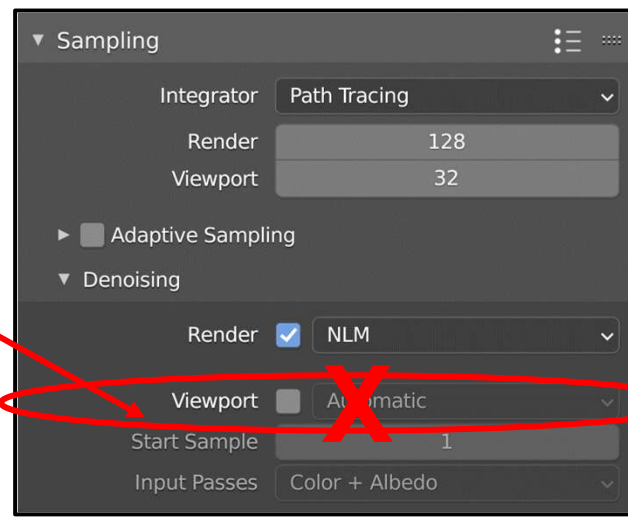


No Denoising
1 minute, 39 seconds



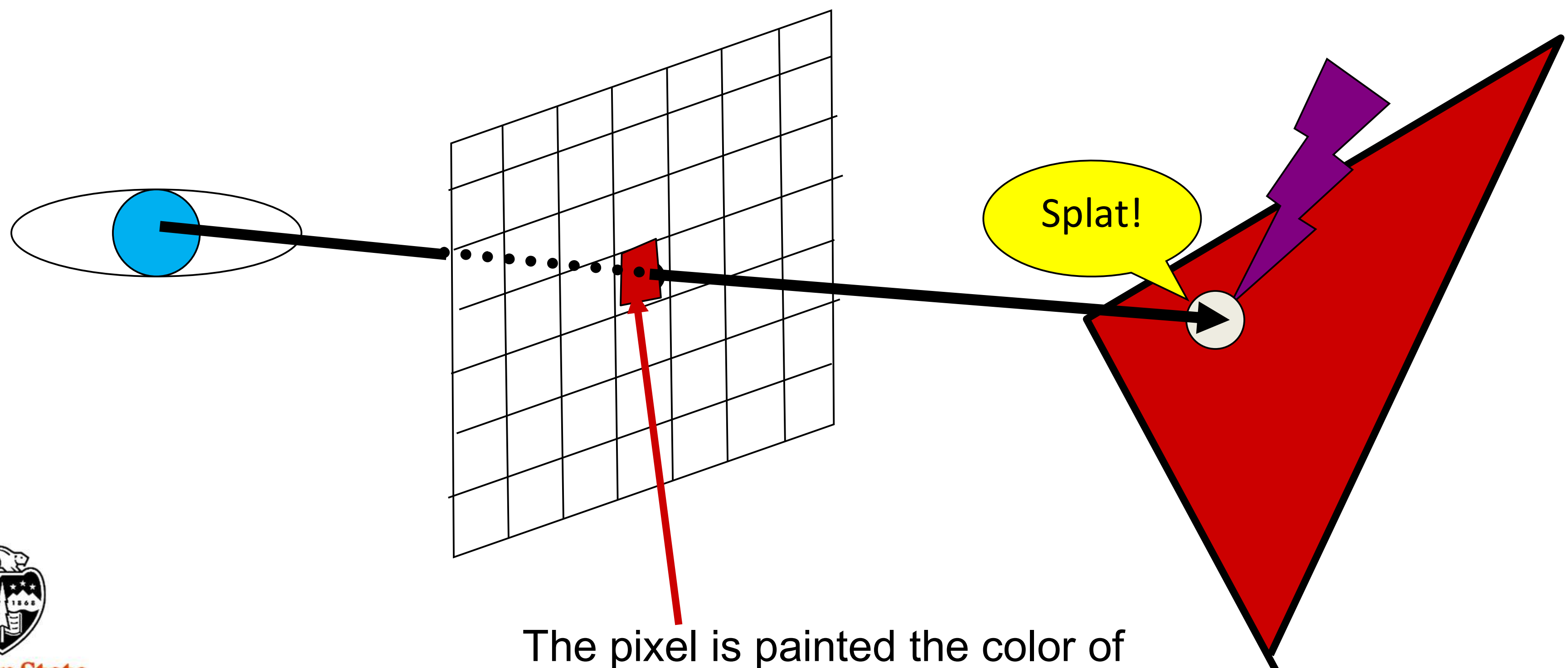
Denoising
2 minute, 14 seconds

BTW, I ***don't*** recommend you turn Denoising on for the Viewport display. It really slows down your interaction when using Cycles.



What is Ray-Tracing?

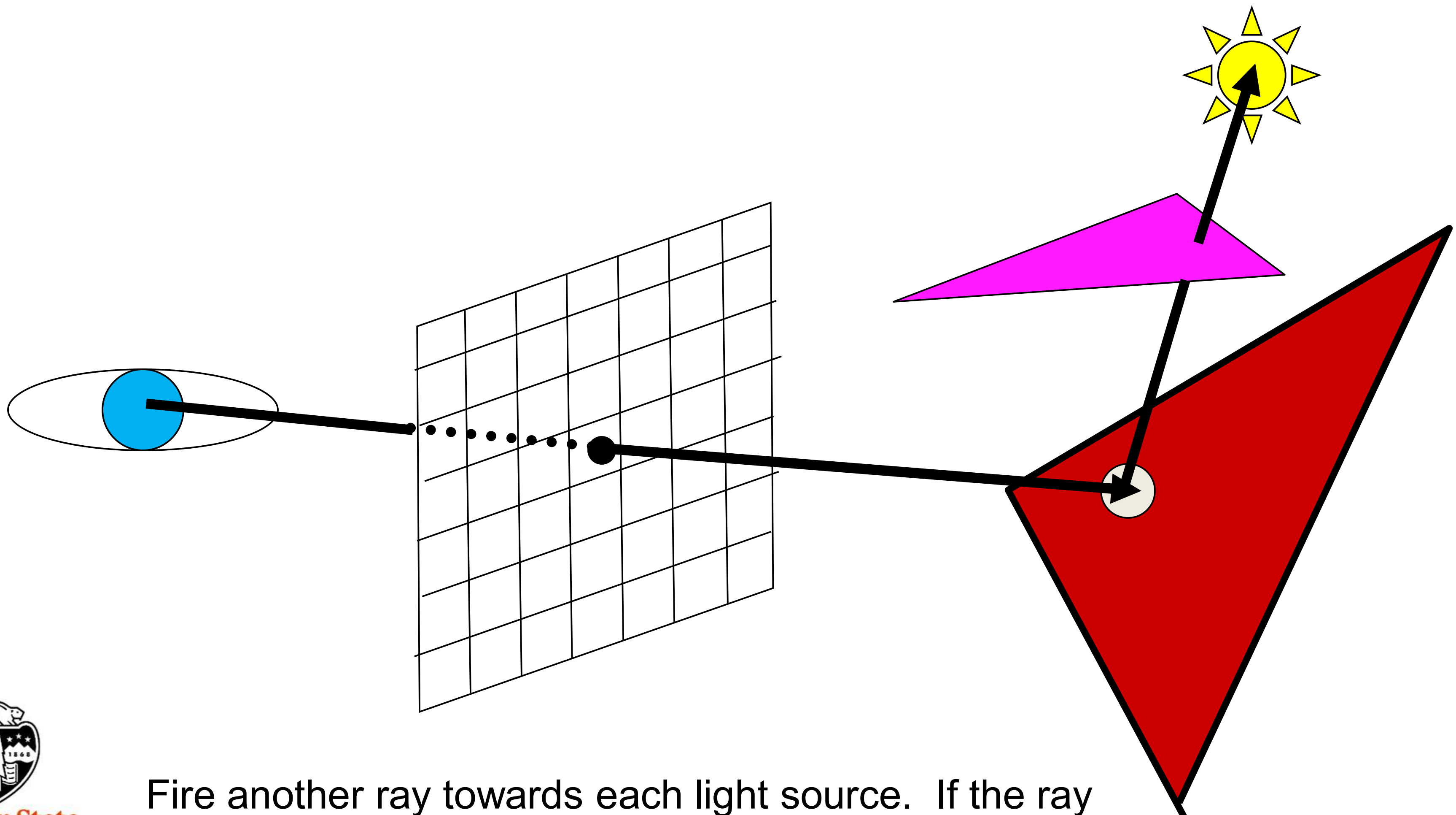
It starts at the eye:



The pixel is painted the color of
the nearest object that is hit.

What is Ray-Tracing?

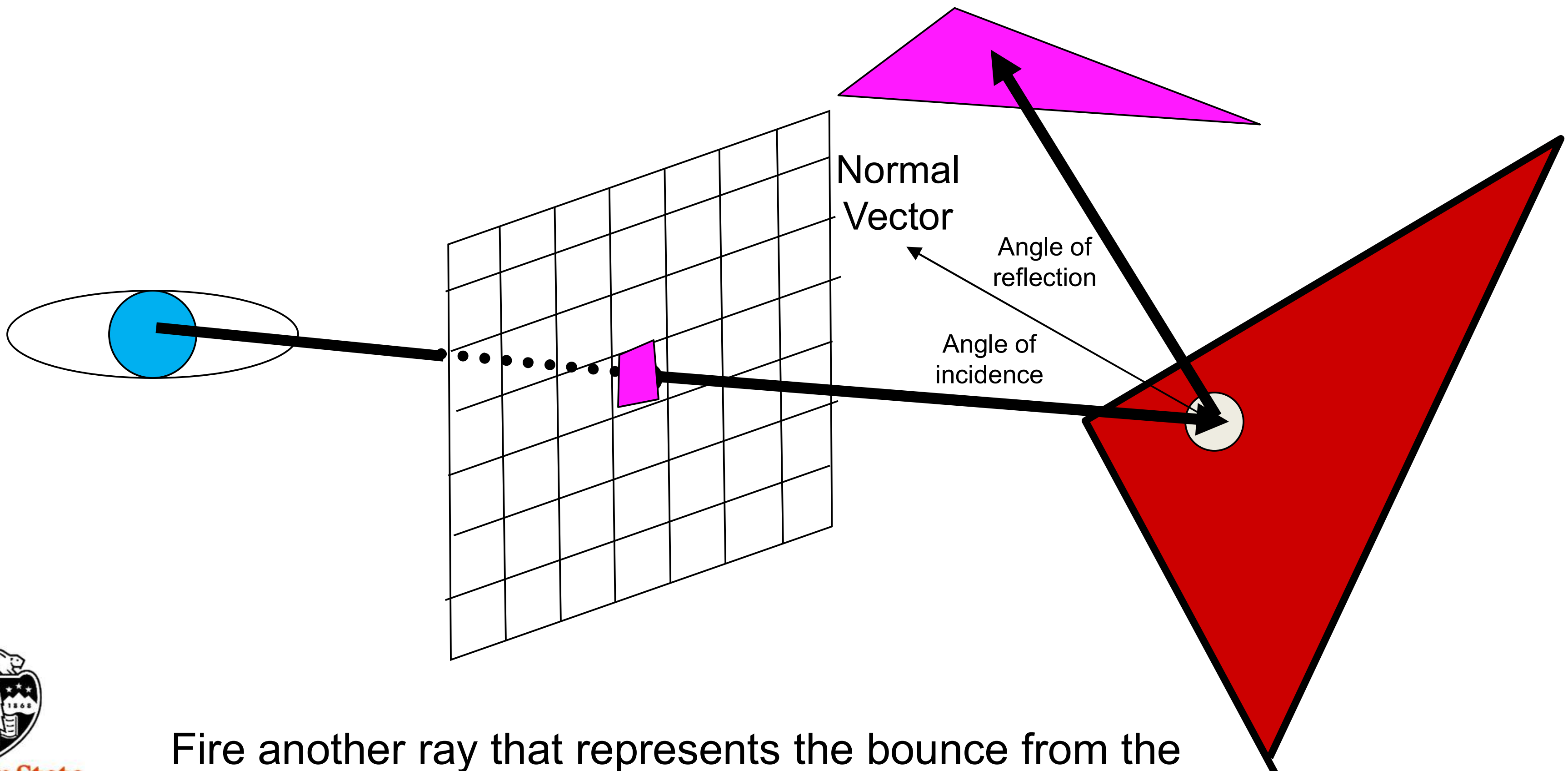
It's also straightforward to see if this point lies in a shadow:



Fire another ray towards each light source. If the ray hits *anything*, then the point does not receive that light.

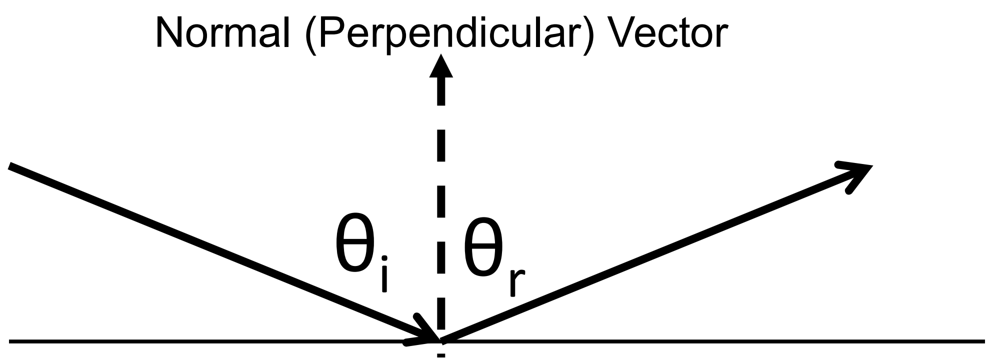
What is Ray-Tracing?

It's also straightforward to handle reflection



Fire another ray that represents the bounce from the reflection. Paint the pixel the color that this ray sees.

The Physics of Reflection



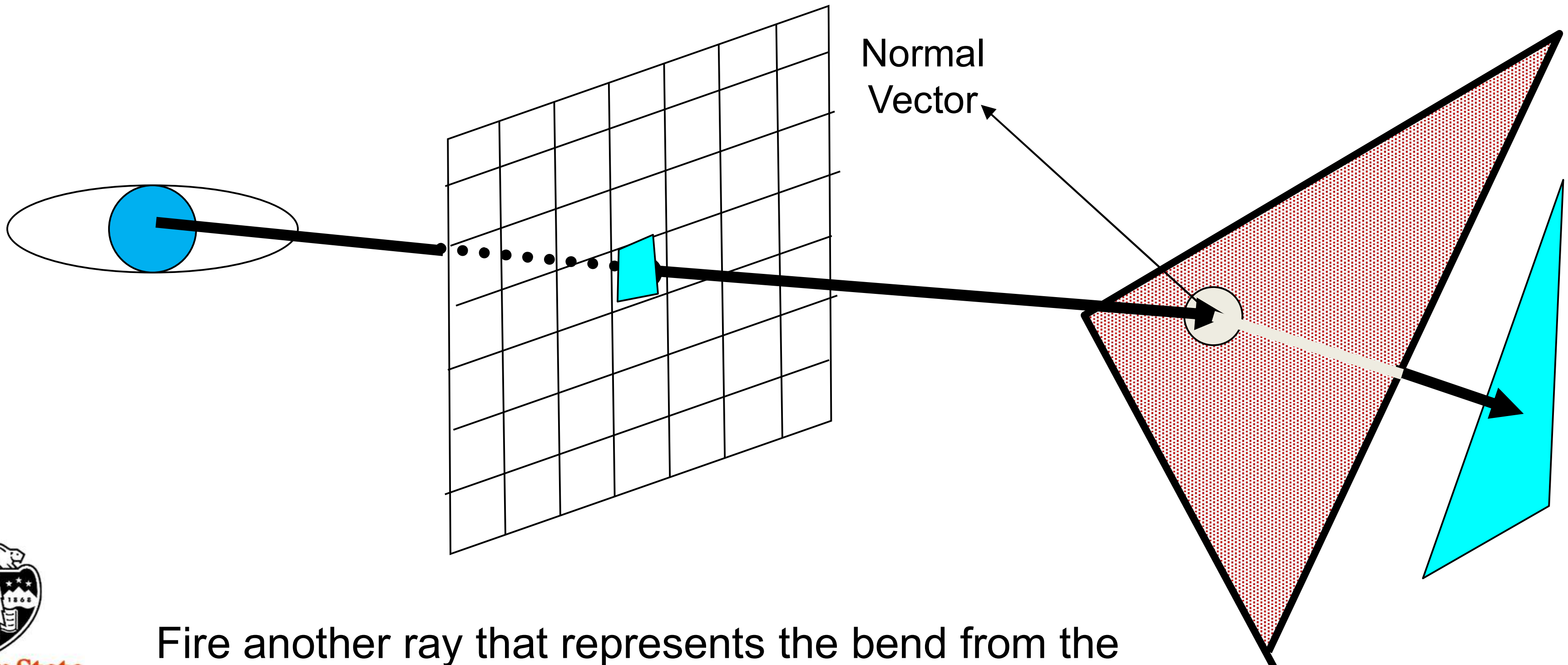
Law of Reflection:

$$\Theta_r = \Theta_i$$

Angle of reflection = Angle of incidence

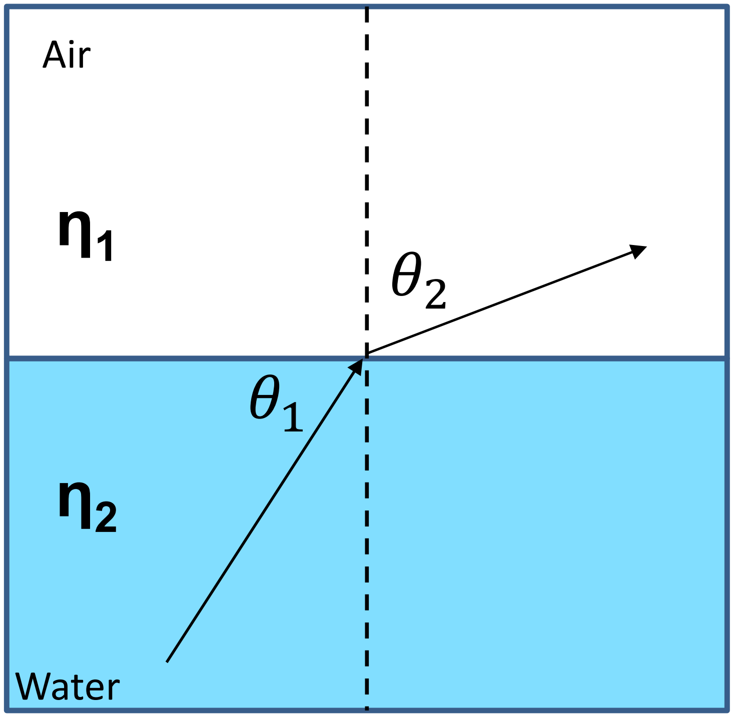
What is Ray-Tracing?

It's also straightforward to handle refraction



Fire another ray that represents the bend from the refraction. Paint the pixel the color that this ray sees.

The Index of Refraction, *η*



The Index of Refraction (IOR) is a measure of how much light slows down as it passes through a particular material.
The larger the IOR, the slower the speed of light in that material.
The larger the change in IOR, the more the light will bend as it passes from one material to another.

Snell's Law of Refraction says that:

$$\frac{sin\theta_2}{sin\theta_1} = \frac{\eta_1}{\eta_2}$$

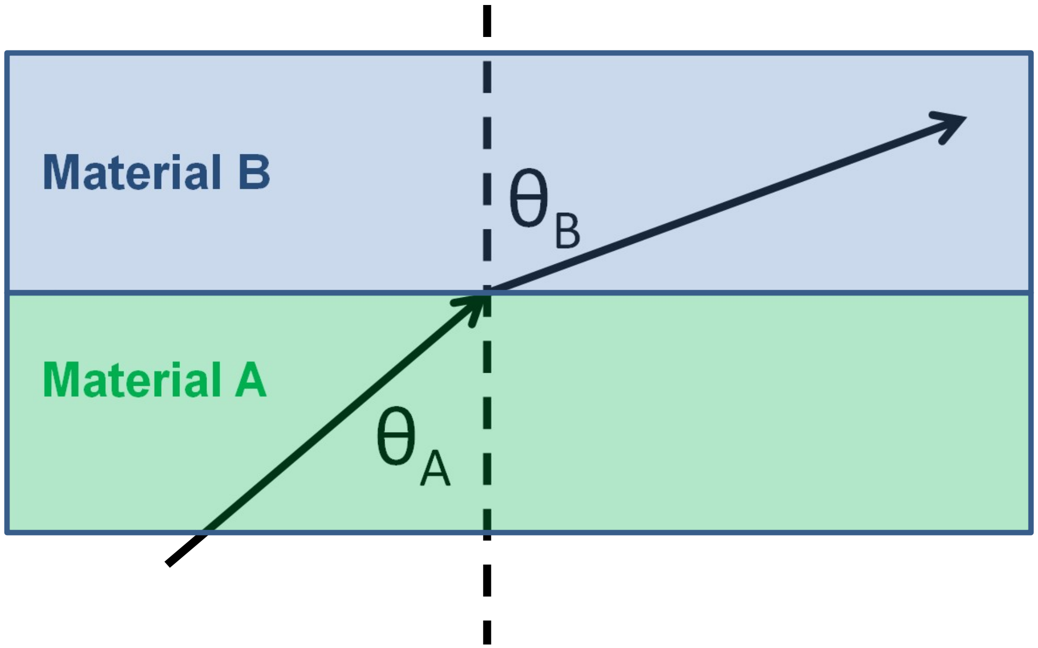
Or:

$$sin\theta_2 = sin\theta_1 \frac{\eta_1}{\eta_2}$$

Notice that there are certain combinations of the η's that require $\sin\Theta_2$ to be outside the range -1. → +1., which is not possible. This indicates that the refraction has actually become a reflection.

https://en.wikipedia.org/wiki/Snell's_law

The Physics of Refraction



Snell's Law of Refraction:

$$\frac{\sin \Theta_B}{\sin \Theta_A} = \frac{\eta_A}{\eta_B}$$

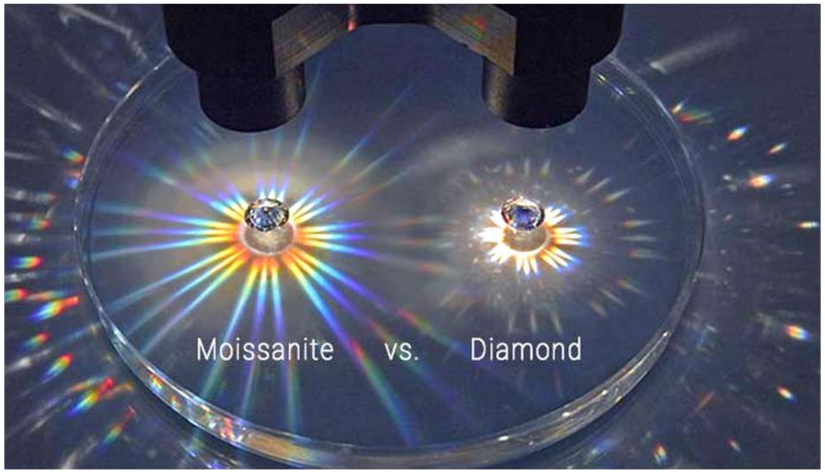
Material	Index of Refraction
Vacuum	1.00000
Air	1.00029
Ice	1.309
Water	1.333
Plexiglass	1.49
Glass	1.60
Diamond	2.42

http://en.wikipedia.org/wiki/Refractive_index

Common Indices of Refraction

Material	Index of Refraction
Vacuum	1.00000
Air	1.00029
Ice	1.309
Water	1.333
Plexiglass	1.49
Glass	1.60
Diamond	2.42

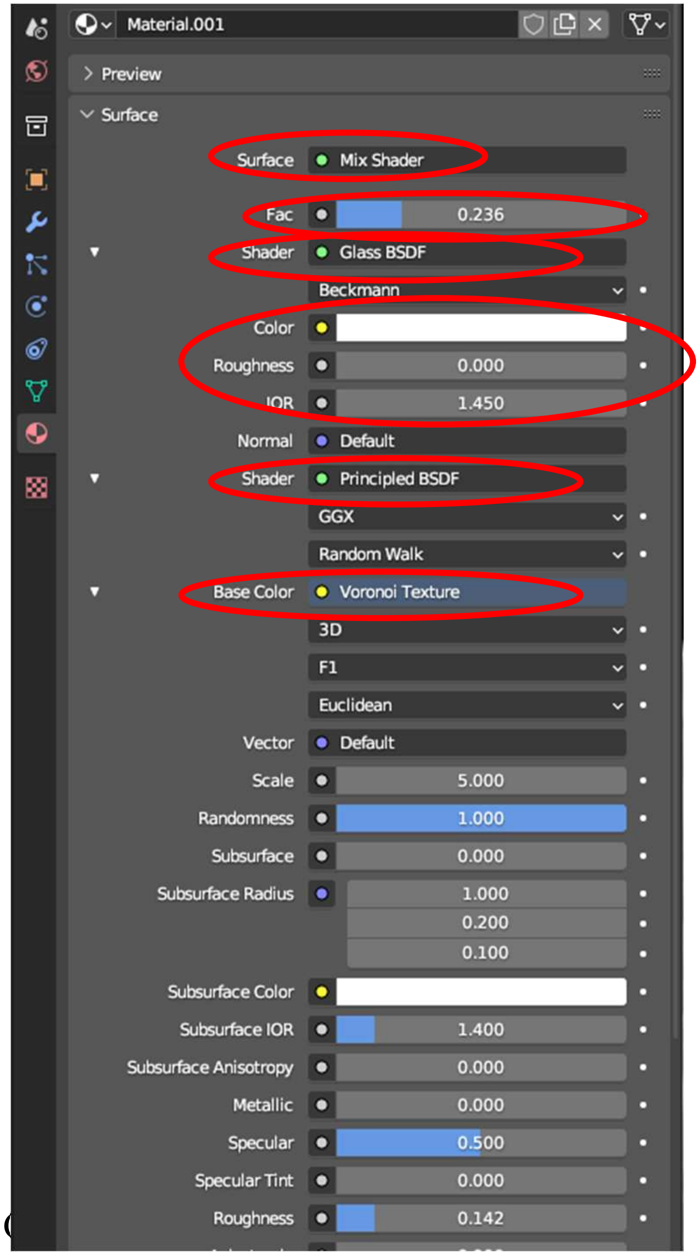
Something New: Moissanite

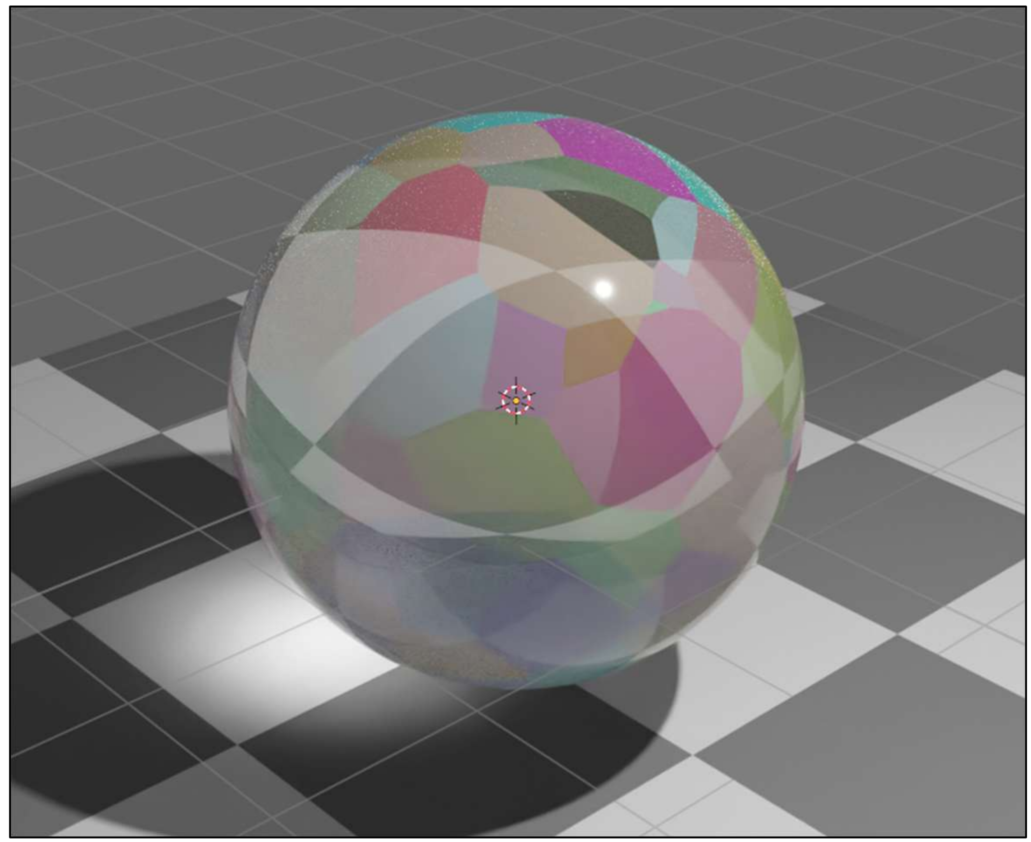


η=2.62

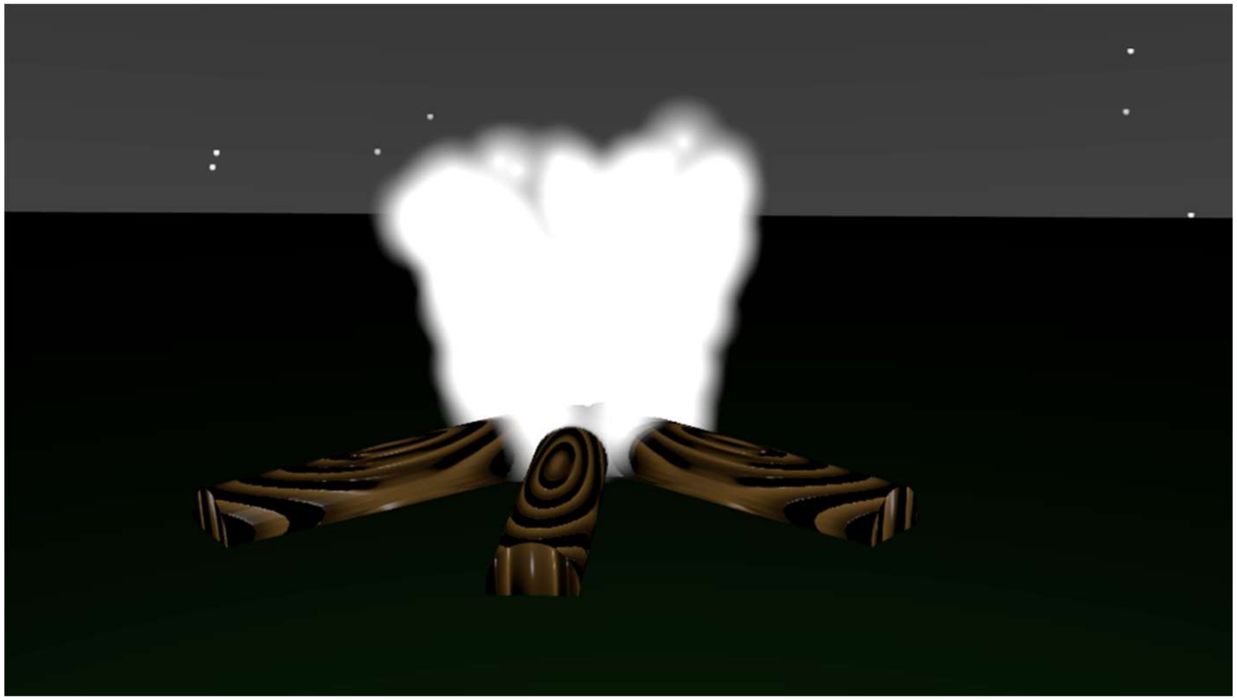
https://discover.charlesandcolvard.com/our-brand/everything-you-need-to-know-about-moissanite-vs-diamonds/

You Can Also use a Mix Shader to Blend Glass and a Texture





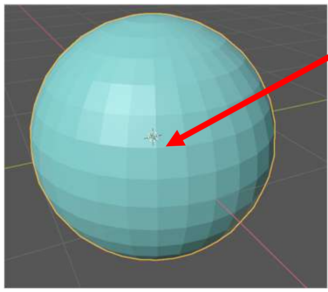
11. Vertex Sculpting



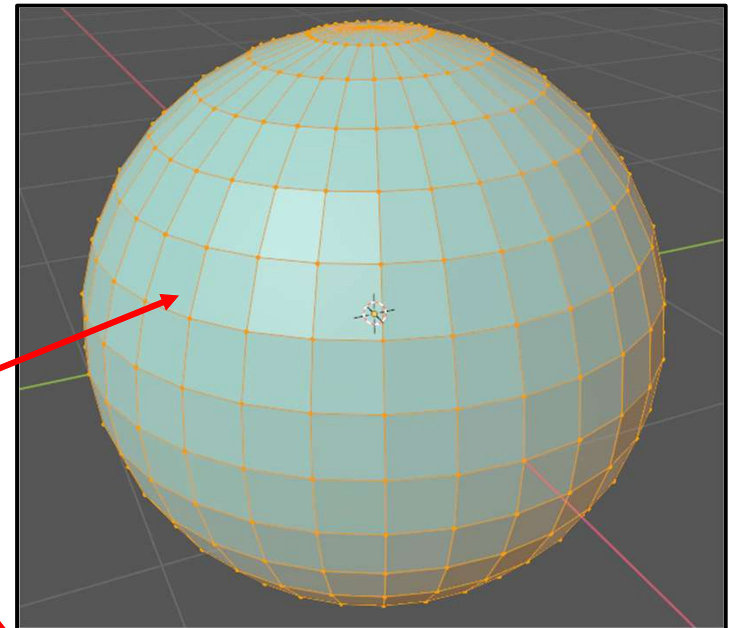
Vertex Sculpting

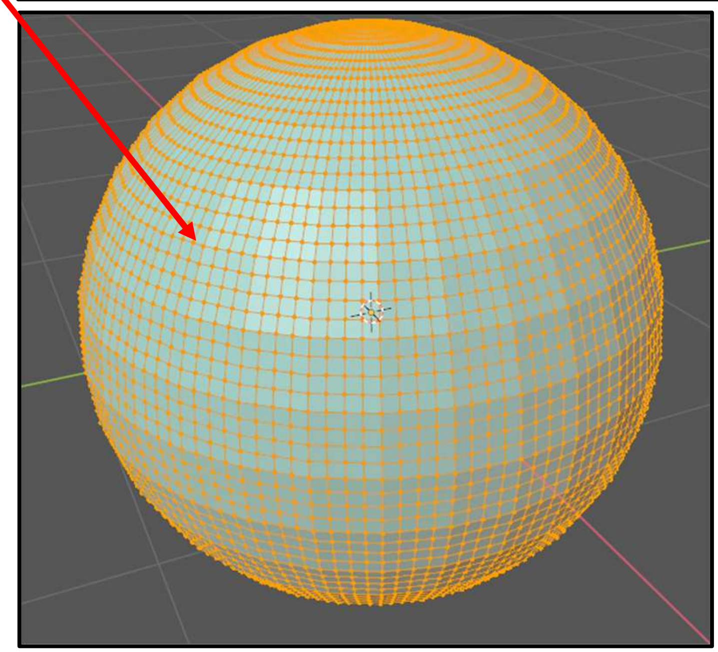
Vertex Sculpting is, well, sculpting vertices. But, in order to do this well, we need a lot of vertices.

Start with a UV sphere mesh object.



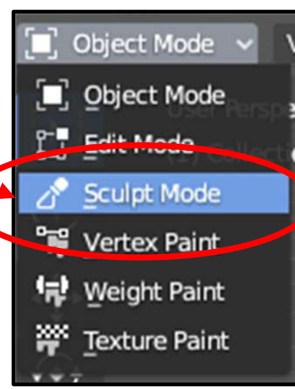
Tab over to **Edit Mode**.
RMB → Subdivide → Subdivide





When you get back to Object Mode, the sphere won't look any different than before because you just subdivided the polygons, not smoothed them. If you had wanted smoothing, you could have used the **Subdivision Surface Modifier.**

Now go to **Sculpt Mode**.



Vertex Sculpting

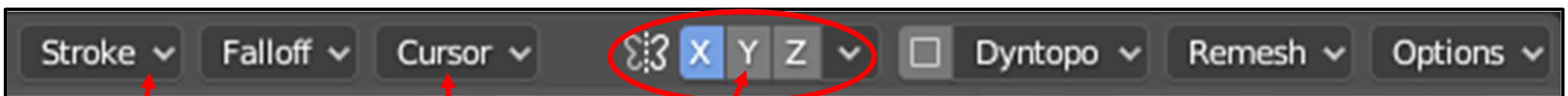
Lots of new options will appear at the top:

Brush Radius
(I like **25-100,** depending on the size of the object)

Brush Strength (height)

Add Material (+) or Subtract Material (-)

Brush Characteristics



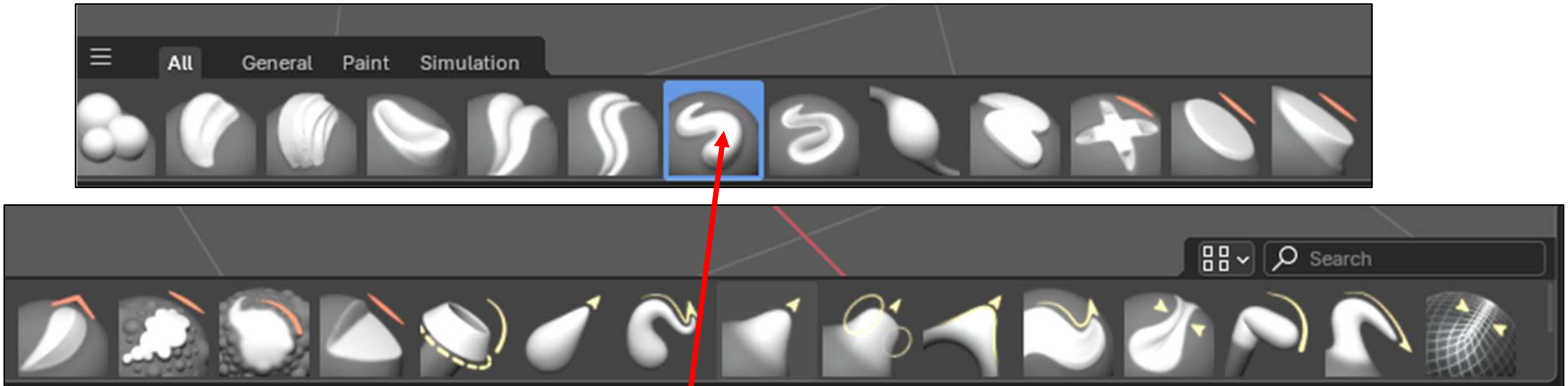
Stroking Characteristics

Surface Falloff from the Center of the Brush
(I like **Smoother**)

Symmetry Control
(I recommend you click all of these off for now.)

Vertex Sculpting -- Brushes

You will see a whole bunch of sculpting options along the bottom of the screen.
Hover above each one and a description will pop up:



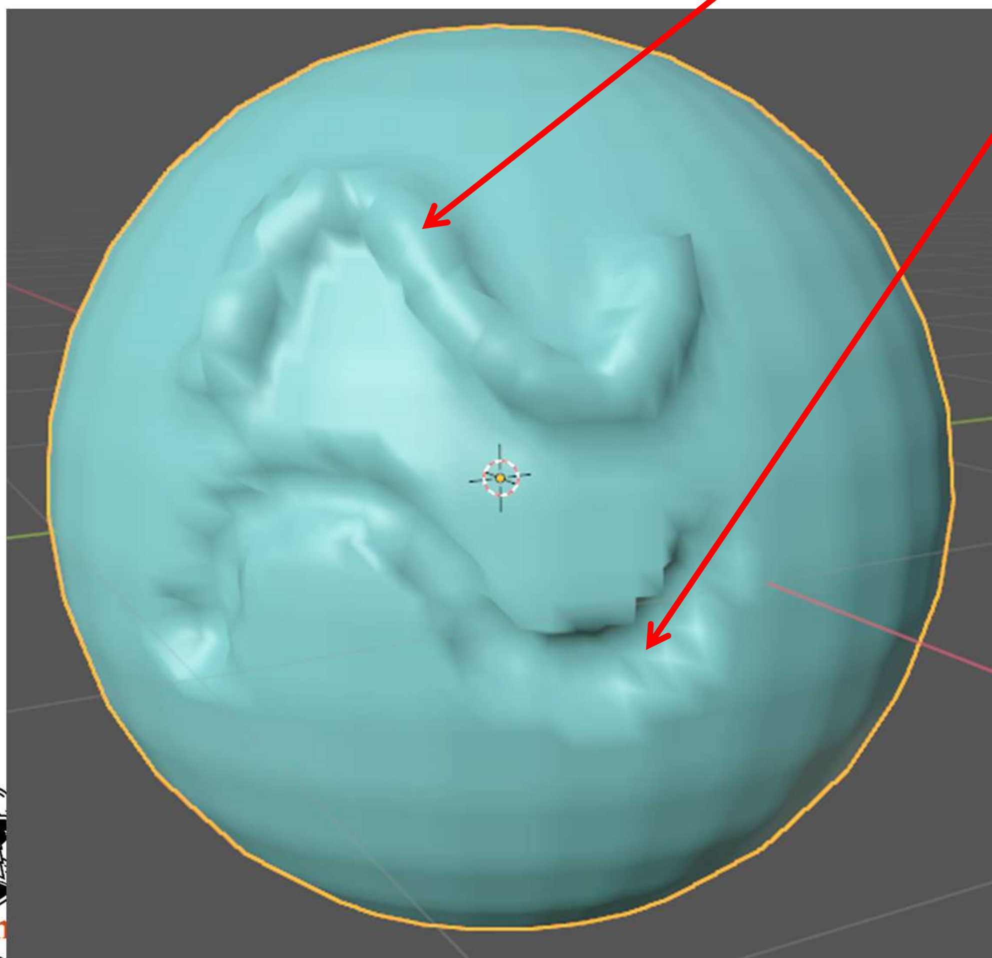
Confused about where to start? I like this one, called "Draw":

Vertex Sculpting

Go back and forth over the object with the brush to increase the sculpting effect

Add material

Subtract material



Sculpting usually looks better if you quick get over into **Object Mode**, **RMB → Shade Smooth**

Vertex Sculpting with Dynamic Topology (“Dyntopo”)

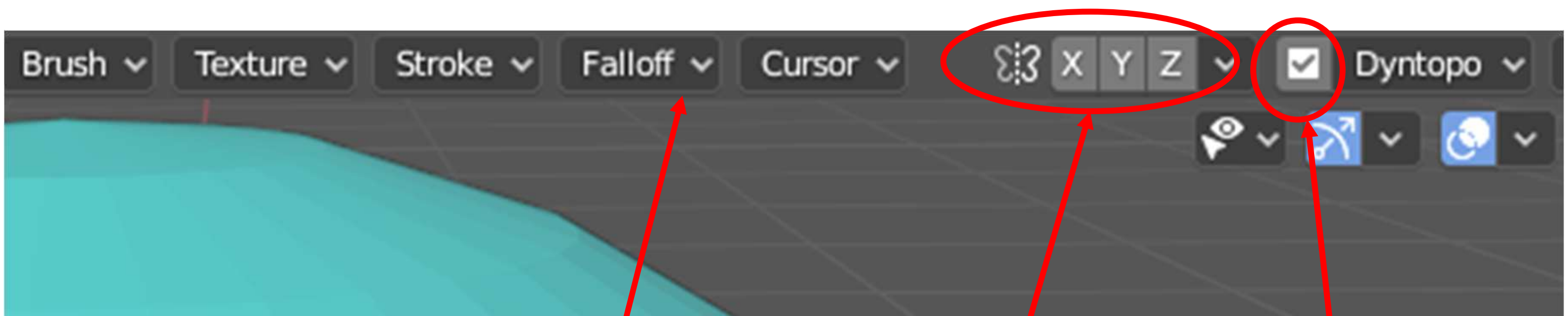
This cool – you are really going to like this!

Set the Sculpt Mode to **Draw**

Set Radius to **20**

Set Brush Strength to **1.0**

Add Material (+)

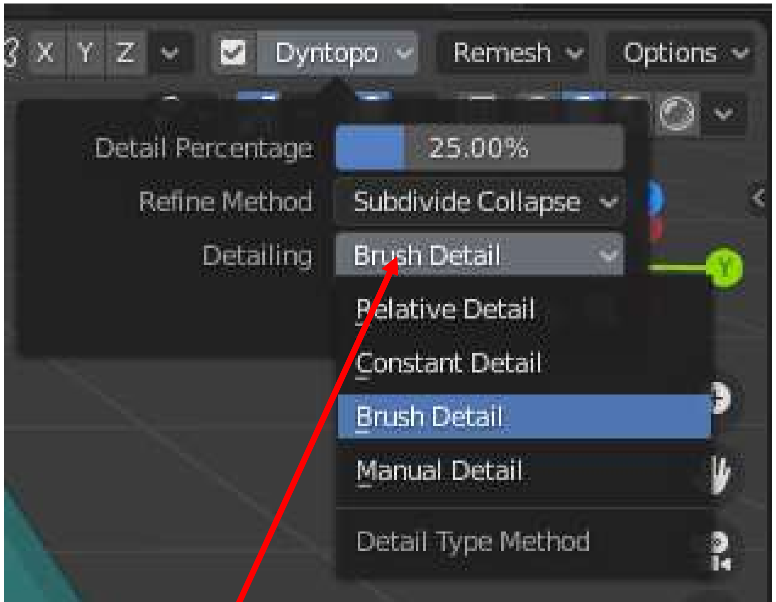


Surface Falloff from the Center of the Brush to **Smoother**

No Symmetry

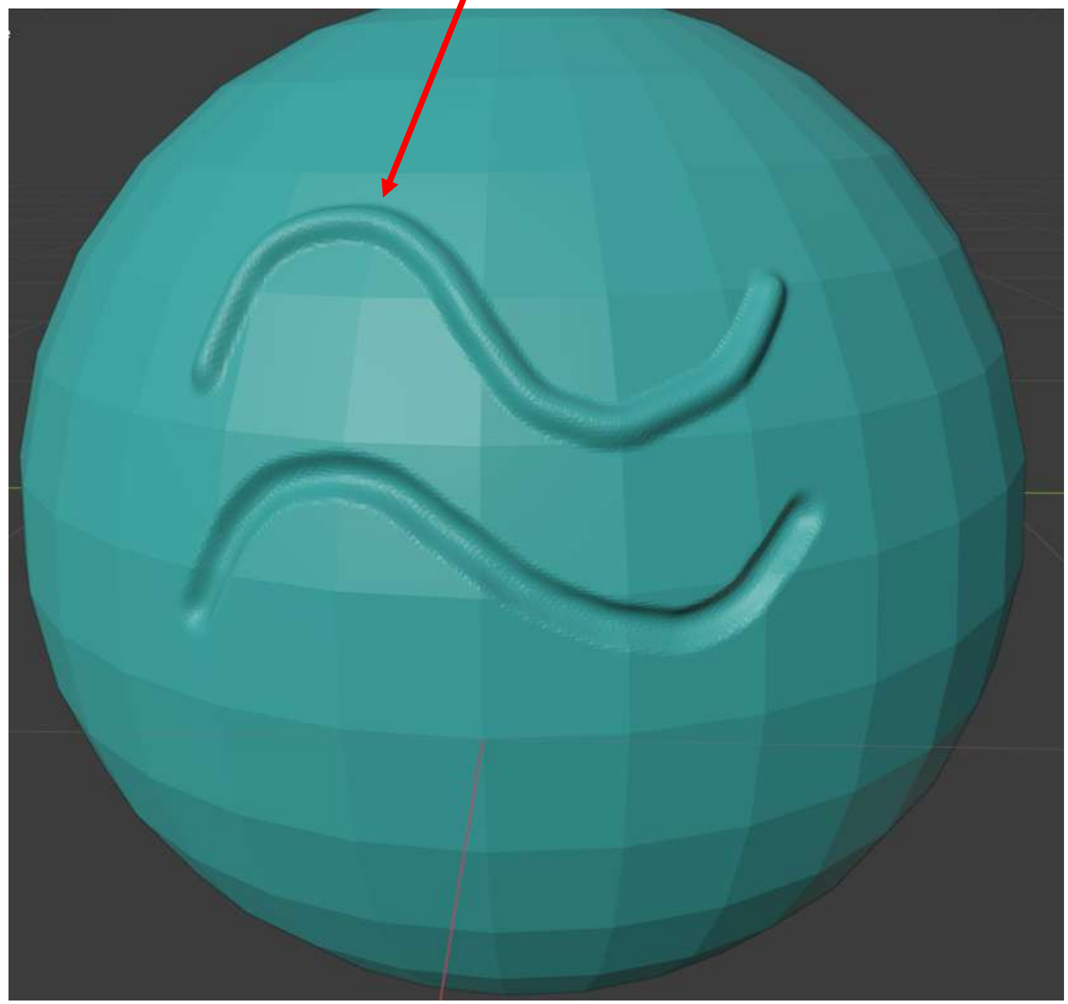
Click **Dyntopo** on (if you get a message, just click **OK**)

Vertex Sculpting with Dynamic Topology ("Dyntopo")



Set Dyntopo Detailing to
Brush Detail

And, have at it!



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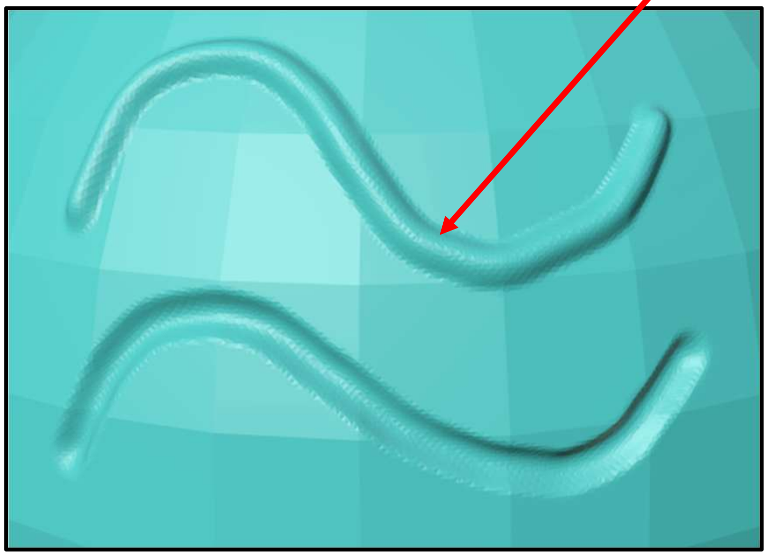
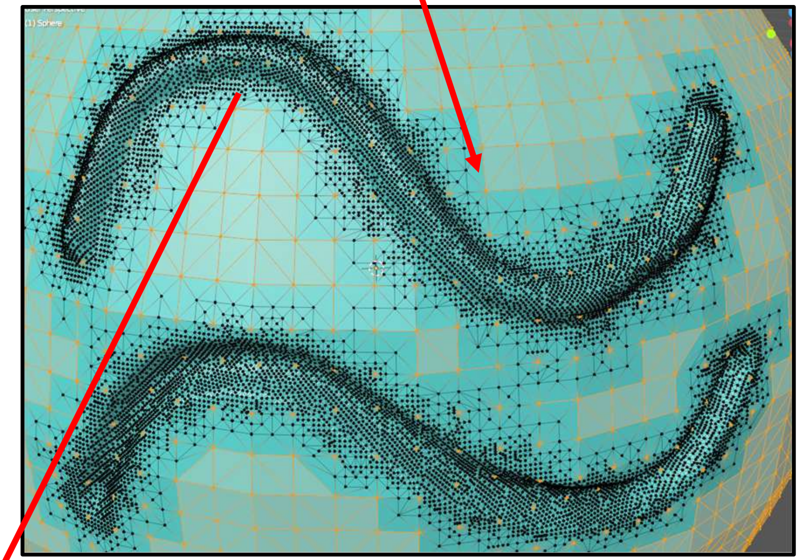
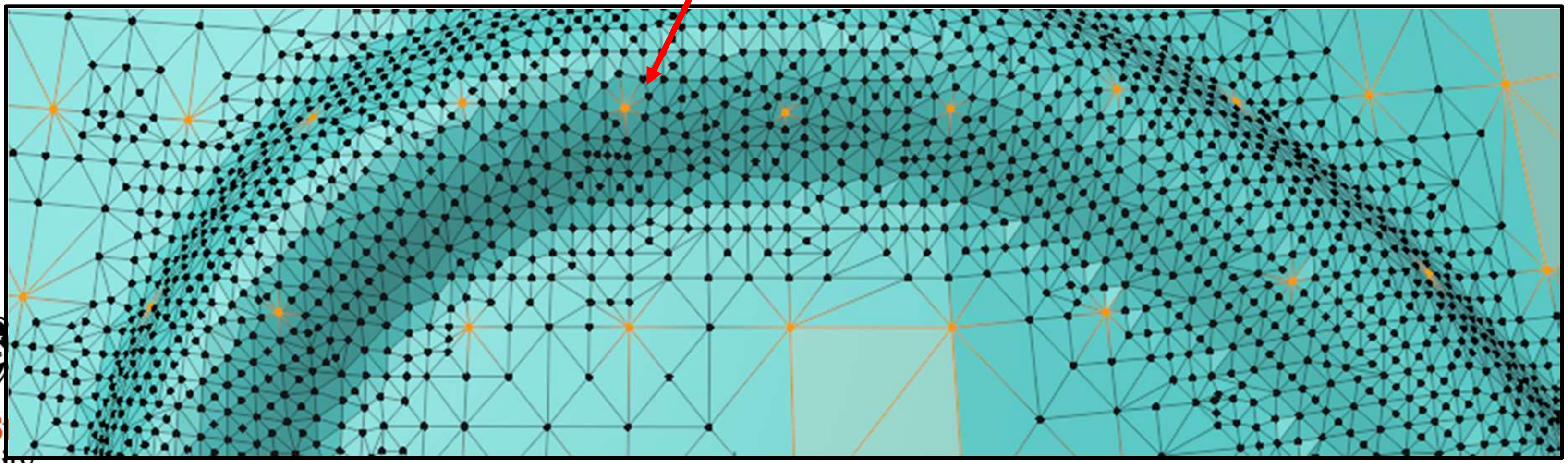
Vertex Sculpting with Dynamic Topology ("Dyntopo")

How does Dyntopo Mode make such a smooth sculpt?
Let's look at this in **Sculpt Mode** and then in **Edit Mode**:

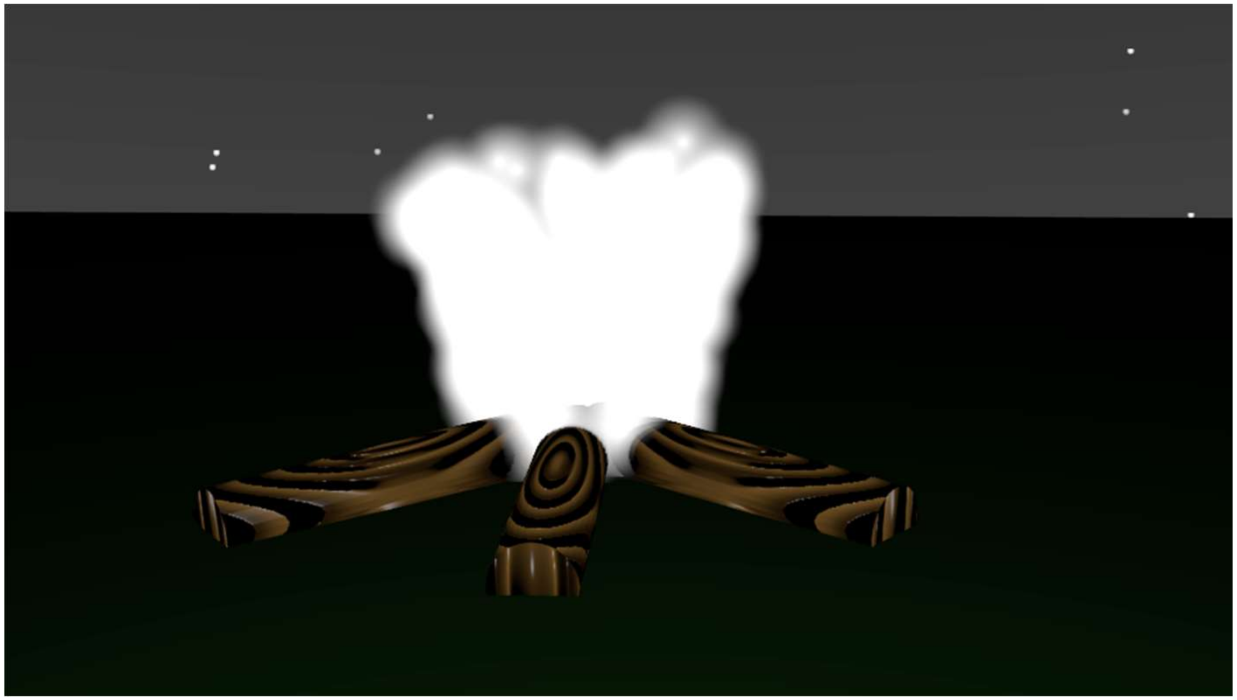






That's why it is called ***Dynamic Topology***!

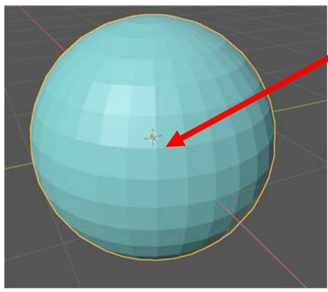
12. Vertex Painting



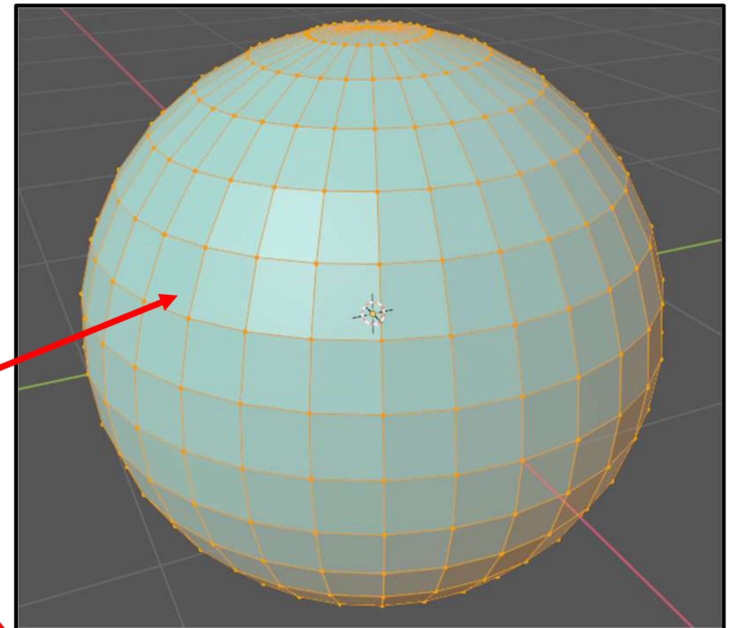
Vertex Painting

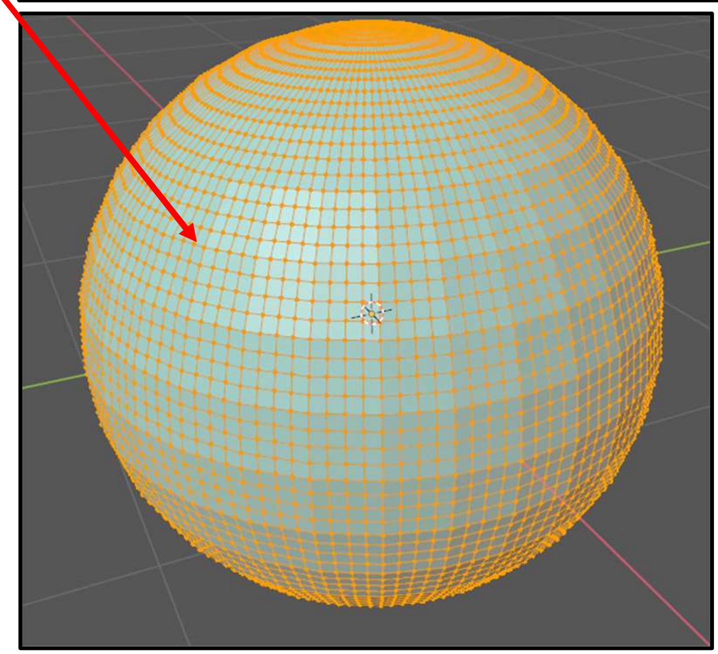
Vertex Sculpting is, well, sculpting vertices. But, in order to do this well, we need a lot of vertices.

Start with a UV sphere mesh object.



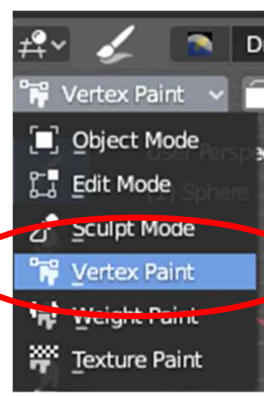
Tab over to **Edit Mode**.
RMB → Subdivide → Subdivide





When you get back to Object Mode, the sphere won't look any different than before because you just subdivided the polygons, not smoothed them. If you had wanted smoothing, you could have used the **Subdivision Surface Modifier.**

Now go to **Vertex Paint Mode**.



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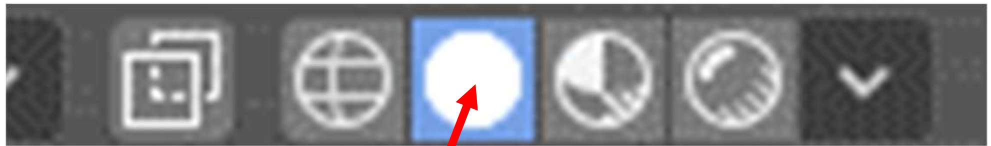
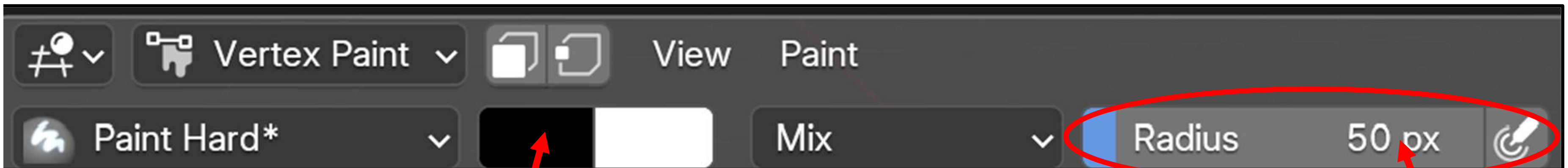
Setting up for Vertex Painting



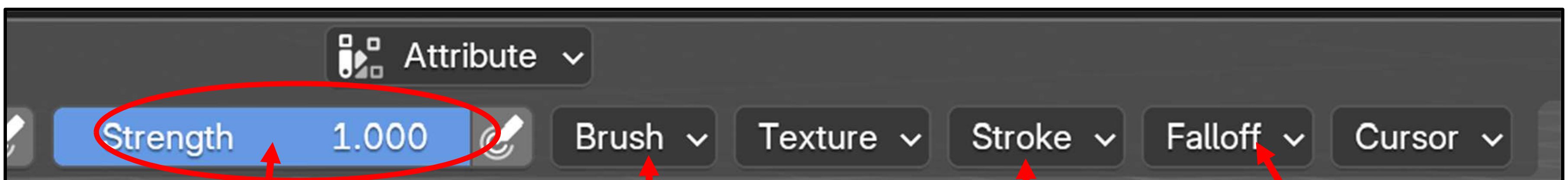
Be in **Viewport Solid Shading** mode



Brush Color

Don't be fooled! Even though this looks like a black-nothing color, it is the actual brush color. You can, and should, change it.

Brush Radius
(I like **25-100**)



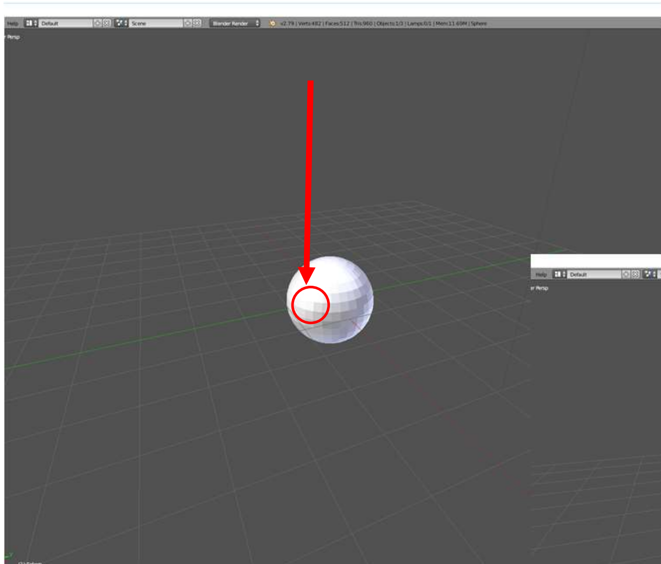
Brush Strength

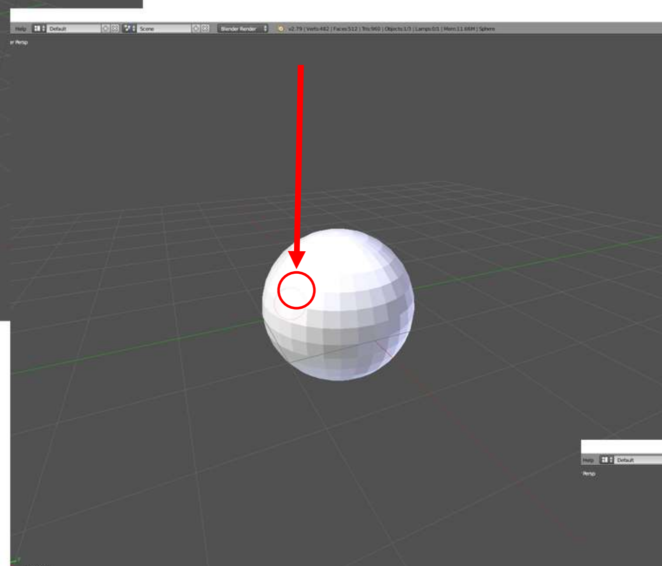
Brush Characteristics

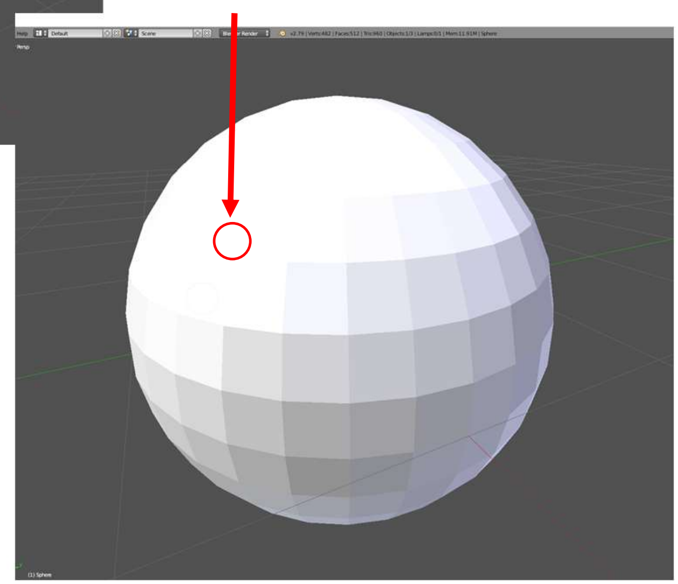
Stroking Characteristics

Surface Falloff from the Center of the Brush
(I like **Smoother**)

A Word on Brush Size







Note: the brush size does not scale with zooming in or out. It stays the same size.

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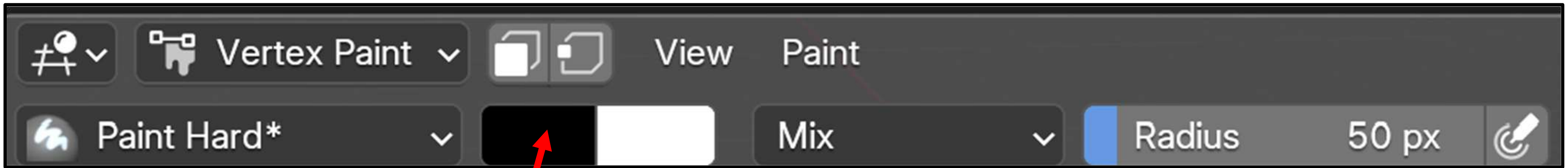
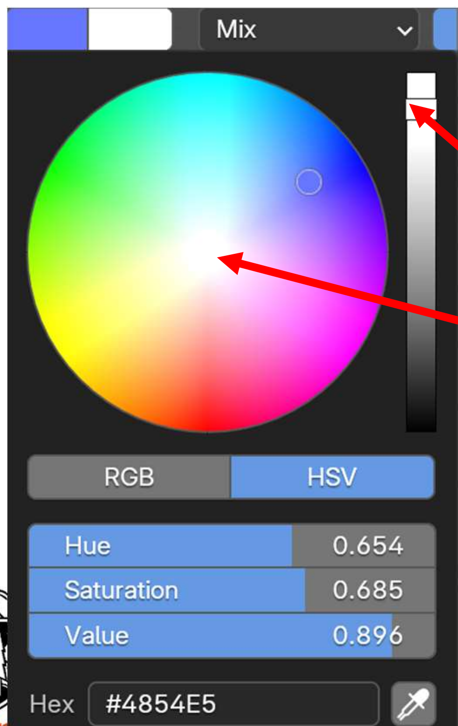
Selecting the Painting Color



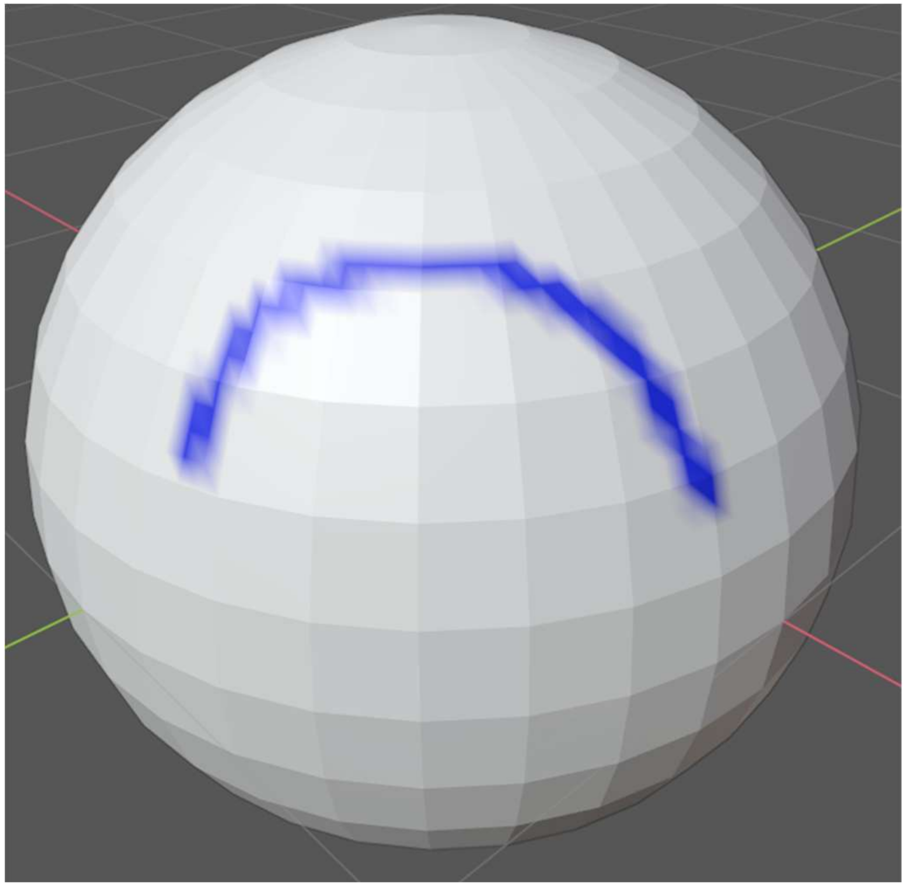
Brush Color
Click here to get the color wheel



Set the brightness (“value”)

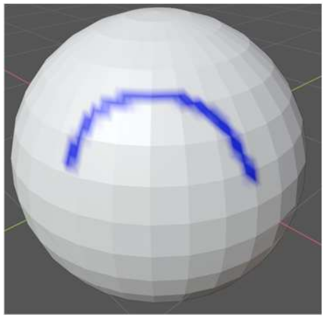
Set the hue and saturation

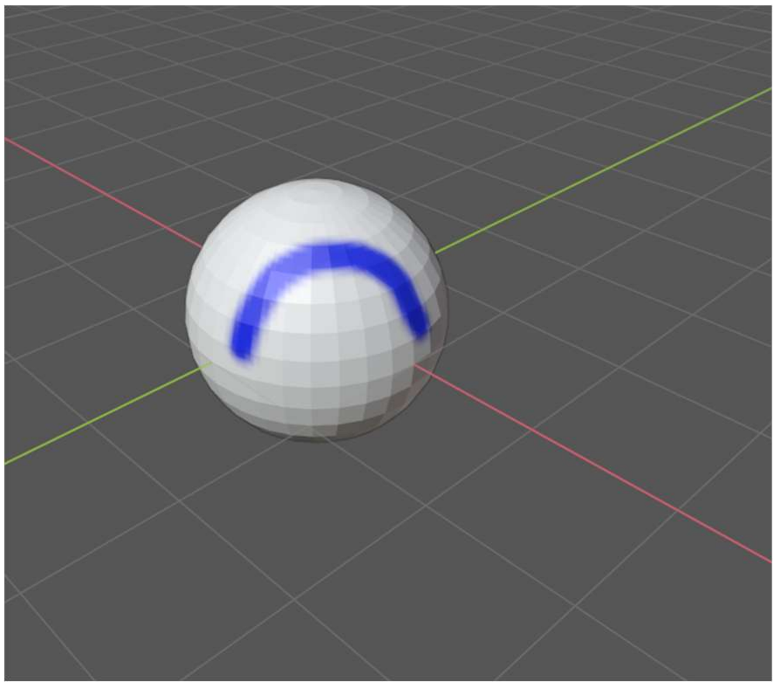
How Does Vertex Painting Work?

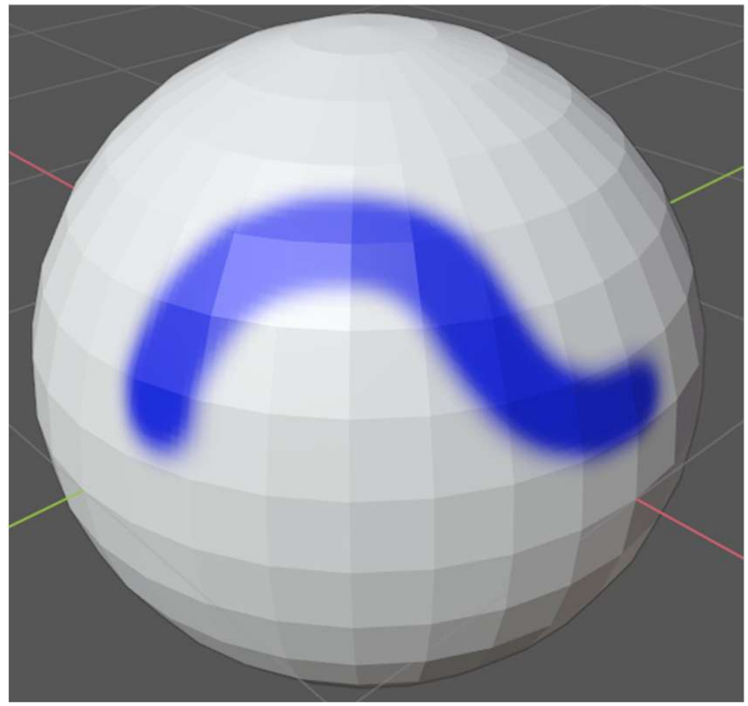


The “paintbrush” only drops “paint” when a vertex is *inside* the circle brush. This means that the paint does not smear along a nice line but can look splotchy like this. This is why we subdivided before – so we get more vertex density.

How Do We Make it Look Less Splotchy?



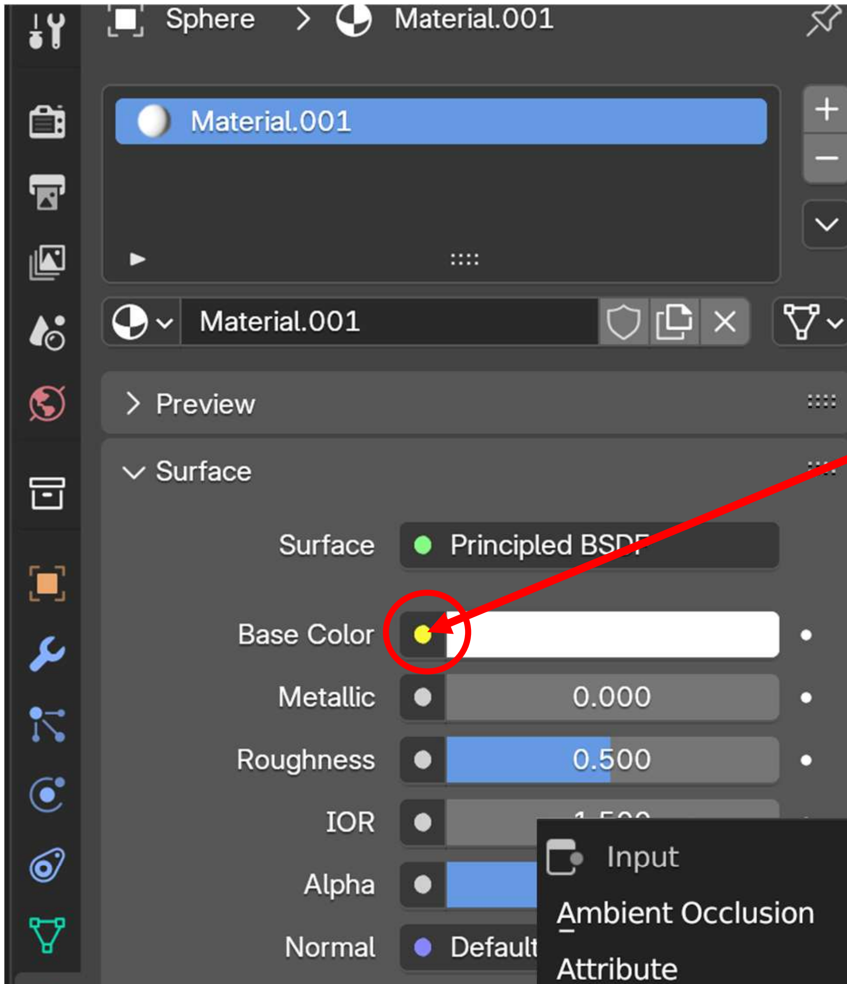


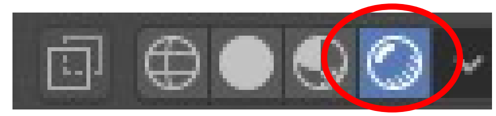


Two approaches:

1. Make the object look smaller. That way more vertices will end up inside the brush circle.
2. Use **Subdivide** or **Subdivision Surfaces** to add more vertices

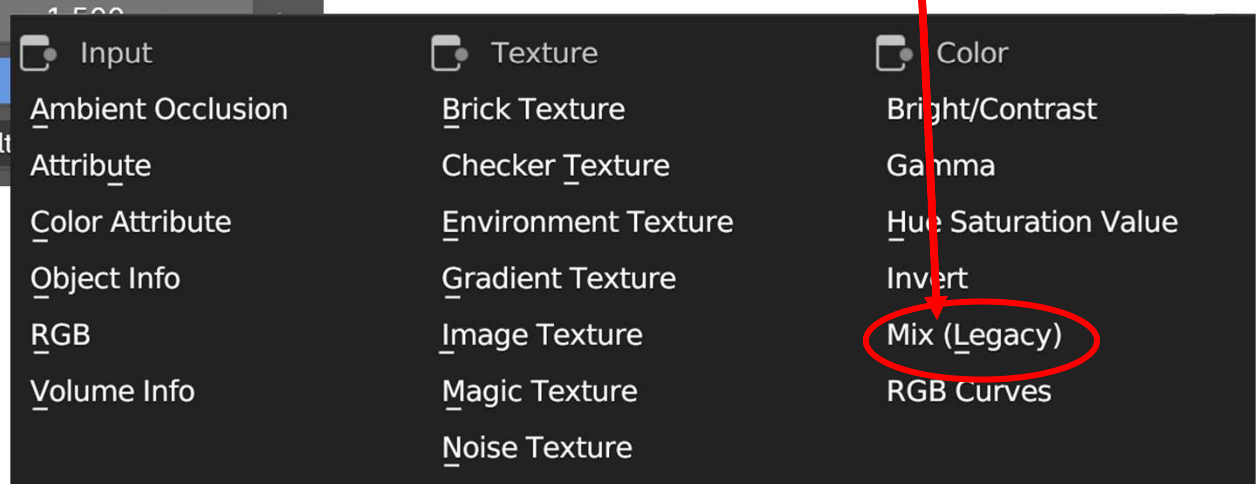
Making Your Vertex Painting Show Up





Be in **Rendered Shading** mode

Click on the small circle next to Base Color and select **Mix (Legacy)** from the pop-up menu



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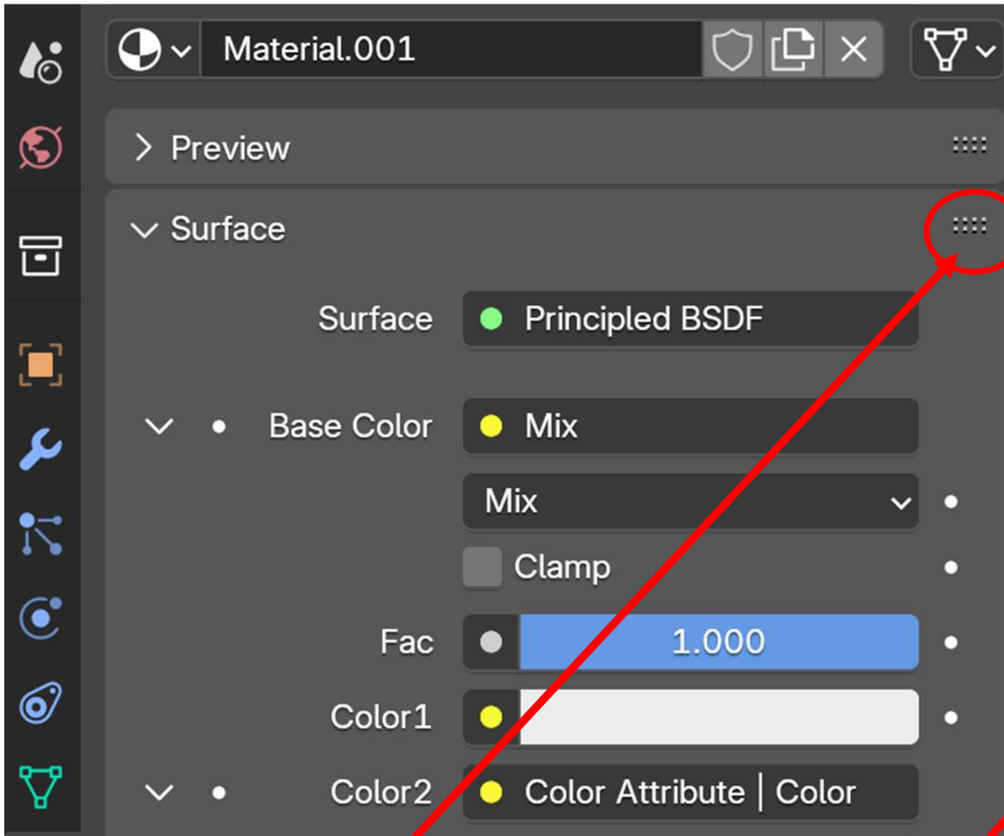
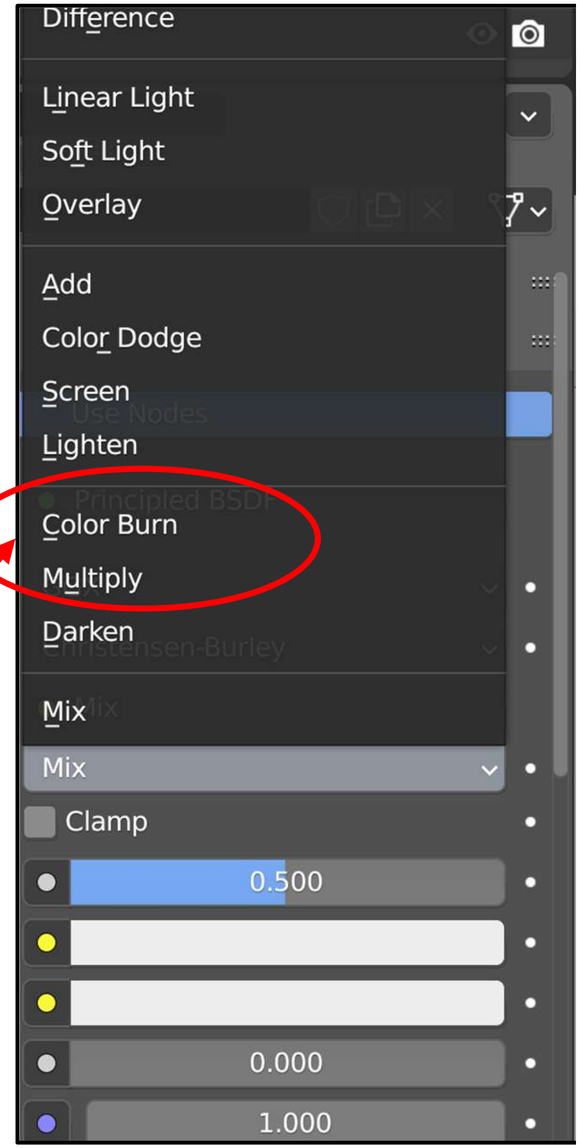
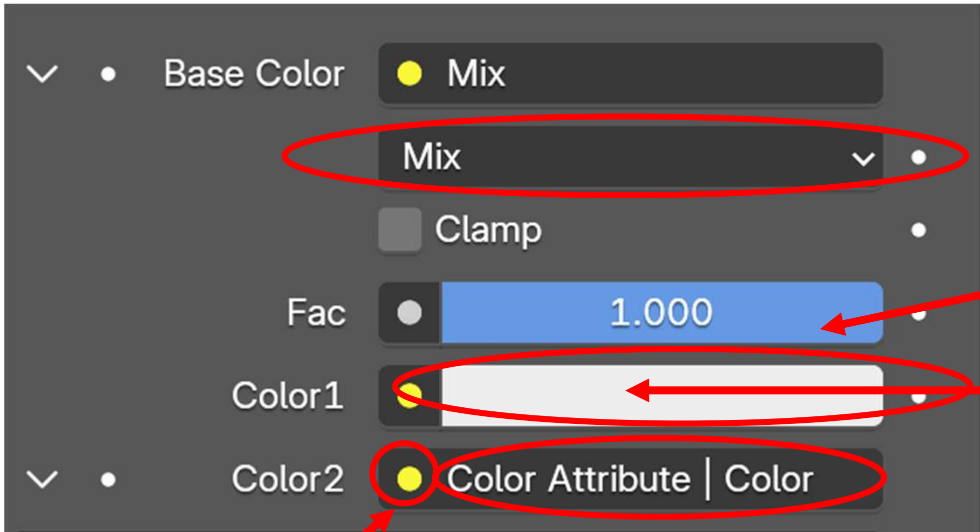
Making Your Vertex Painting Show Up





Then click **here** and select **Color Burn** or **Multiply** from the pull-down menu
("Mix" will change to whichever you picked)

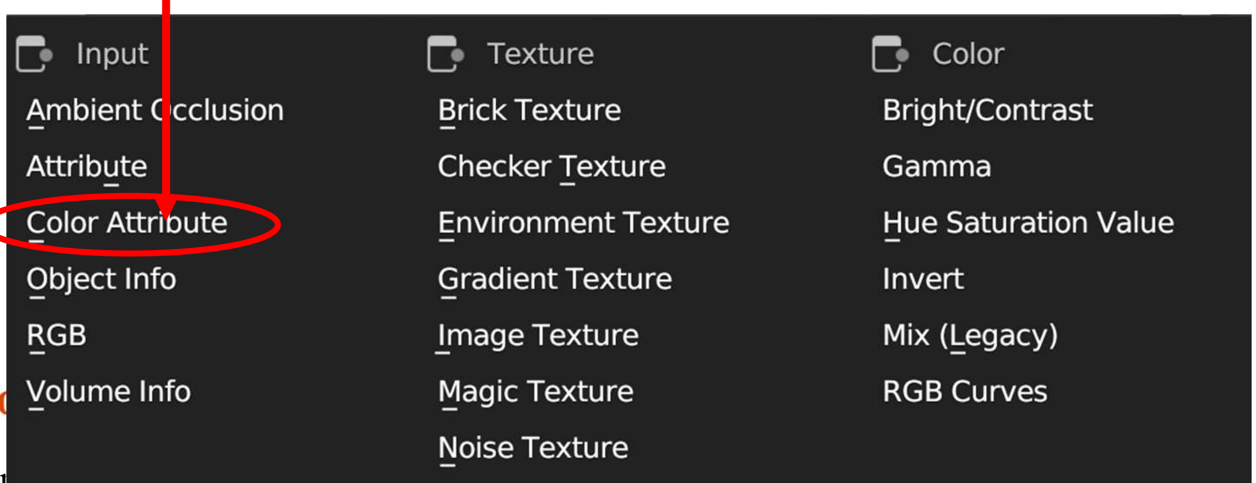
Making Your Vertex Painting Show Up



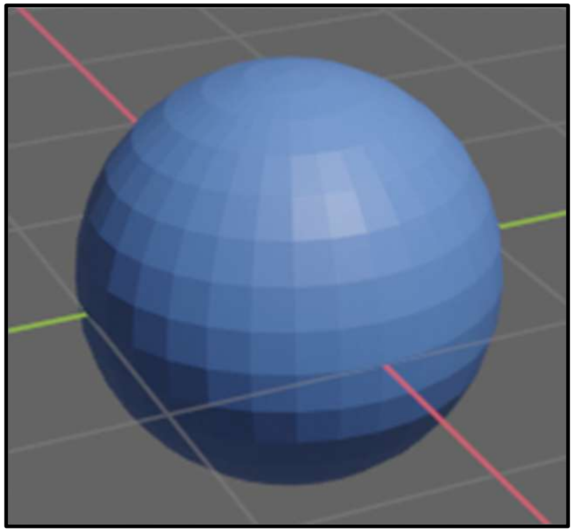
Click and adjust the value of **Fac** (the interpolation Factor)

Click here and select a base color for the sphere

Click on the small yellow circle and select **Color Attribute** from the left column of the pop-up menu

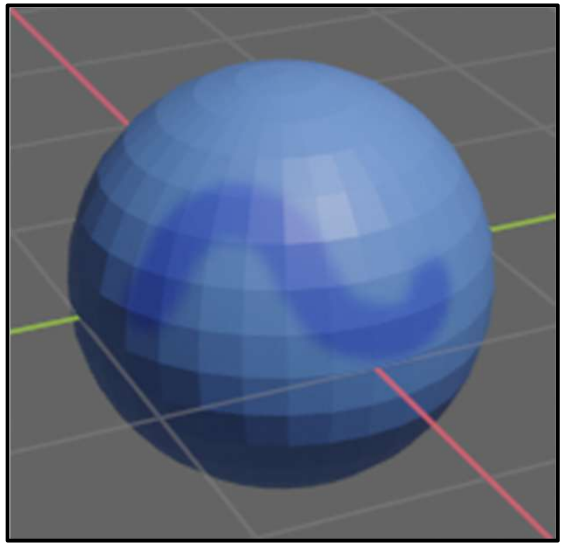


The *Fac* Parameter Tells Blender What to do on the Parts of Your Object that have both an Object Color and a Paint Color



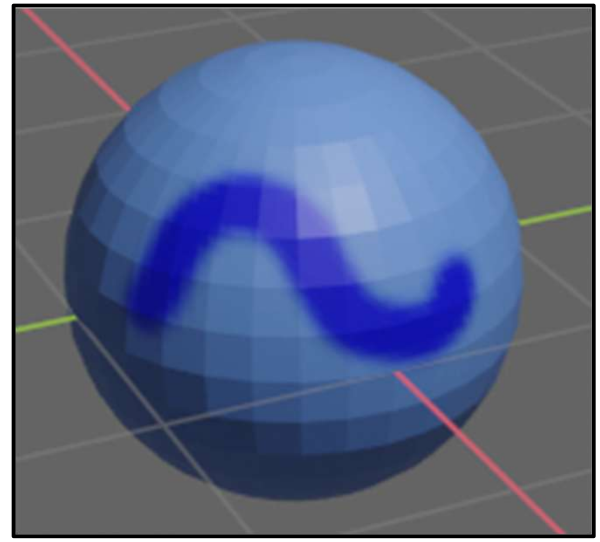
Multiply
Fac = 0.00

All Object Color



Multiply
Fac = 0.50

Half of Each

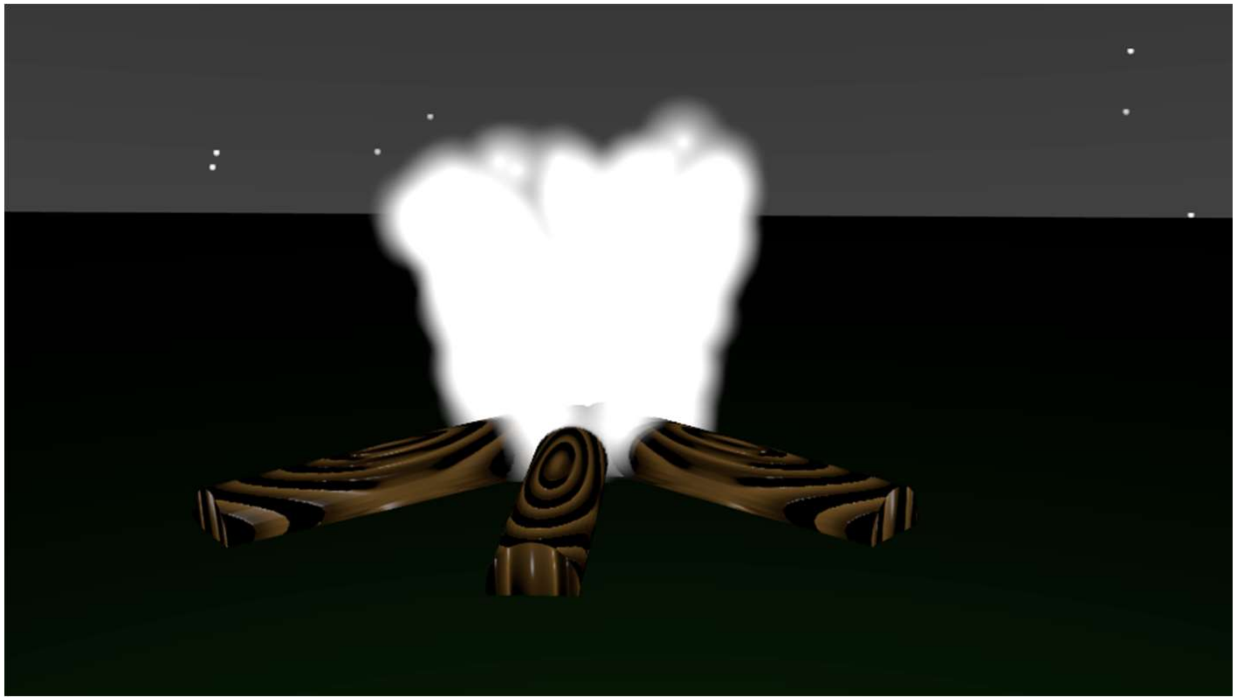


Multiply
Fac = 1.00

All Paint Color

Have a Nice Day!

13. Keyframe Animation

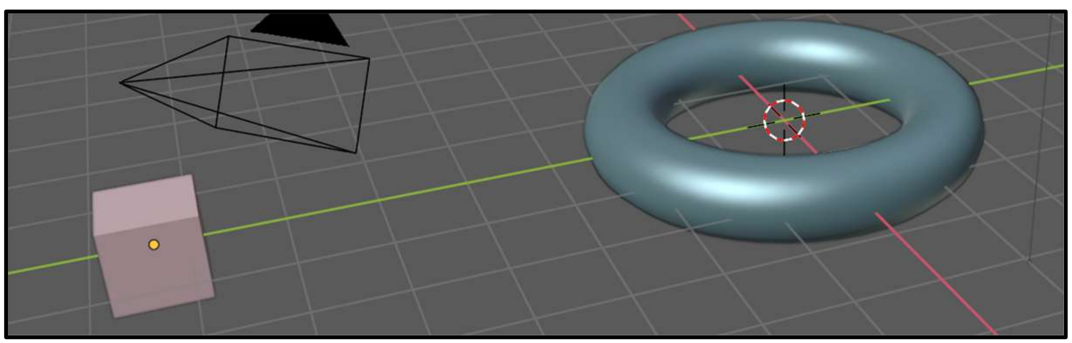


Blender Drivers

There are times when we want to relate some aspect of a part's modeling to something else. That is, we want one measurement to drive another. Not surprisingly, these are called ***Blender Drivers.***

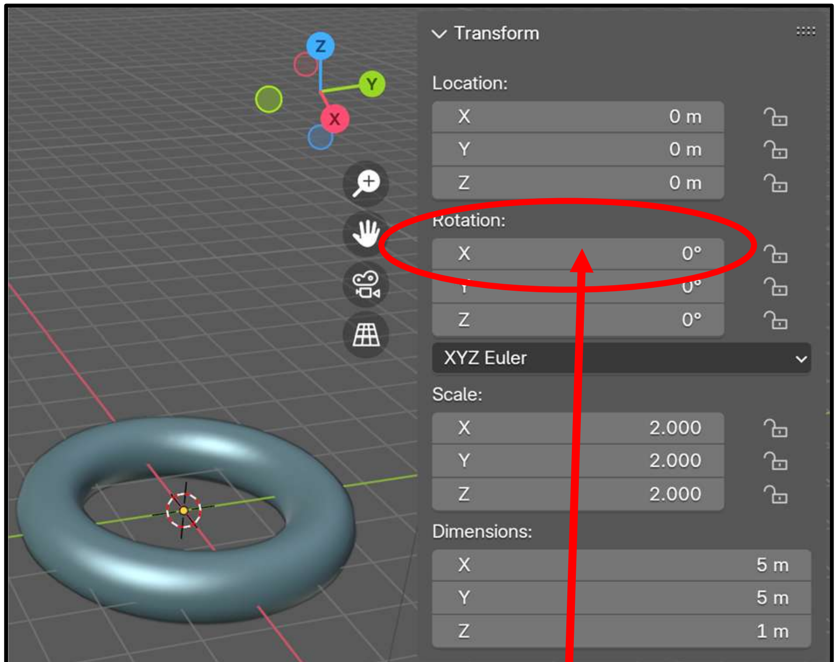
Blender Drivers are very useful. But they don't really fall under any specific major category. So I put them here. I am open to suggestions about where they should really go.

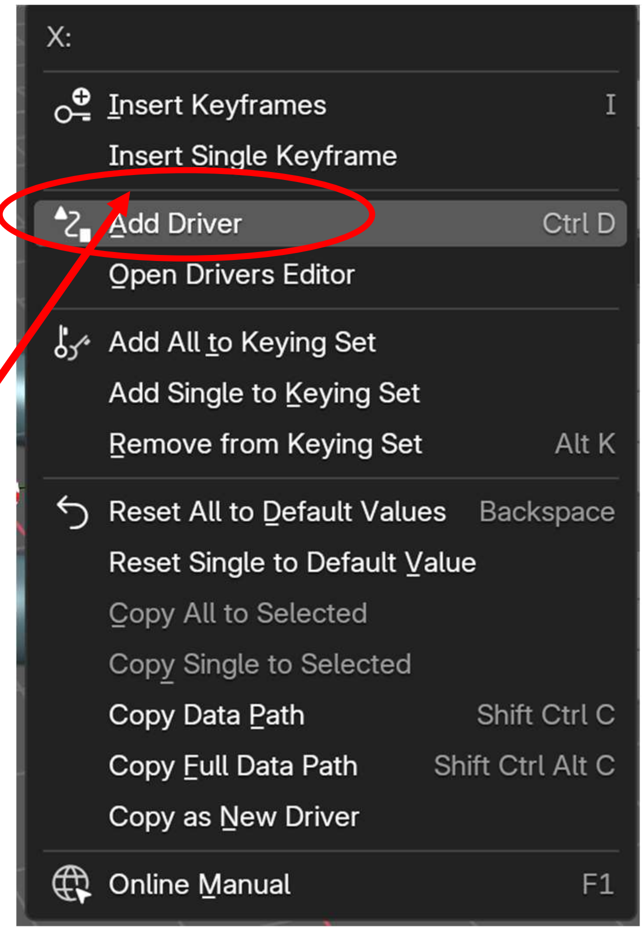
Here our goal is to control the rotation of the torus with the translation of the cube.



Blender Drivers

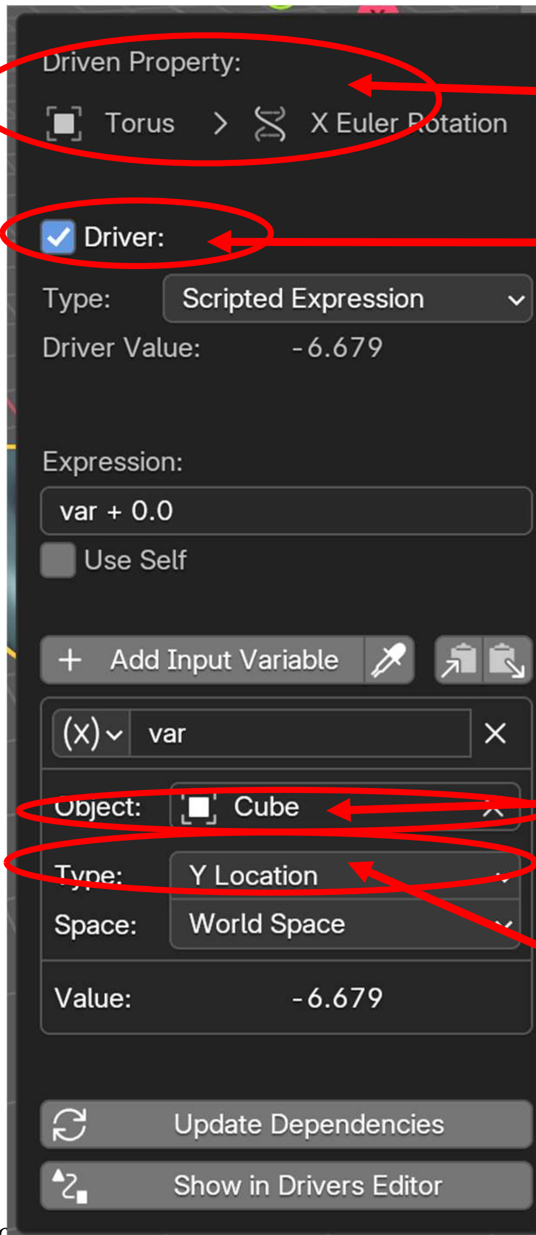
Select the **torus** and hit the 'n' key to bring up the **Transform Properties Panel**:





Right-click in the torus's **X Rotation** slot
and select **Add Driver**

Blender Drivers



This reminds us that the Torus object is what is being driven

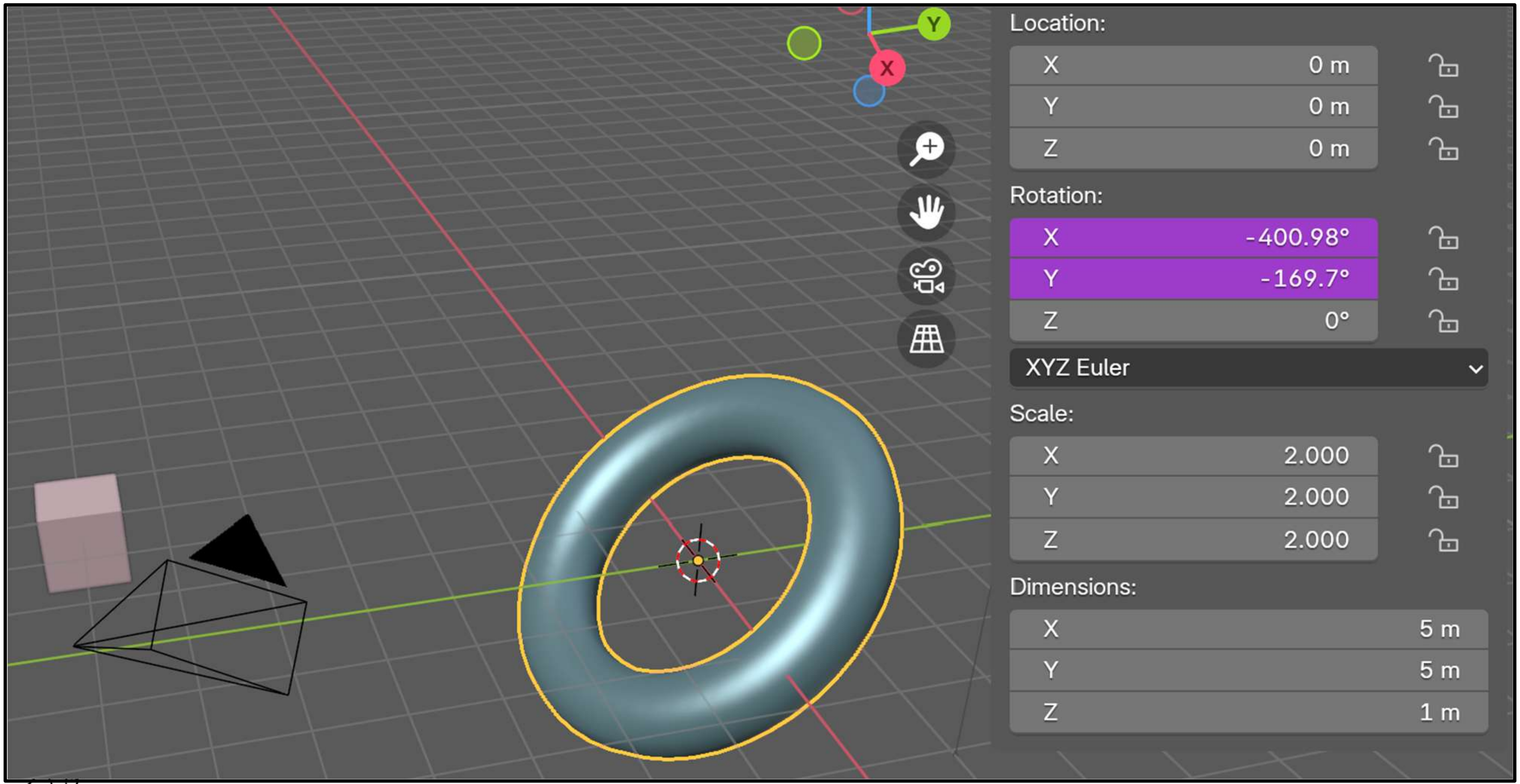
This section is where we get to specify the Driver object

Click here and specify the Cube as the driver

Click here and specify the Y translation as the driving direction

Blender Drivers

I decided to also specify the Cube's X Location as driving the Torus's Y rotation:



So now moving the cube in X and Y **('gZ')** will rotate the torus in 2 directions

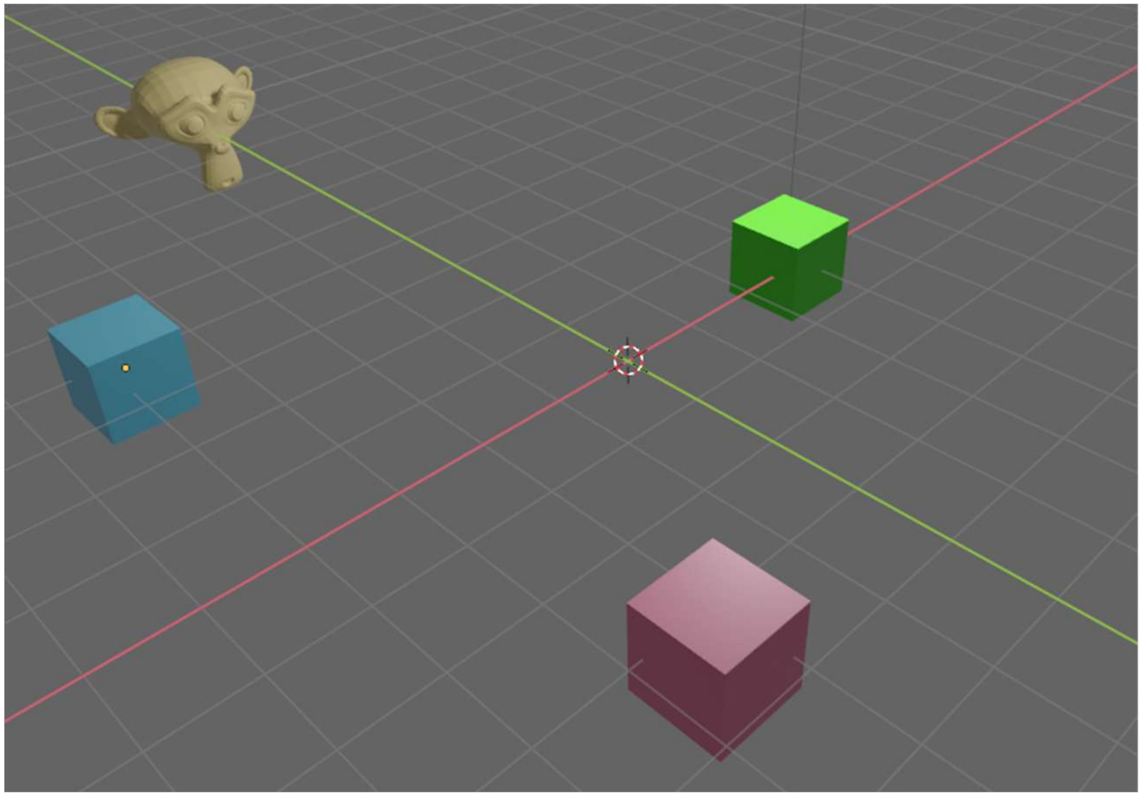
Now On To Keyframing

http://ieeexplore.ieee.org/ieee_pilot/articles/05/ttg2009050853/figures.html

Keyframe Animation

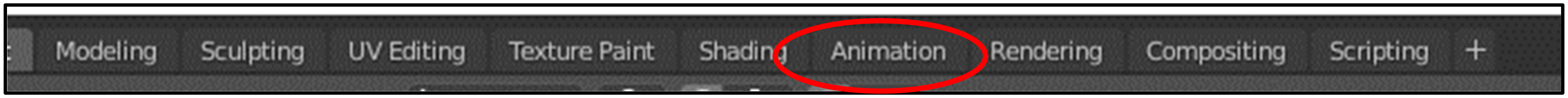
Keyframe animation is a technique that goes all the way back to the beginning of hand drawn animation (e.g., Walt Disney). Senior animators would specify key positions for the animated characters and then more junior animators would fill in the frames in between. This became known as **keyframing** and i**n-betweening**.

Blender allows you to create the keyframes and gets the computer to do the in-betweening. Here, we will keyframe-animate the monkey as she slaloms around a group of colored cubes:

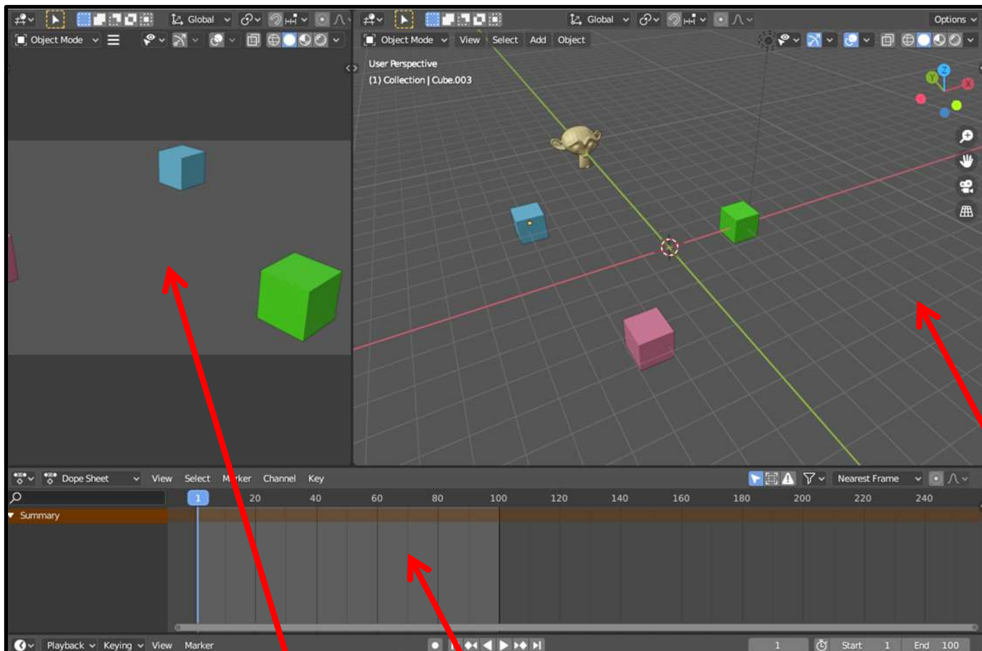


Keyframe Animation

Select the **Animation** workspace from the list at the top. This creates a screen layout that looks like this:



This makes your screen look like this. These new sections are:

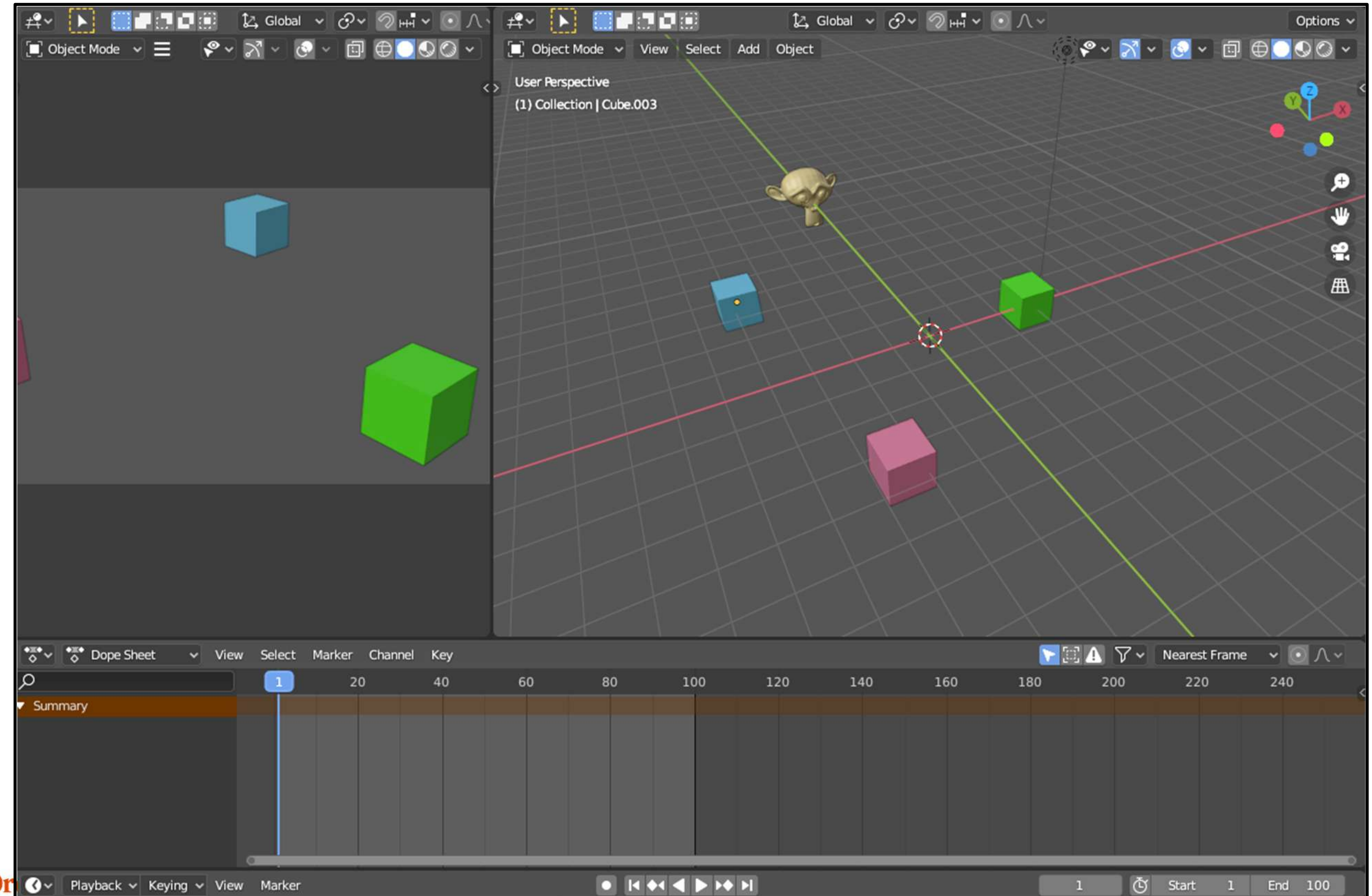


3D Viewport Window – what you are used to

Camera View Window – what you will see if you Render

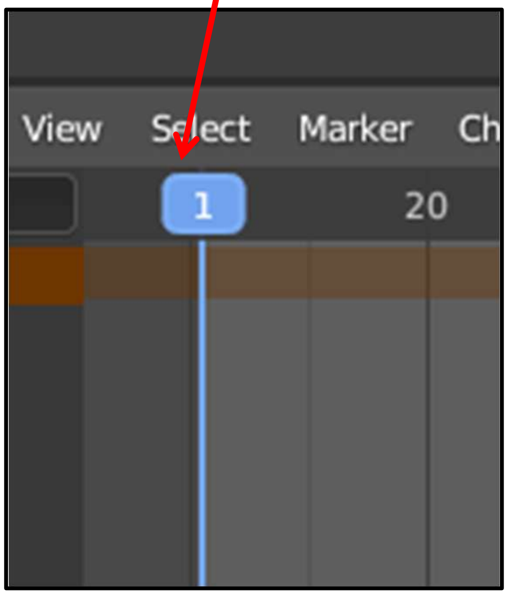
Timeline Window – keeps track of what frame number we are on.

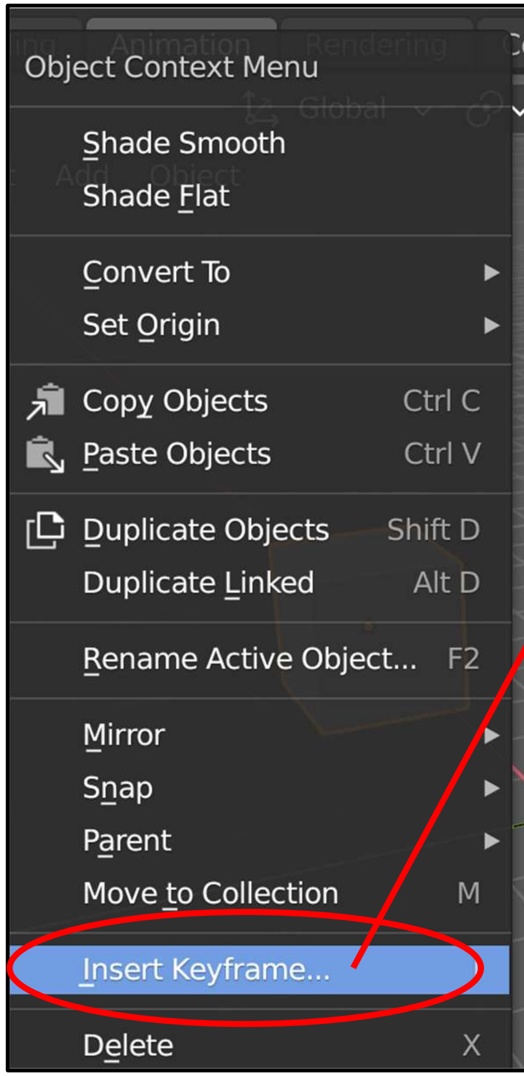
Keyframe Animation

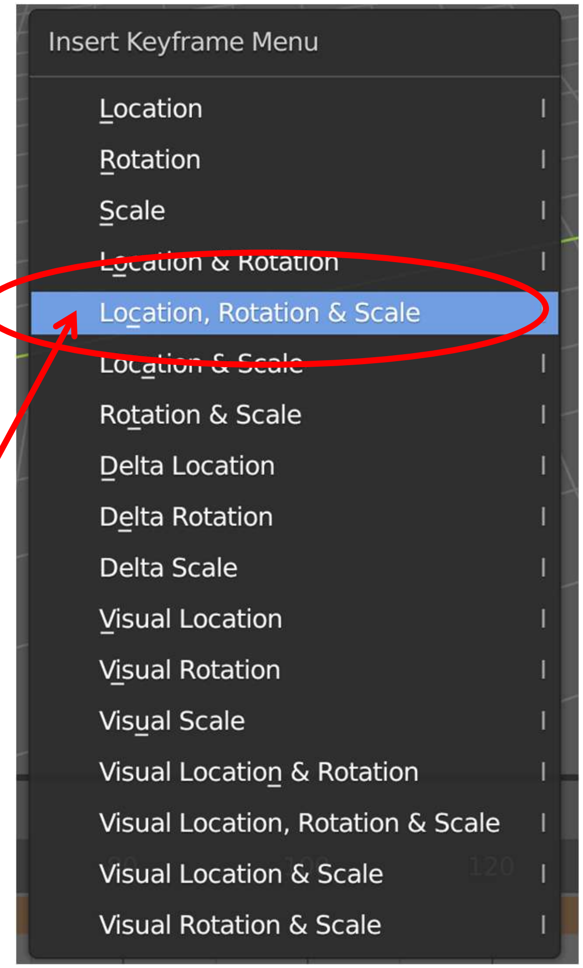


Keyframe Animation

Slide the **timeline indicator** to what frame number you want to set, position the object (grab, scale, rotate) how you want it to be (grab, scale, rotate), and **RMB → Insert Keyframe** (or hit the **'i'** key). From the pop-up menu, select **Location, Rotation, and Scale**, indicating that you want to record location, rotation, and scale factor.

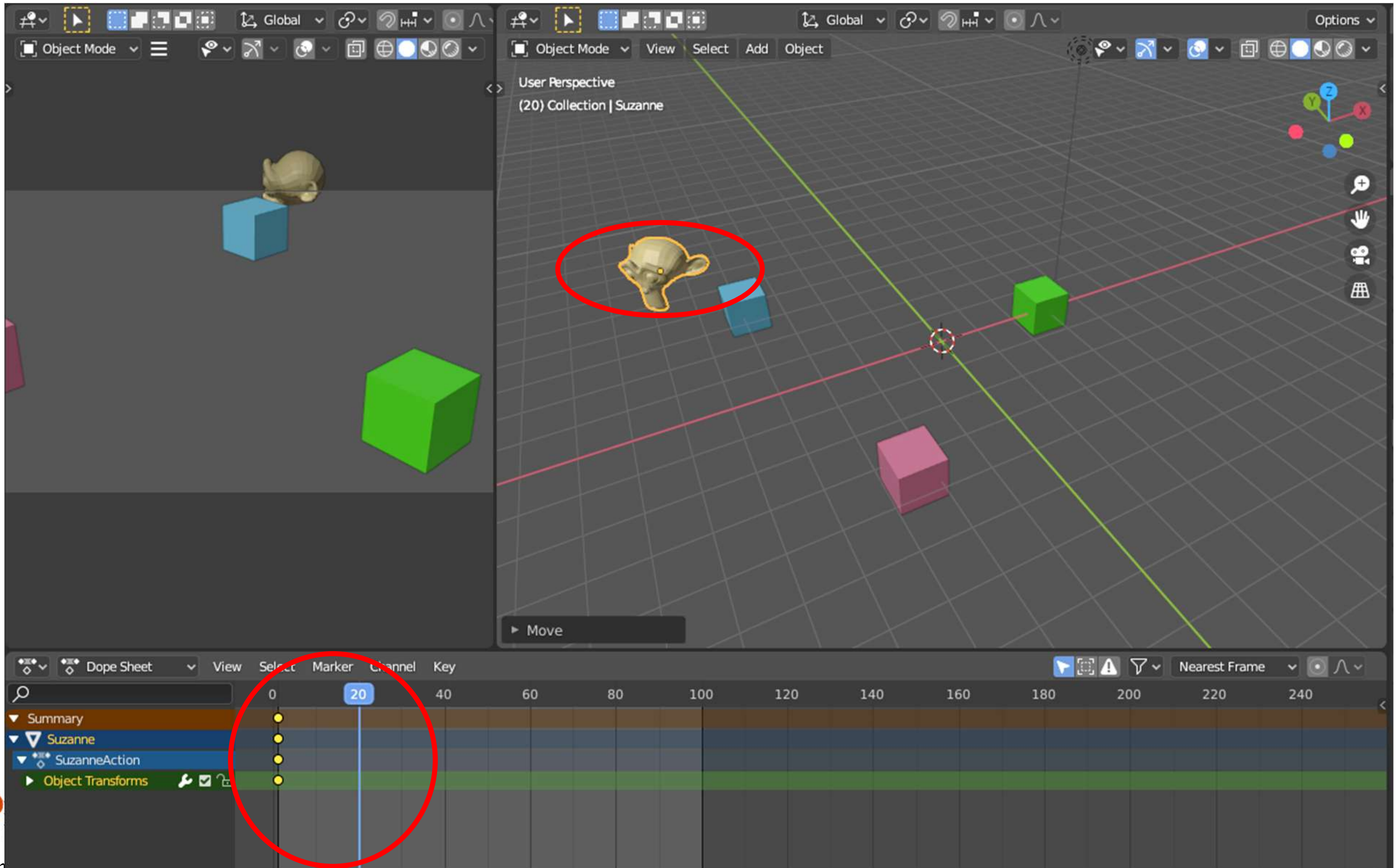






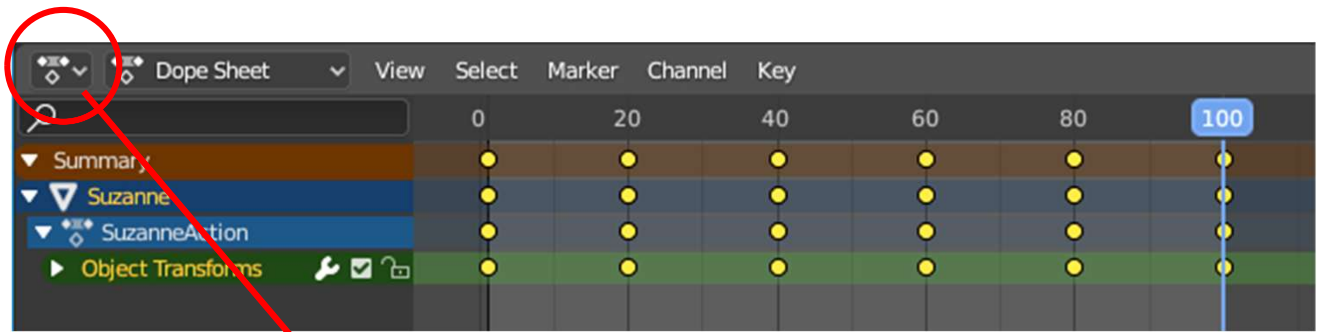
Keyframe Animation

Do it again: slide the timeline indicator to what frame number you want to set, position the object how you want it to look, and **RMB → Insert Keyframe** (or hit the **'i'** key). From the pop-up menu, select **Location, Rotation, and Scale**, indicating that you want to record location, rotation, and scale factor.

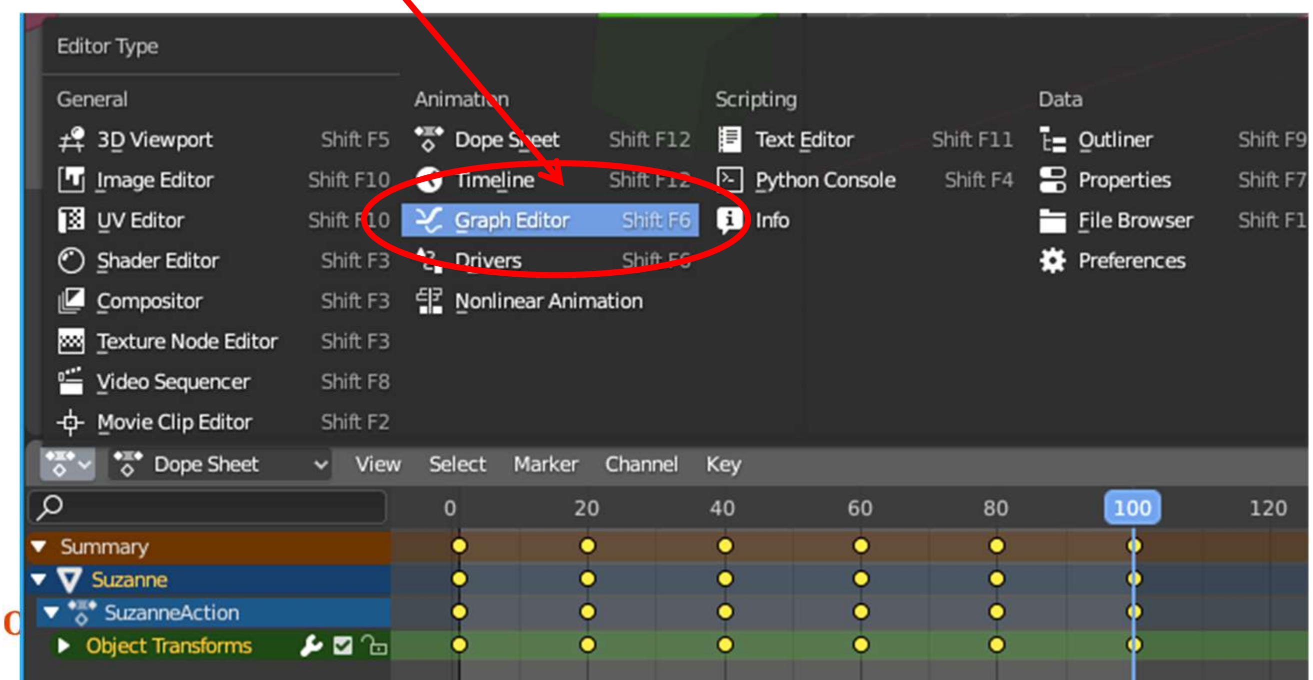


Keyframe Animation

After a while, your timeline will look like this:



Then, click here and change the type of display to the **Graph Editor**:

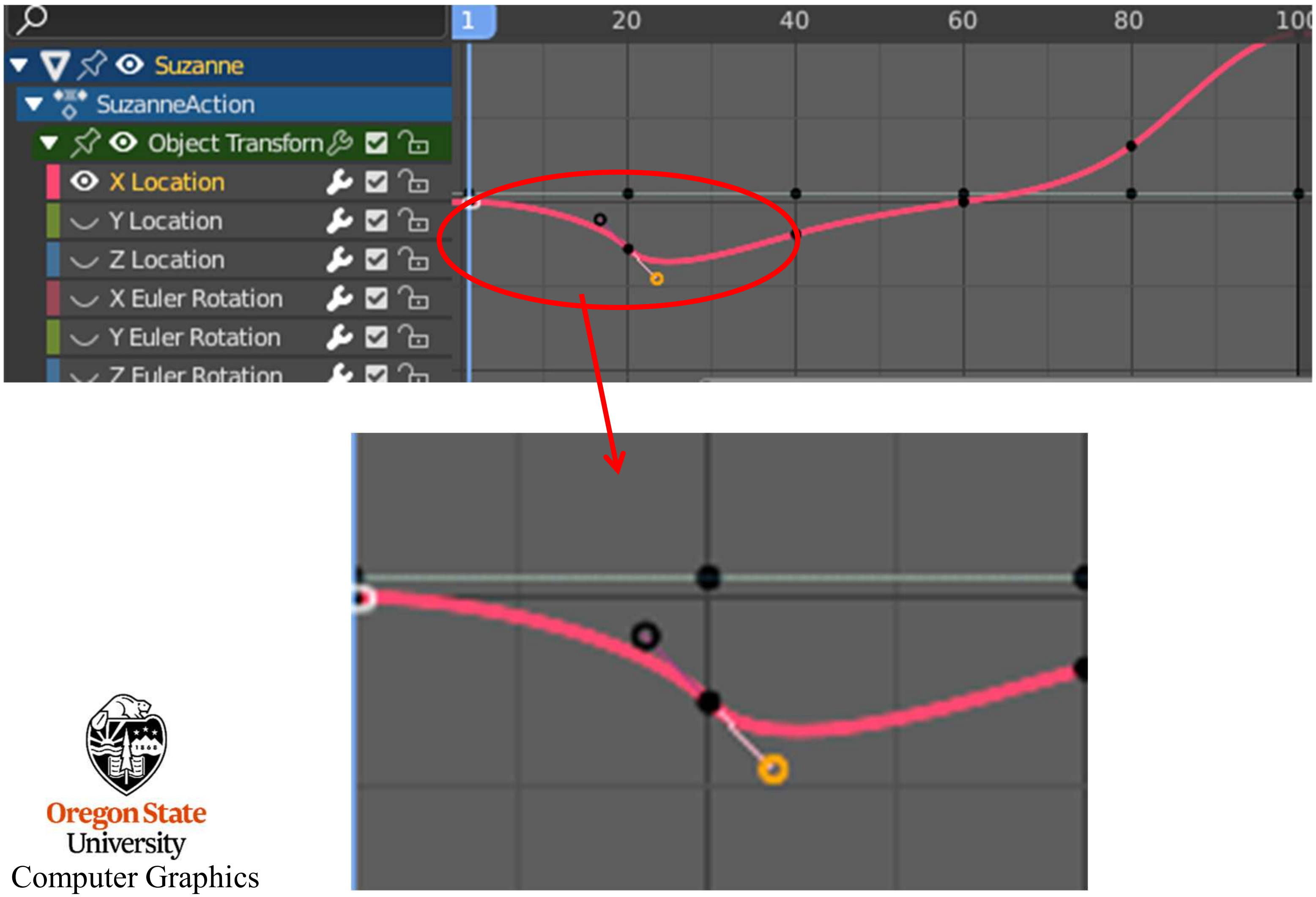


Graph Editor

Keyframe Animation

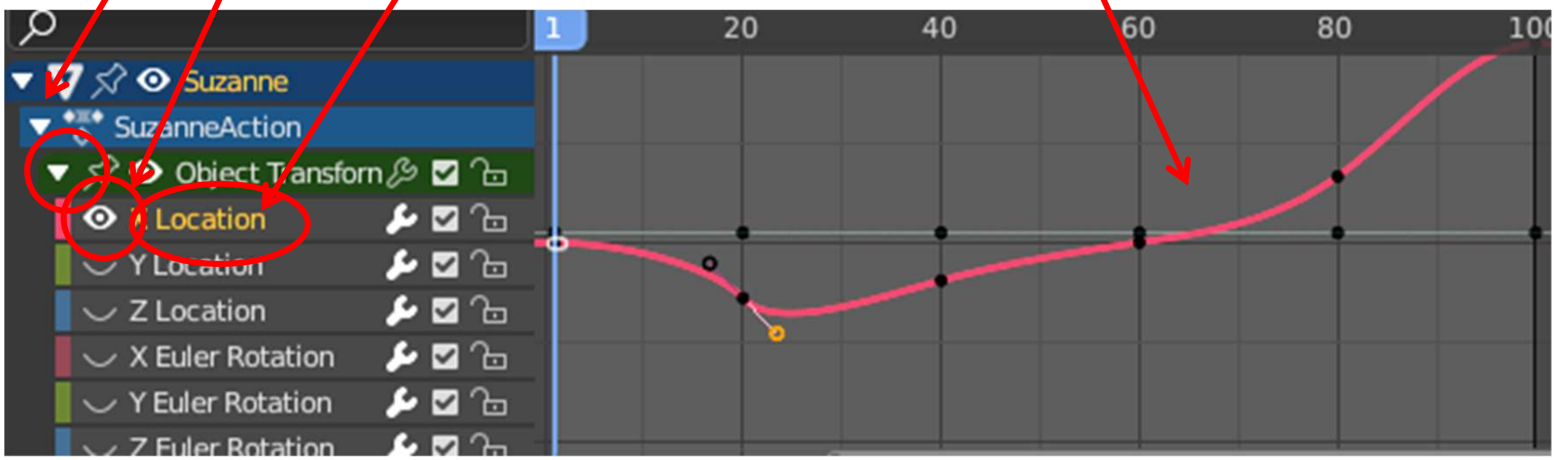
Your **Graph Editor** window should now look about like this.

Note that Blender has filled in the in-between values for you. (This is the **“In-Betweening”**.)



The Graph Editor Window

Click on the triangle. This gives you access to the curves.
Clicking on the eye toggles whether or not you can see a curve.
Clicking on the name of the curve makes that the current curve. You can then edit it.



The Graph Editor Window

Shortcuts when the cursor is in the **Graph Window**:

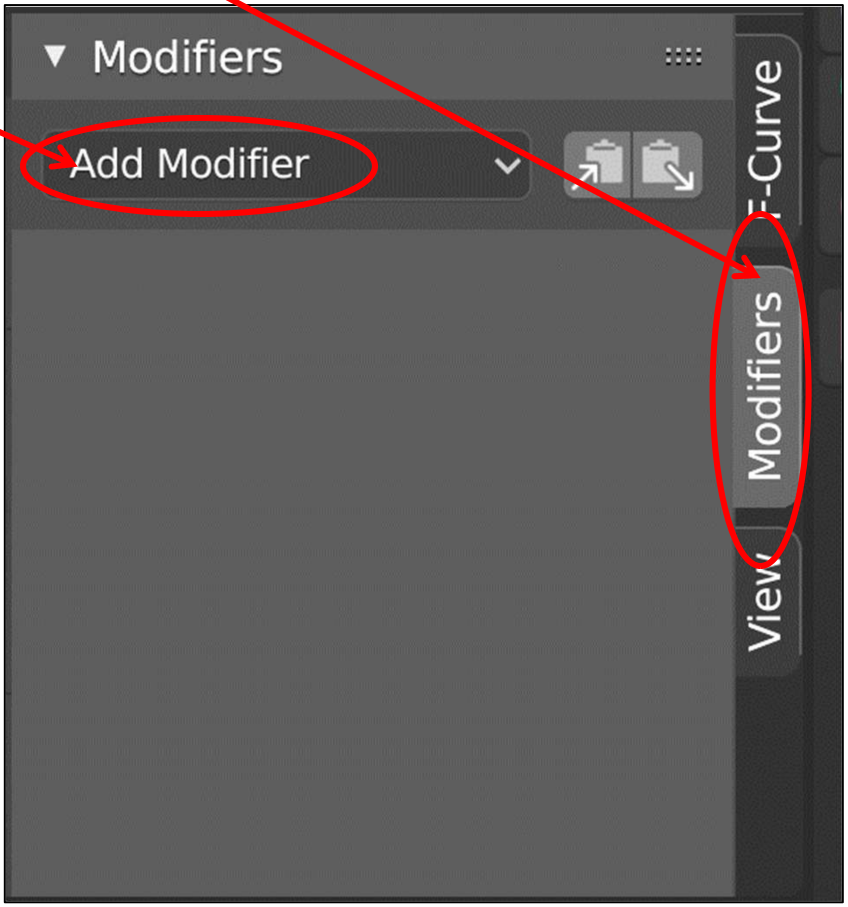
Shortcut	What it does
LMB	Select a keyframe dot
Scroll wheel	Zoom in and out of the Graph
MMB	Pan the Graph
Shift-scroll wheel	Pan in Value (vertical)
Shift-MMB	Pan in Value (vertical) and Time (horizontal)
Control-MMB	Scale in Value (vertical) and Time (horizontal)

Animation Mischief ☺

After you have selected one of the animation curves, hit the **'n'** key. Like in the 3D View, a Number Panel pops up.

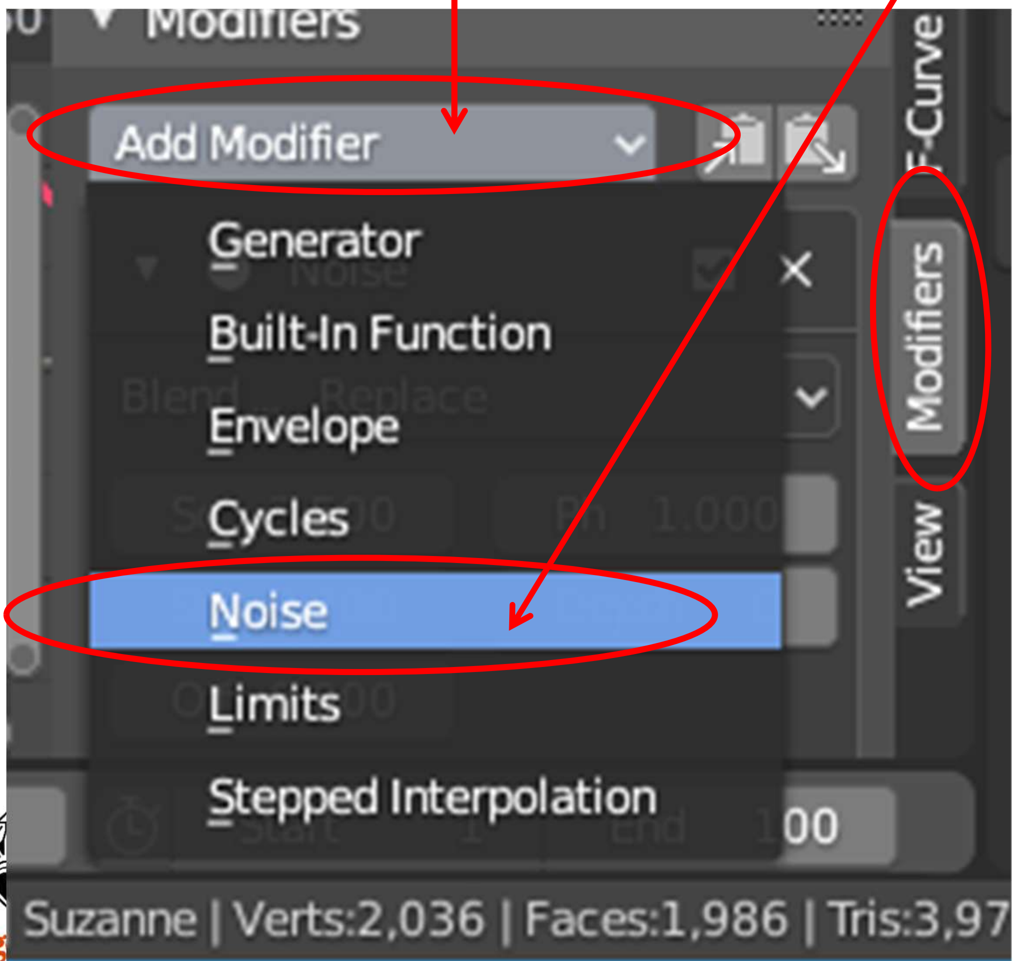
Click on the **Modifier** tab.

Then click on **Add Modifier**.



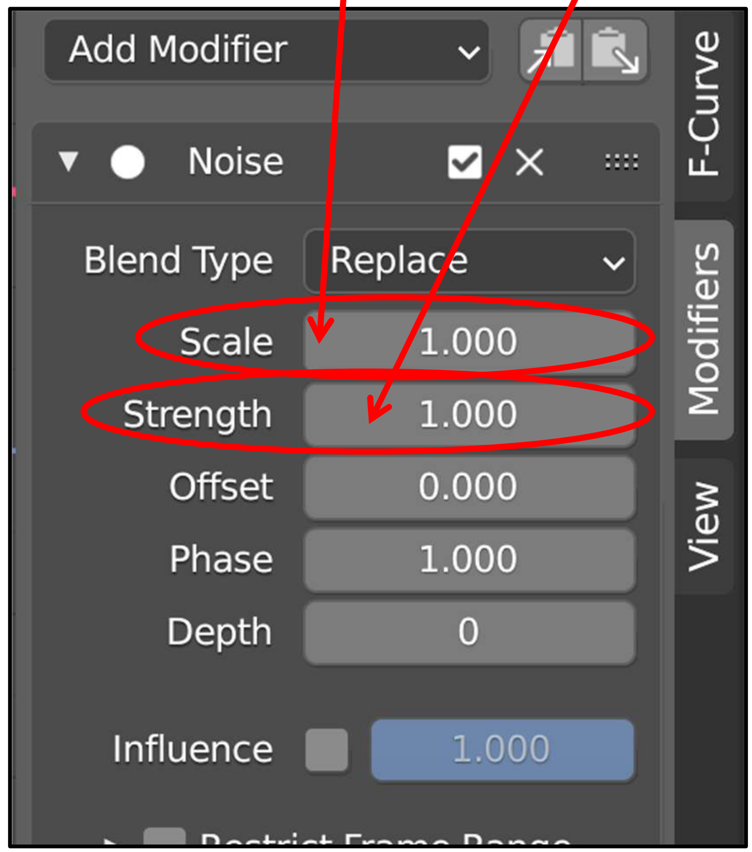
Animation Mischief ☺

Select **Add Modifier**.
From the list of Modifiers, select **Noise**.



Animation Mischief ☺

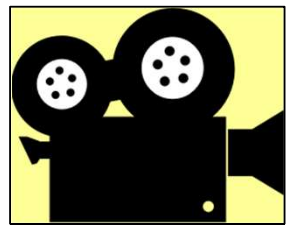
Use this menu to change the noise parameters **scale** and **strength**.
Notice what this does to the curve.
Now play the animation.



Two Characters Interacting

To avoid a collision, the monkey jumps up and the cube squishes

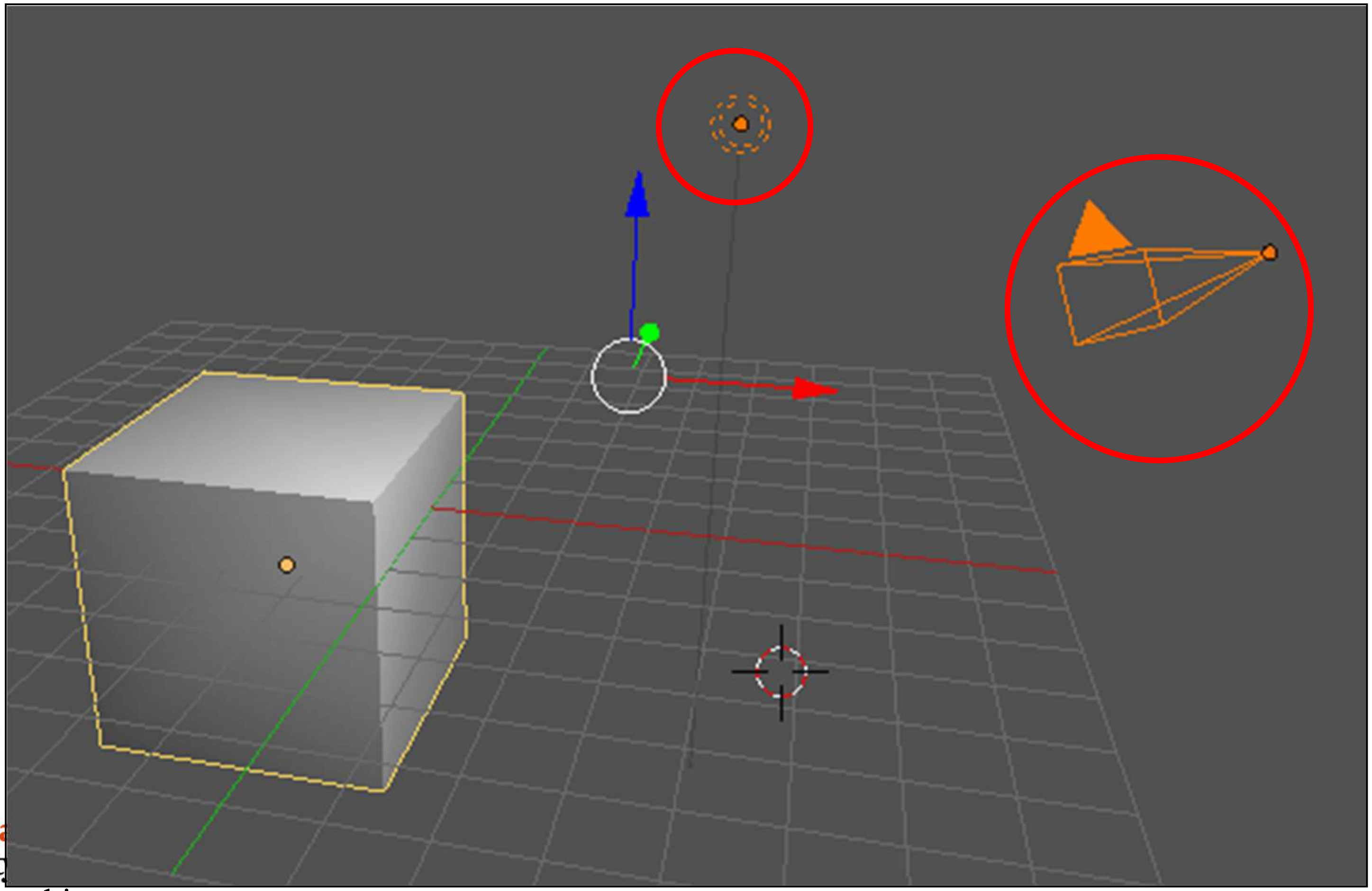
anim2.blend



anim2.mp4

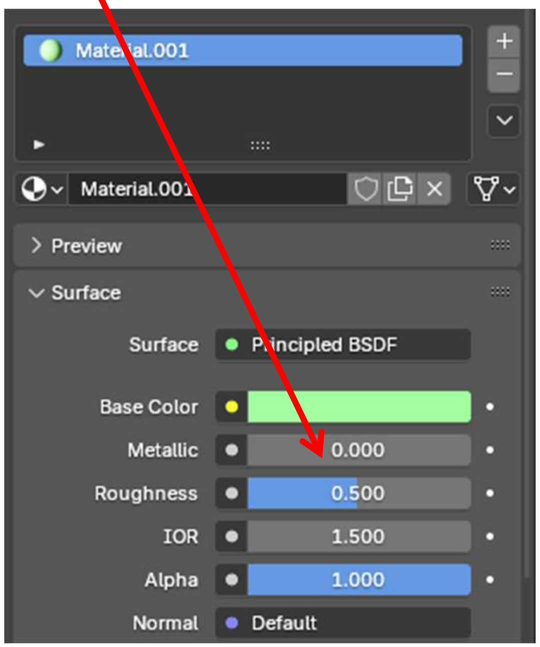
Animating the Camera and the Lamps

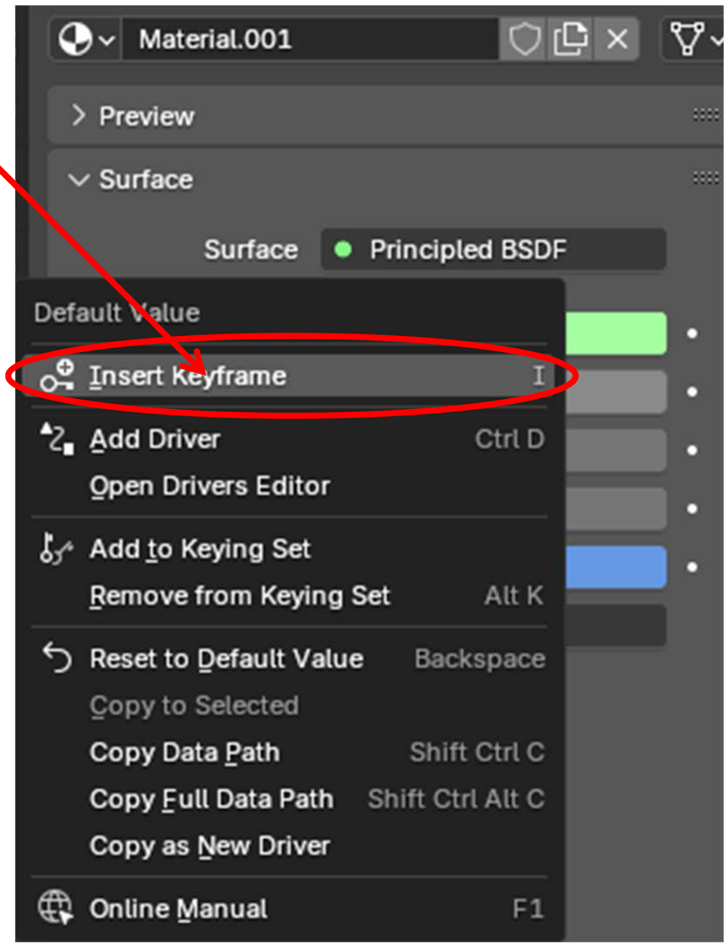
Cameras and Lamps are just like any other object. As you have seen, they can be positioned. They can also be keyframe-animated. Like other objects, just select them and hit the **'i'** key to insert a keyframe.

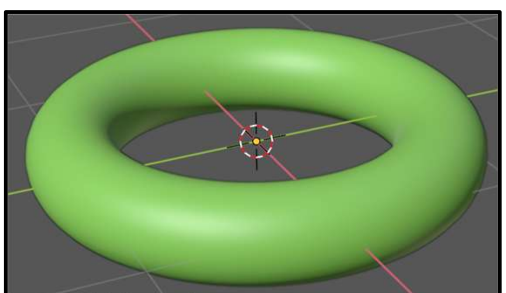


Animating (almost) Any Parameter

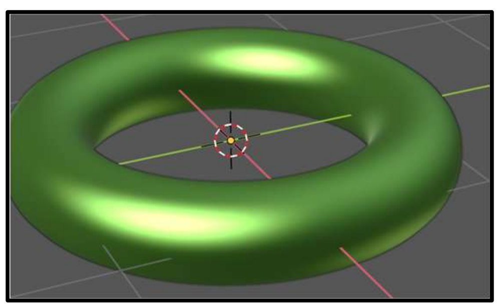
One of the many cool things about Blender is that you can do more than just keyframe-animate the objects, you can also keyframe-animate the parameters you are setting. For example, suppose you want to animate the Metallic-ness. To set a keyframe for this, **right click** on the **Metallic** box and select **Insert Keyframe** from the pop-up menu. Do this for two keyframes and then animate.







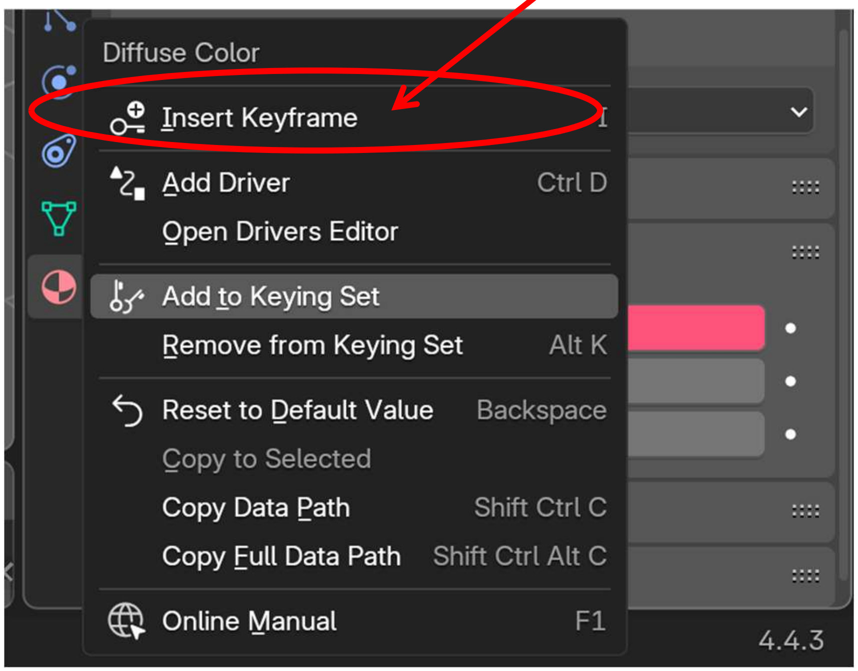
Frame 0

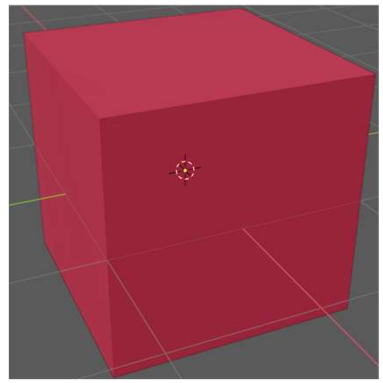


Frame 60

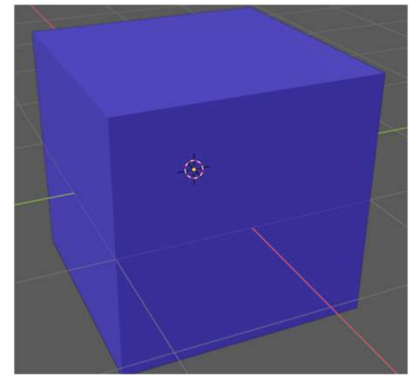
Animating Colors

Blender can also perform keyframe animation on colors. This works in both of the ways that you can set color: Viewport Display and Base Color. In either mode, set the frame counter, and then **RMB → Insert Keyframe:**

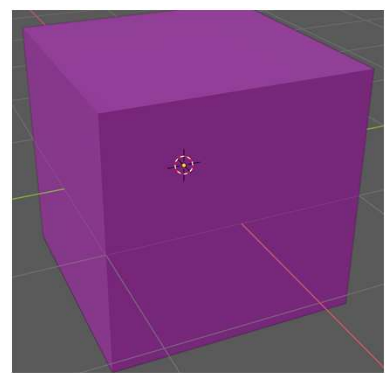




Frame 0



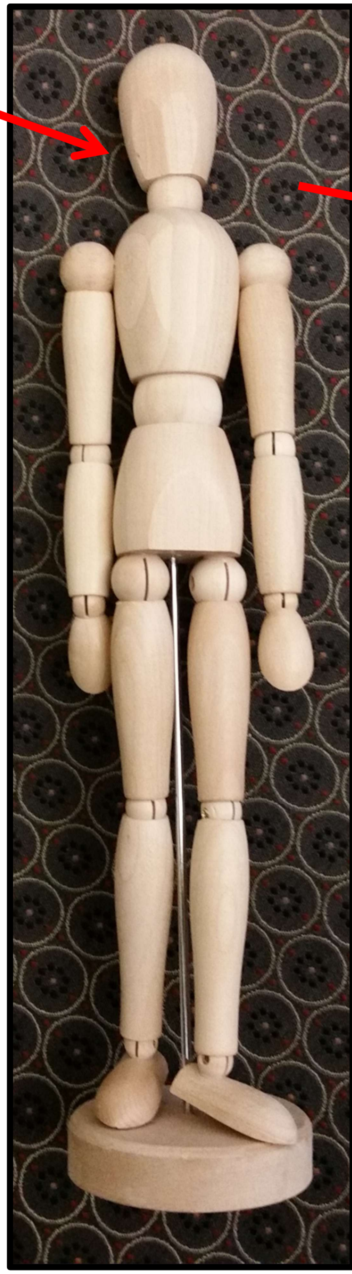
Frame 60



Interpolated Frame 30

Animating a Human-ish Form

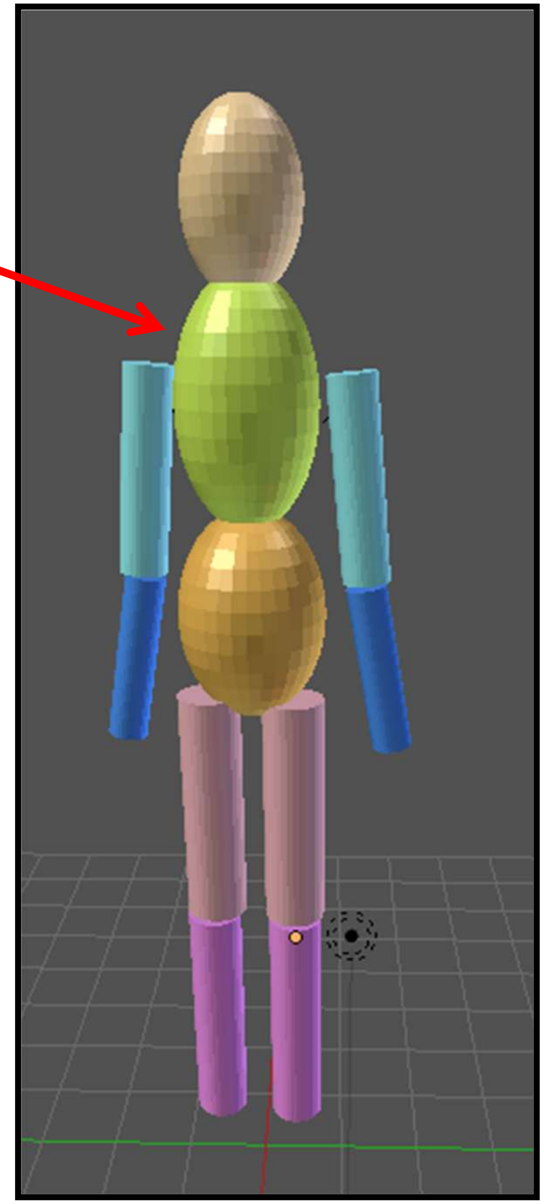
Start with this …



… and turn it into
a Blender model:

model.blend

modelmoved.blend

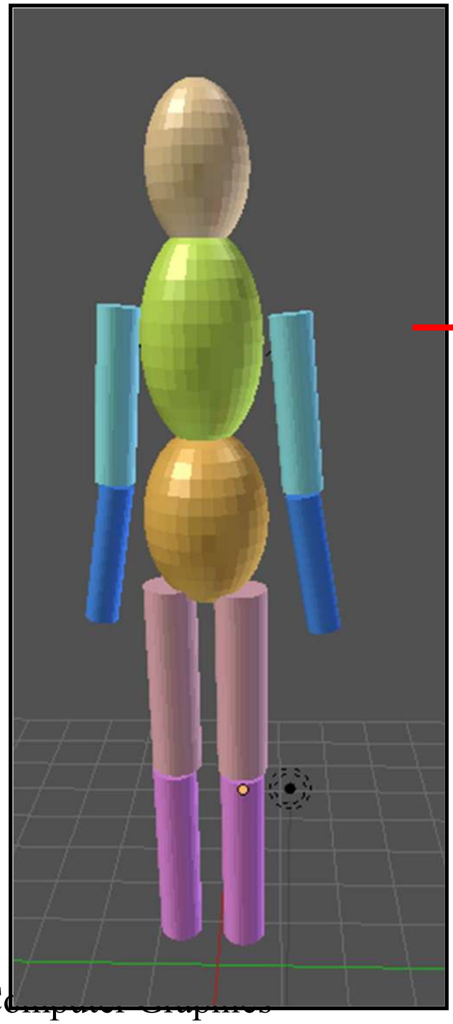


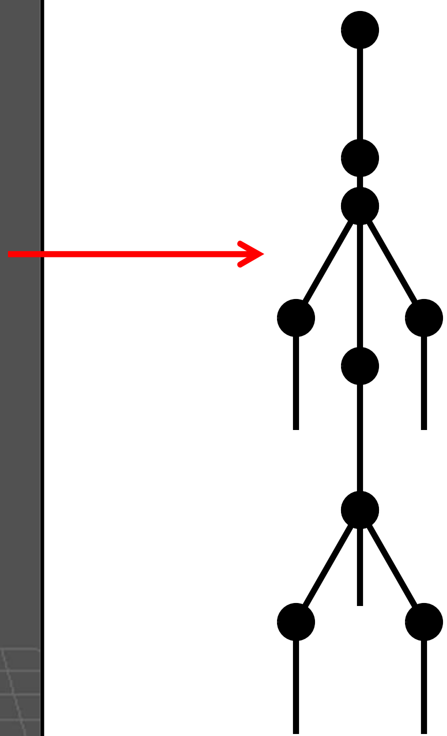
Animating a Human-ish Form

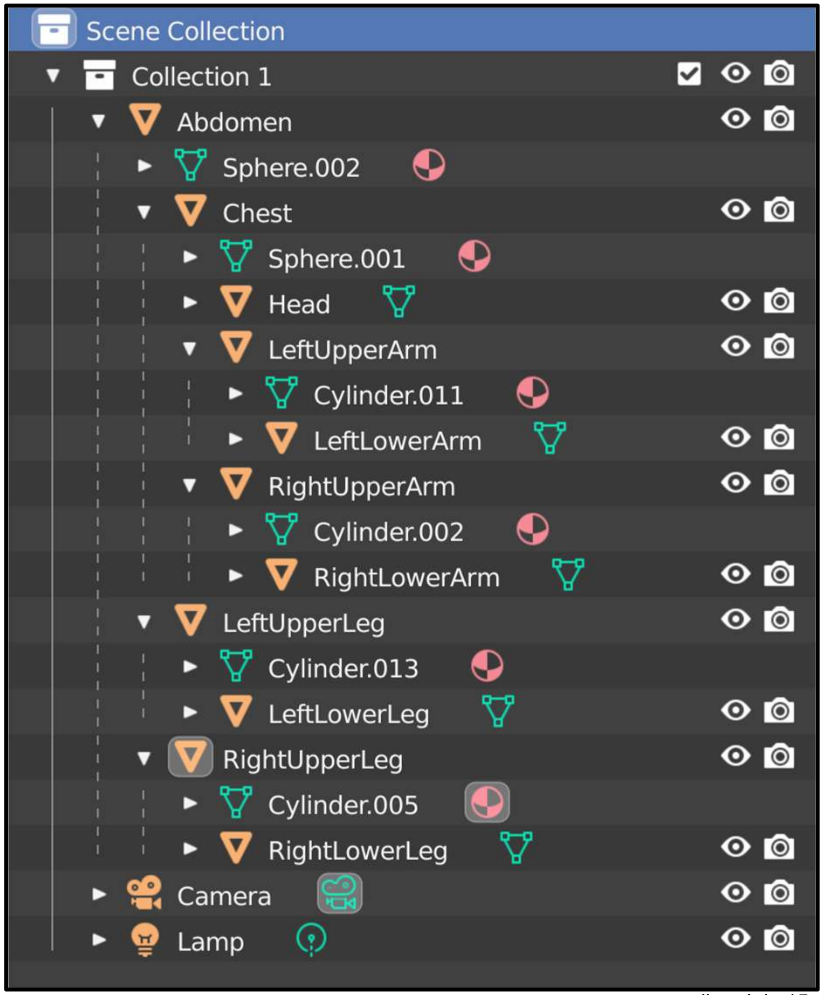
But, it's more than just a collection of parts!

Be sure that the origins of the different parts are where you want the part to pivot around.

Then establish the proper parent-child relationships.

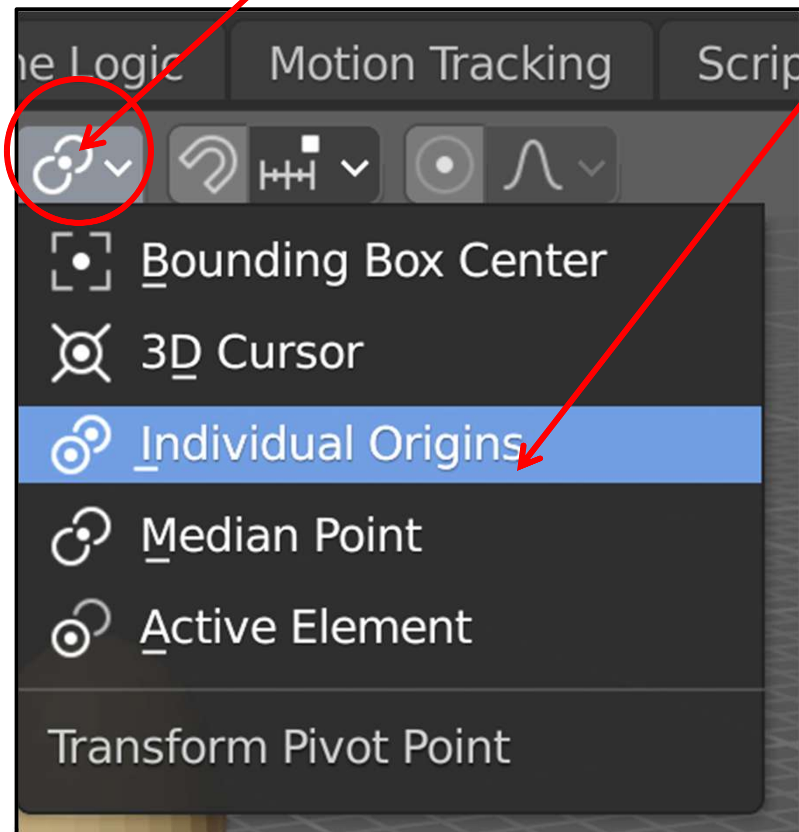




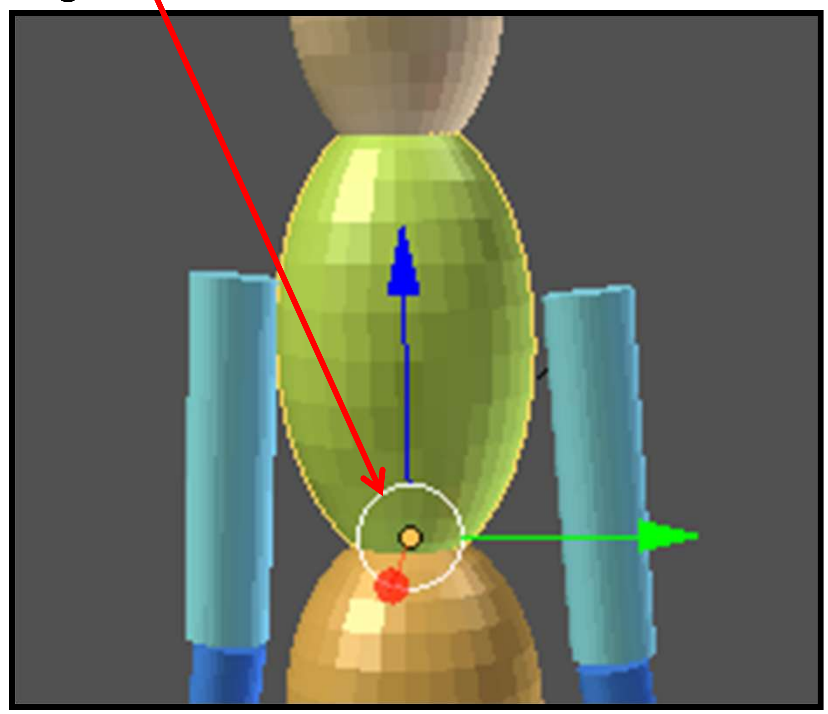


Animating a Human-ish Form

Now tell Blender to do all rotations around each part's origin.
Set the **Transform Pivot Point** by clicking here (near the top center of the Blender window):

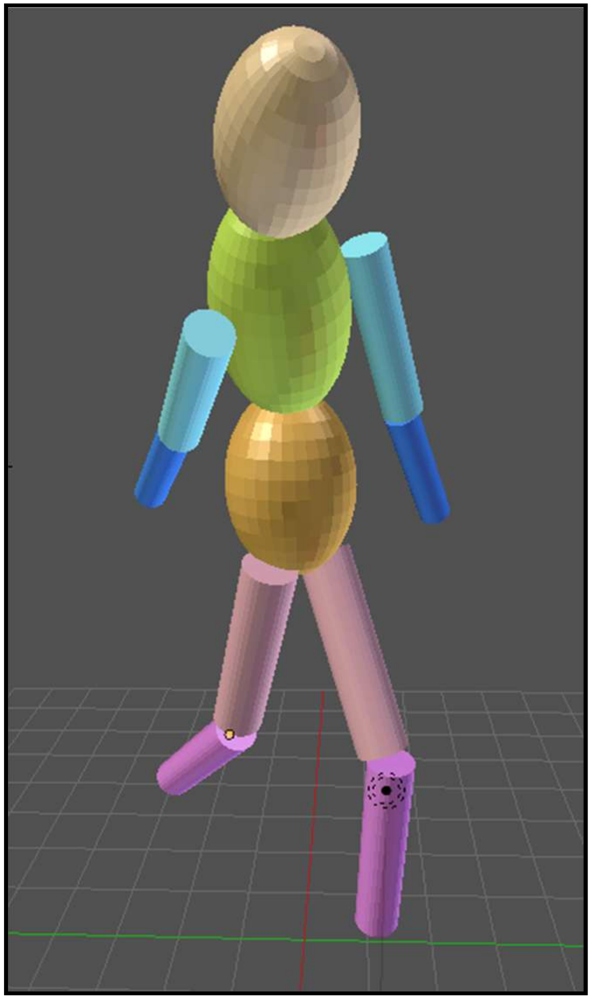


Selecting this … causes object rotation to happen about the previously-set origin



Animating a Human-ish Form

Now try rotating the individual parts.



Be sure you are rotating in *local coordinates*, e.g., r→y→y

Rigging for Animation

Laika

There is a time-honored tradition in stop-motion animation to use an internal support, called an **armature**, to help position the object at each frame.

Digital animation has adopted the same technique, and has even retained the same terminology, armature.

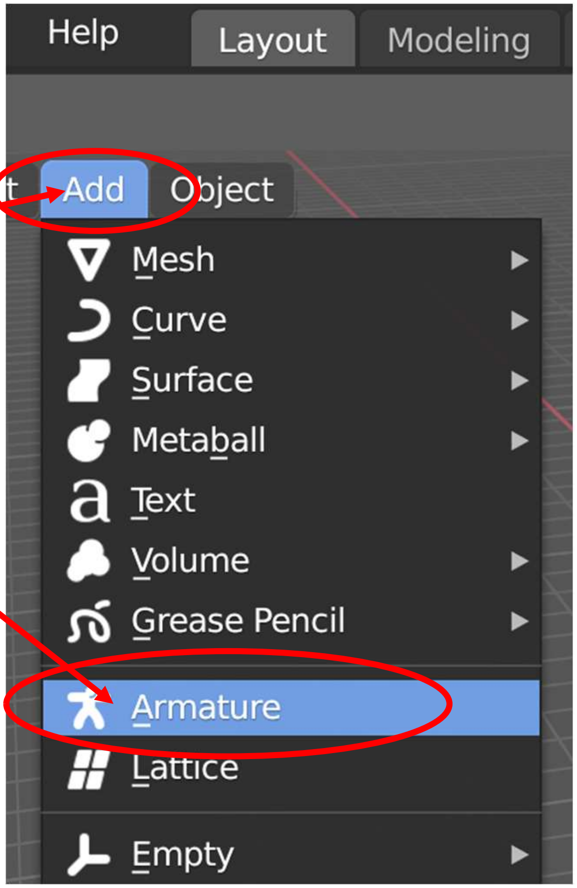
The process of creating this digital armature is referred to as **Rigging**.

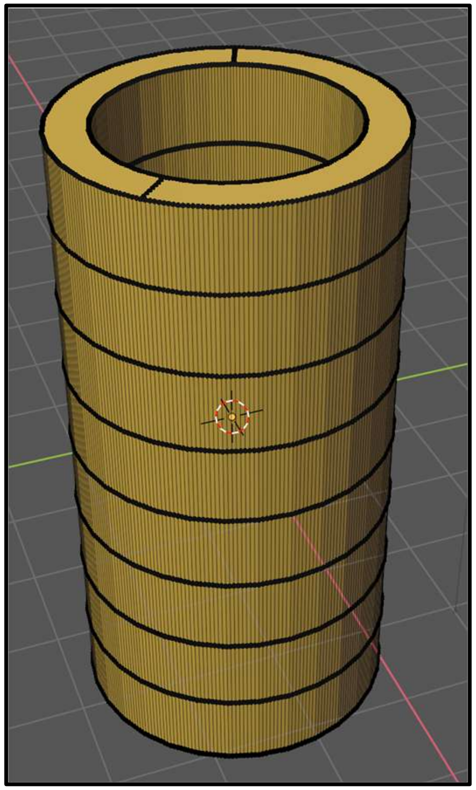
Rigging for Animation

Let's say we have a cheesy noodle character named ***Mac***. We would like to rig him to bend.

The first step is to create Mac's geometry. In this case, one cylinder was Boolean-subtracted from another and then was **Edit → Subdivide'd** a couple of times.

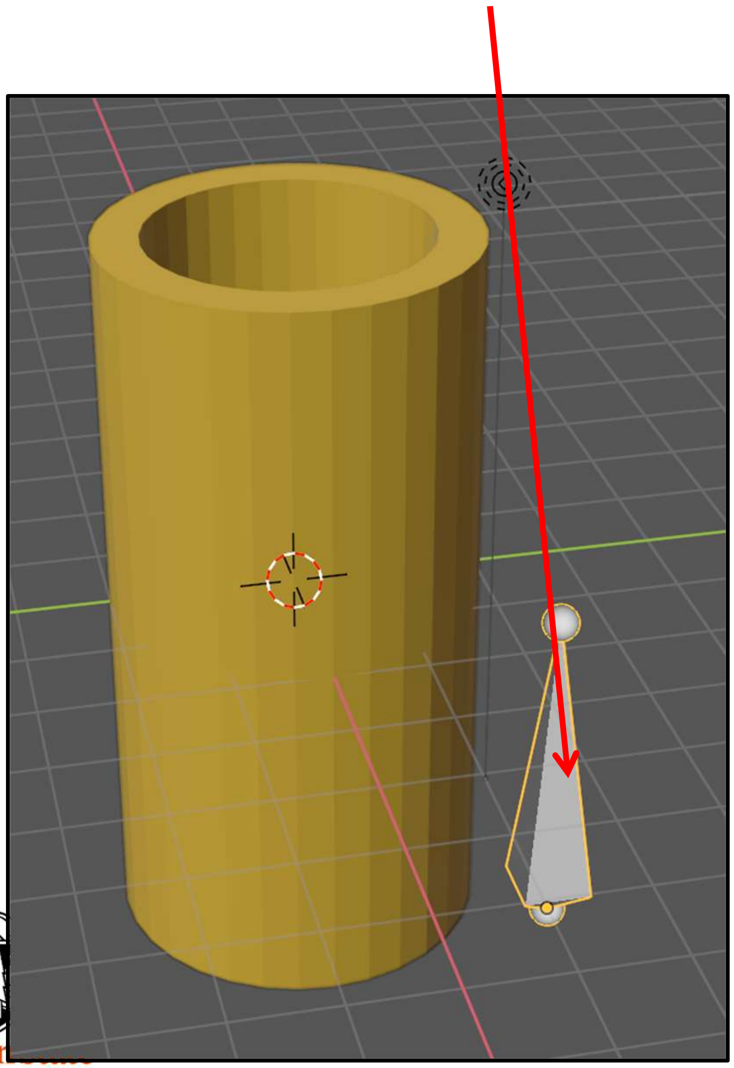
The second step is to go to the **Add** tab on the Object Tools and click on **Armature**. This brings up the sub-menu here.



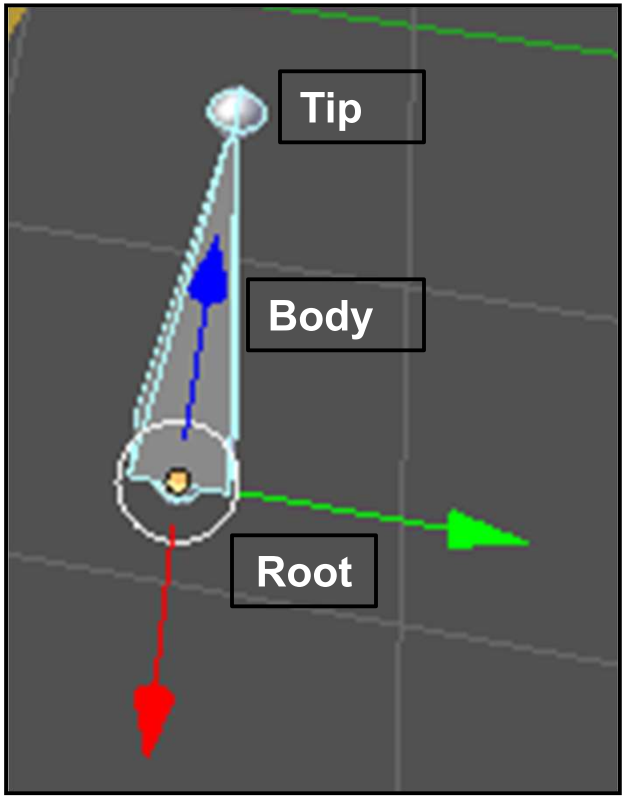


Rigging for Animation

Grab the armature just like you would any other object and position it next to Mac. (I scaled it up a couple of times to make it more visible.)



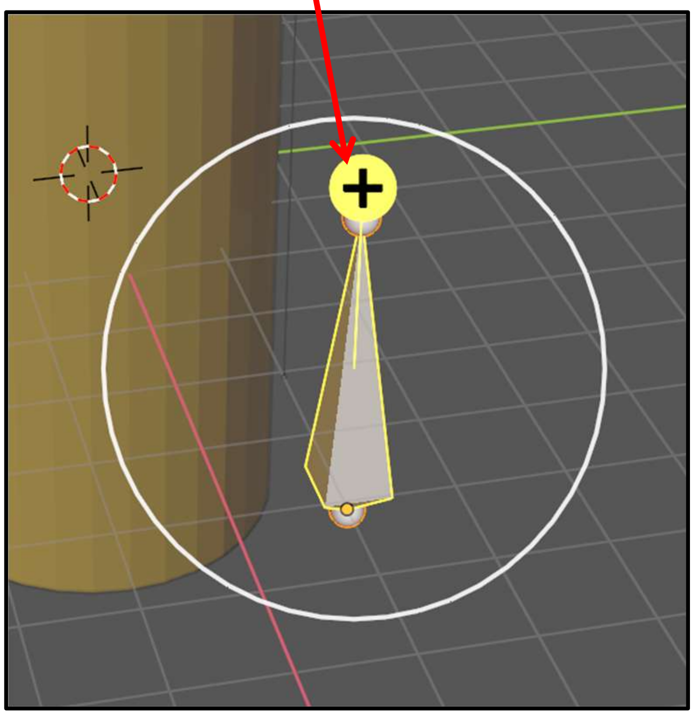
This is what the pieces of a Blender armature look like. The three sections of one of these bones are the root, the body, and the tip.

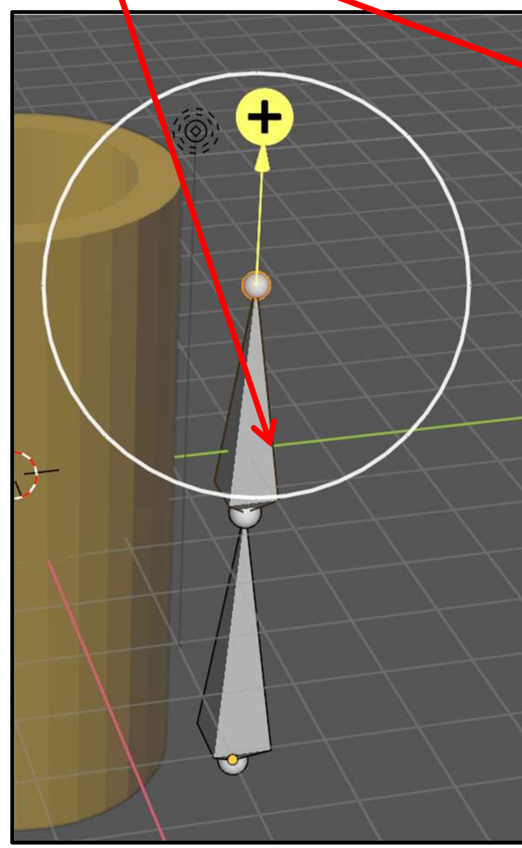


Rigging for Animation

We could put lots of bones in place to animate Mac, but, for simplicity we will just use two.

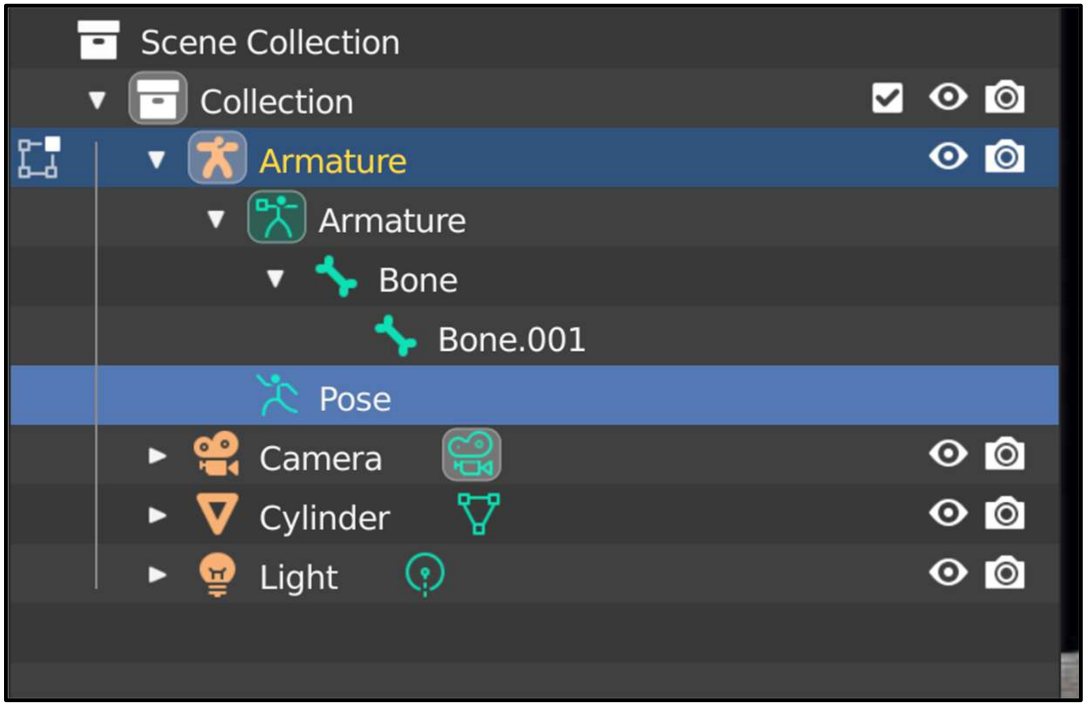
Tab into **Edit Mode**, select the **Armature**, then select **Extrude**. Lift up on the **plus sign**. This will add a second armature on top of the first and connect them tip-to-root. Click here to let go. Tab back to Object Mode.





Rigging for Animation

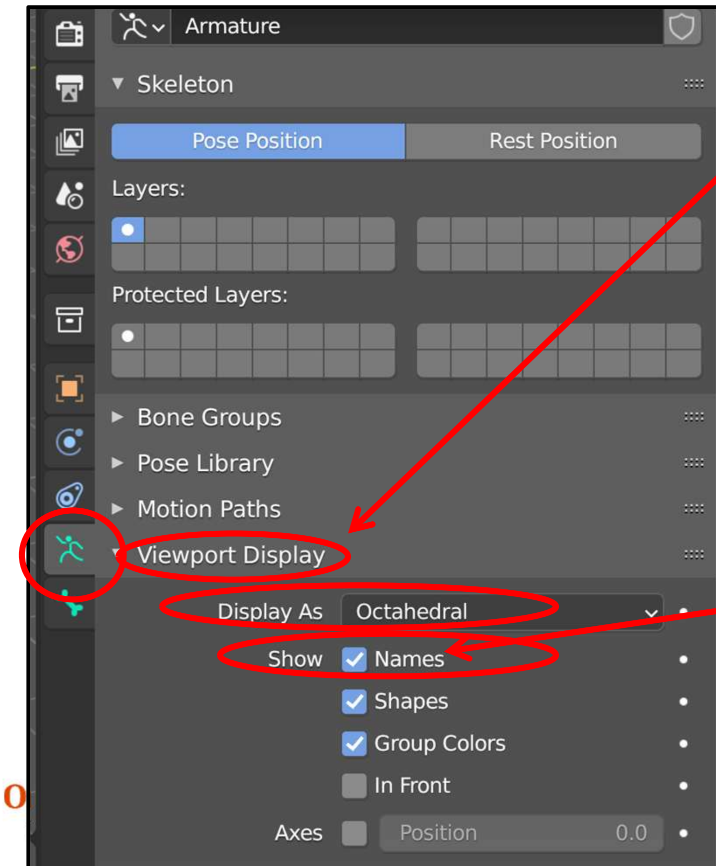
In the **Outliner**, you can see the bones you have created.



Also, in the Properties buttons, you will see that there are now **Armature** and **Bone** buttons.

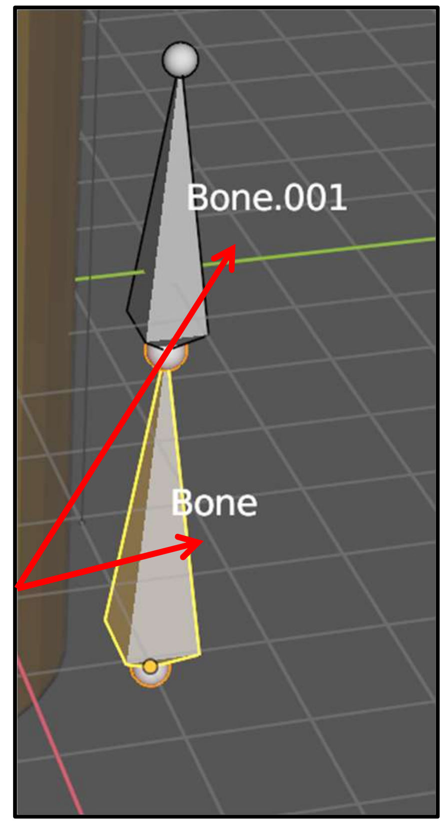
Rigging for Animation

When you click the **Armature Properties** button, a bunch of new information comes up. The most important for right now is in the **Viewport Display** tab:



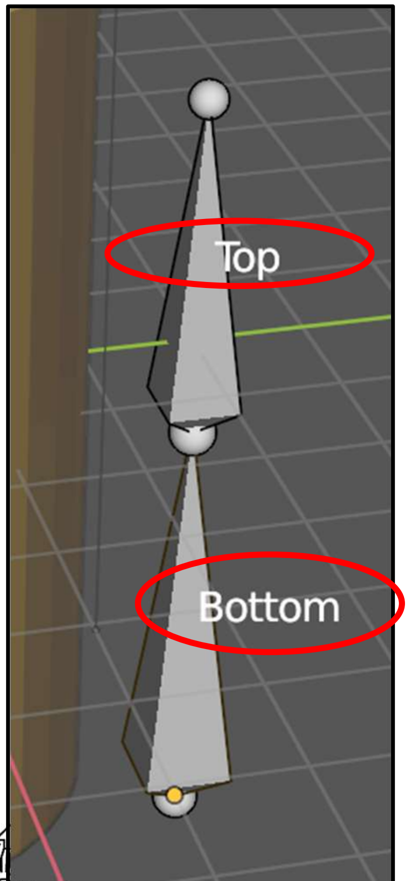
Try these. They change the appearance of the Bones.

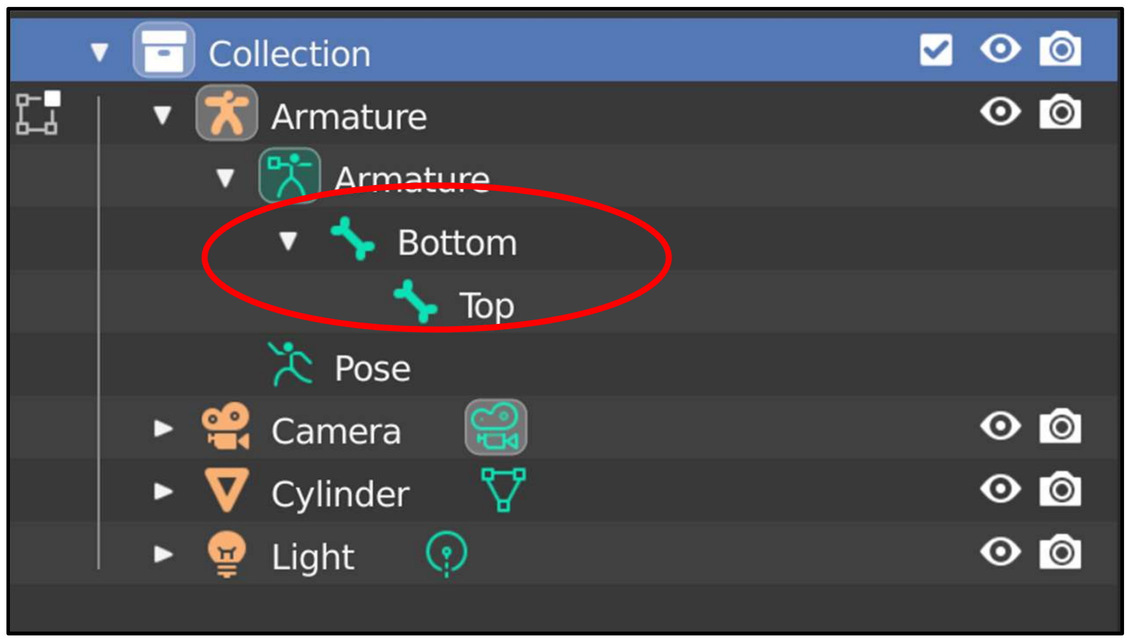
Click on **Names**. It puts the name of the Bone next to it so you know which one is which.



Rigging for Animation

It's always good to name your Bones. In the Outliner, double-left-click on **Bone.001** and rename it **Top**. Double-left-click on **Bone** and rename it **Bottom**. Your display now looks like this:

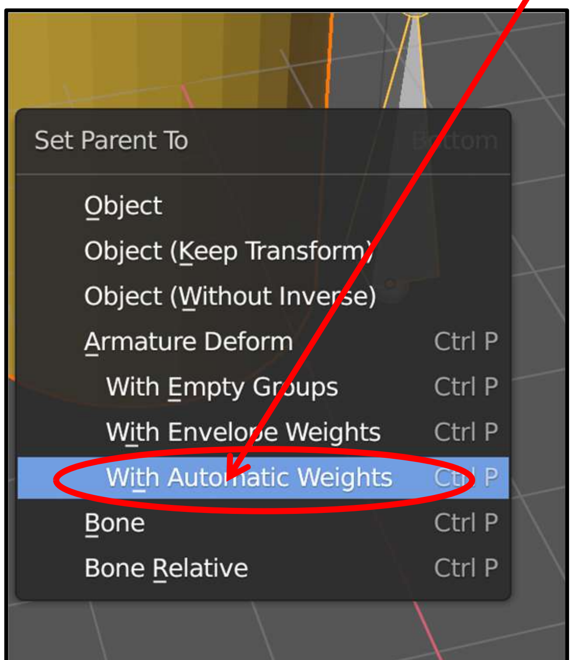


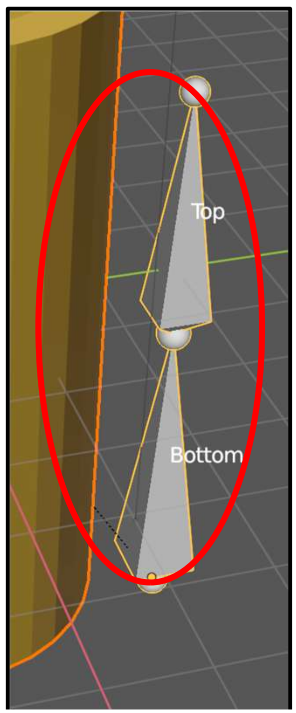


Rigging for Animation

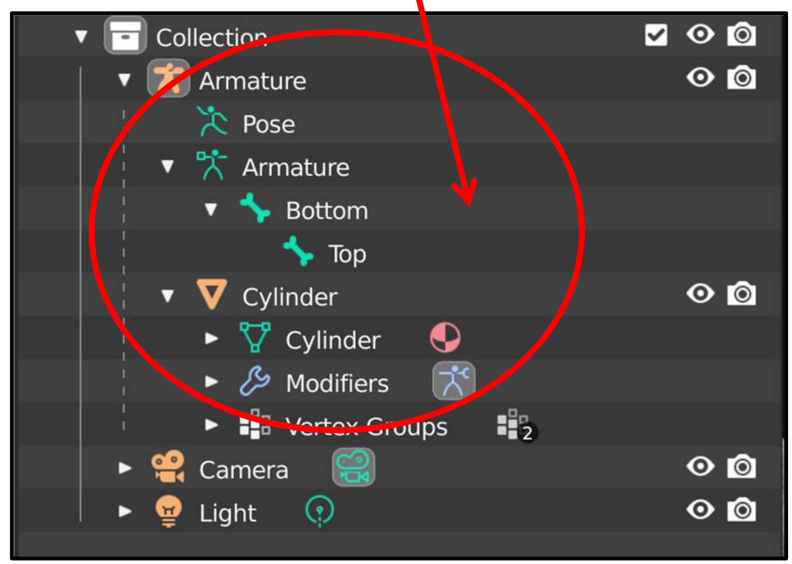
We next need to make the armature a Parent and the object (i.e., Mac) its Child. Select Mac and then shift-select the armature. (The order is important!)

To create the Parent-Child relationship, hit **Control-P**. In the pop-up menu, select **Armature Deform With Automatic Weights**





To verify that this worked, the **Outliner** will show that Mac is now part of the Armature.

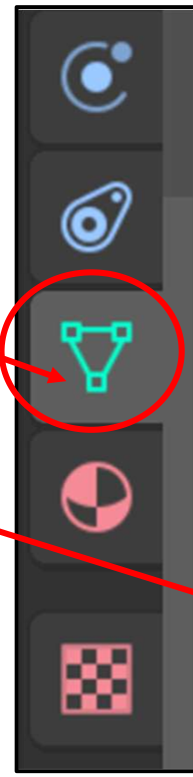


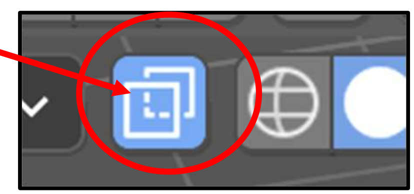
Rigging for Animation

Almost there – the last step is to assign which vertices on Mac will be deformed by the Bottom Bone and which will be deformed by the Top Bone. These groups do not need to be mutually exclusive – they can (and should) have vertices in common.

Earlier in these notes we talked about selecting multiple vertices and Vertex Groups. We are going to do that again. We are going to put some of Mac's vertices into a Vertex Group called **Bottom**, and some into a Vertex Group called **Top**. These must match the names of the respective Bones *exactly*,

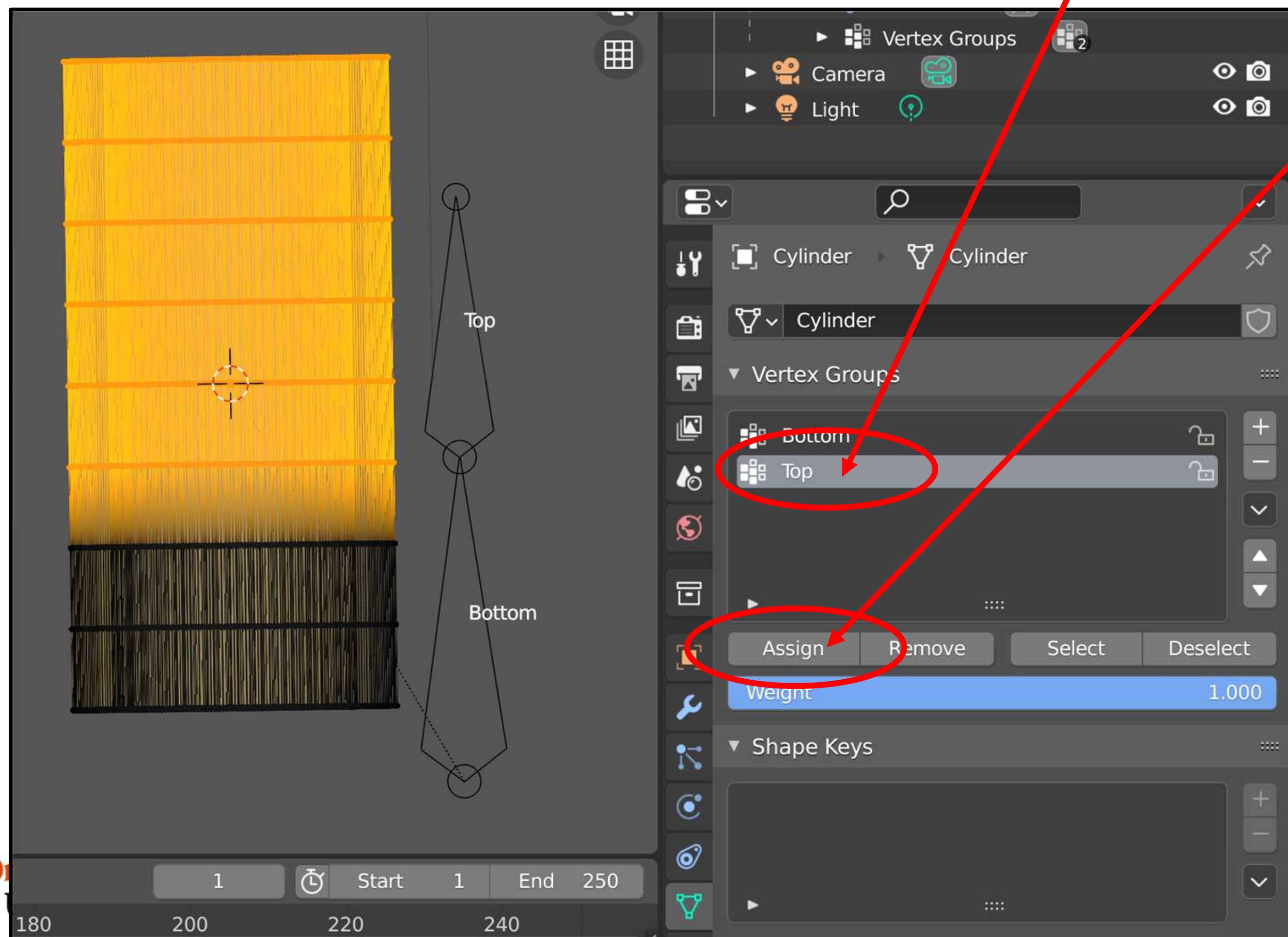
1. Select Mac
2. In the properties area, select the **Object Data Properties**
3. Tab into **Edit Mode**
4. Select **View → Perspective/Orthographic** to place yourself in orthographic display mode
5. Turn on the **X-ray** button at the top
6. Hit 'a' to unselect everything





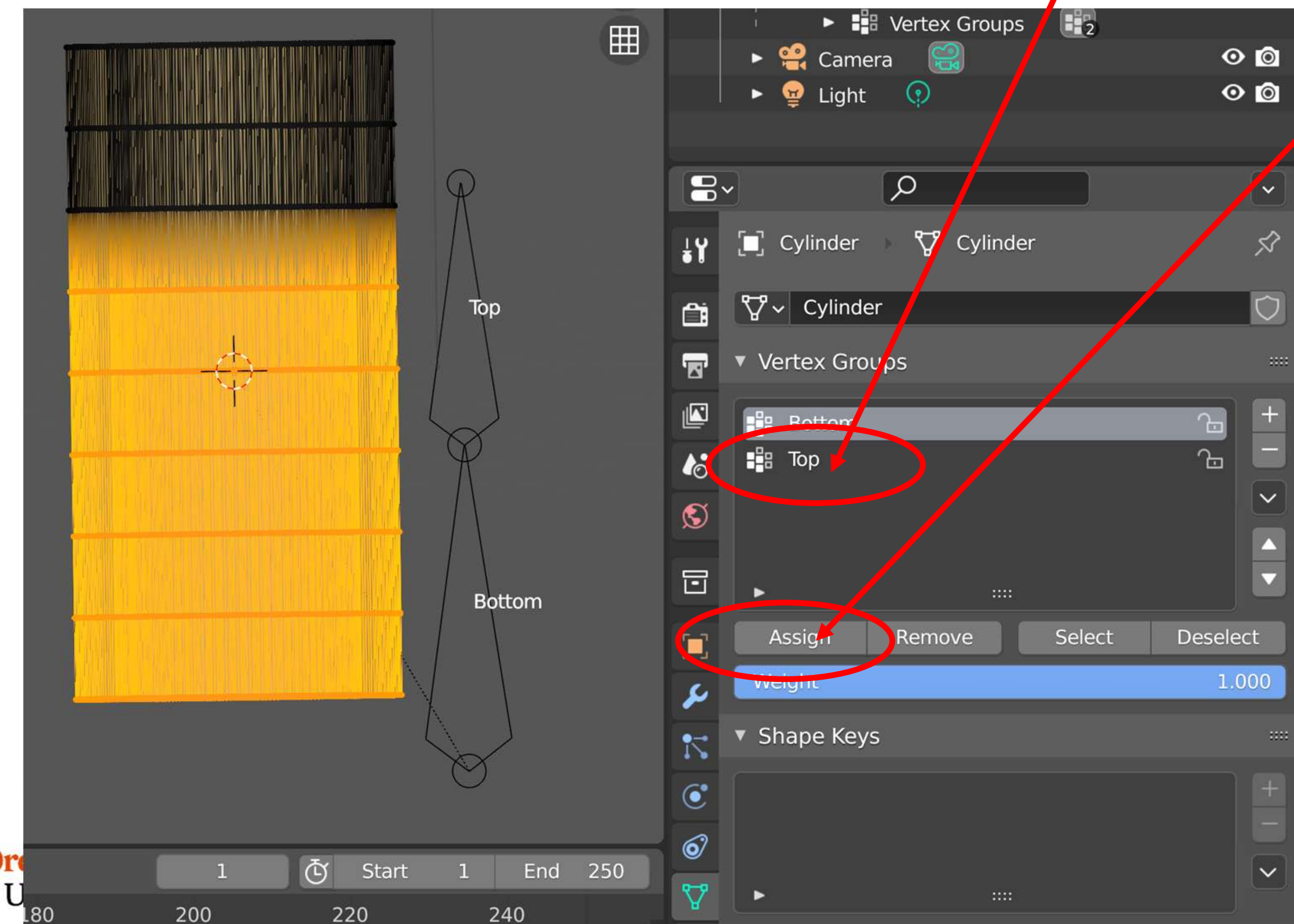
Rigging for Animation

7. Use the Border Select to select the *top 2/3* of Mac's vertices
8. Create a Vertex Group with them called Top by clicking on **Top** and then clicking on **Assign**
9. Hit 'a' to unselect everything



Rigging for Animation

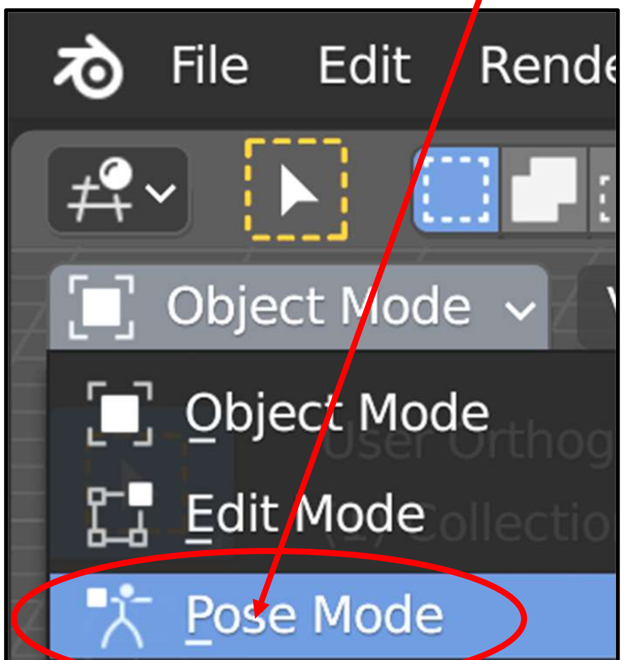
10. Use the Border Select to select the *bottom 2/3* of Mac's vertices
11. Create a Vertex Group with them called Top by clicking on **Bottom** and then clicking on **Assign**
12. Hit 'a' to unselect everything
13. Turn off **X-ray** mode and go back to **Perspective**
14. Tab back to **Object Mode**

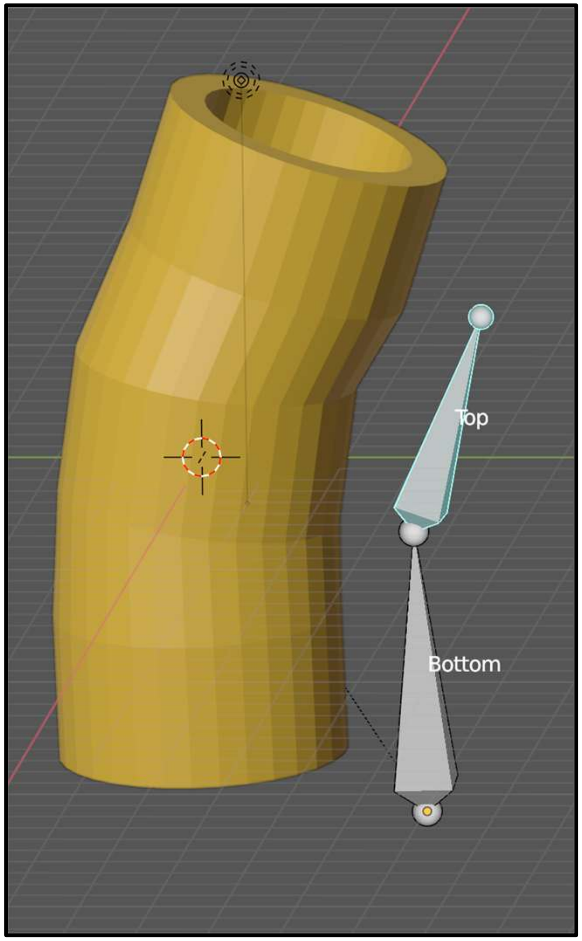


Rigging for Animation

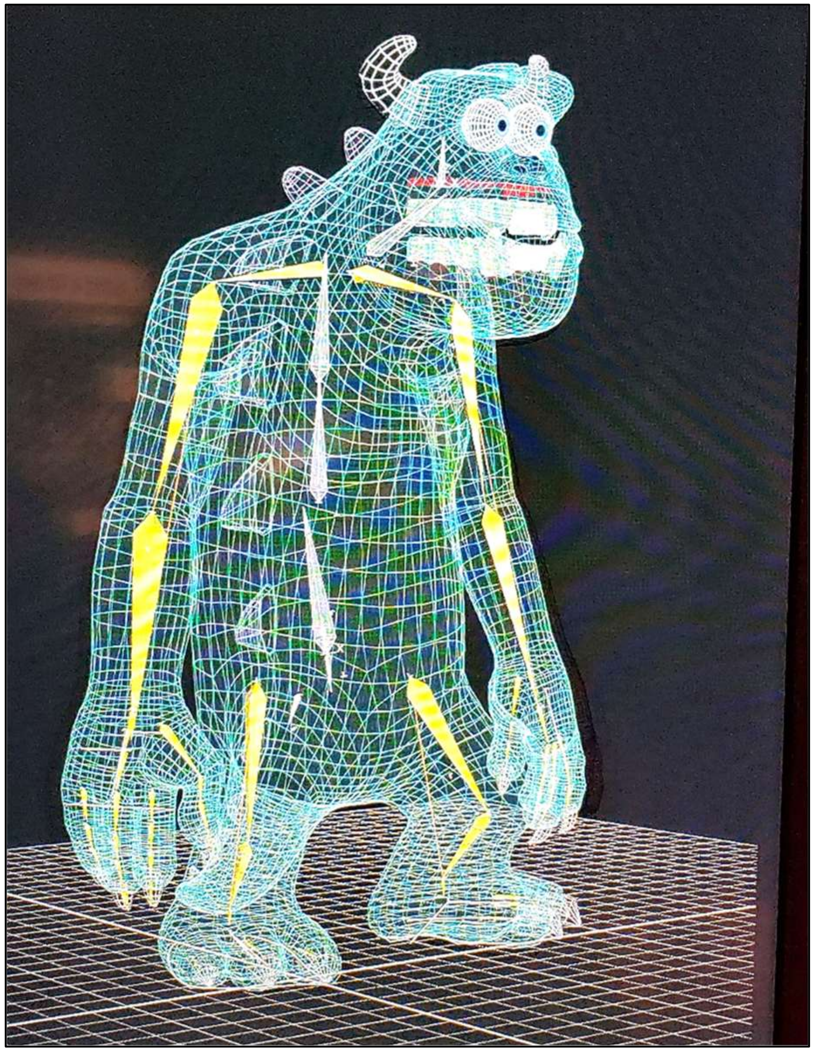
Select the **Armature** and go to **Pose Mode.**

Select the different Bones and try grabbing, rotating, and scaling them. Obviously, a serious Mac animation will require more than two Bones! Bone transformation can be keyframed just like transformation parameters of any other object.





Rigging in the Pixar Movie *Monsters, Inc.*

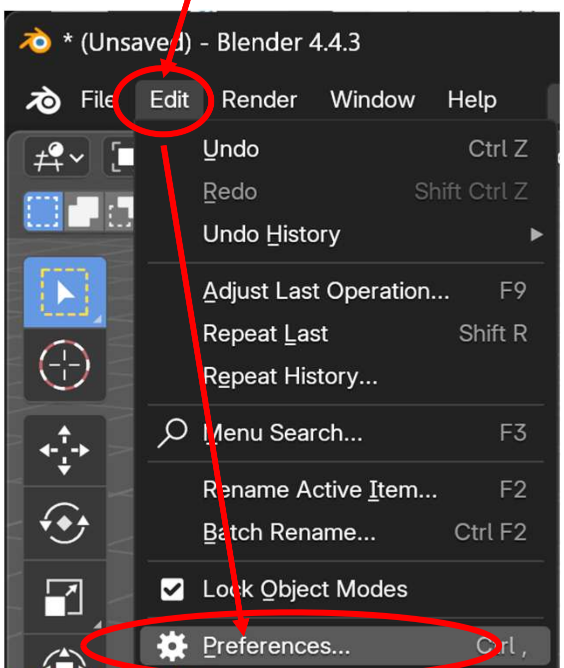


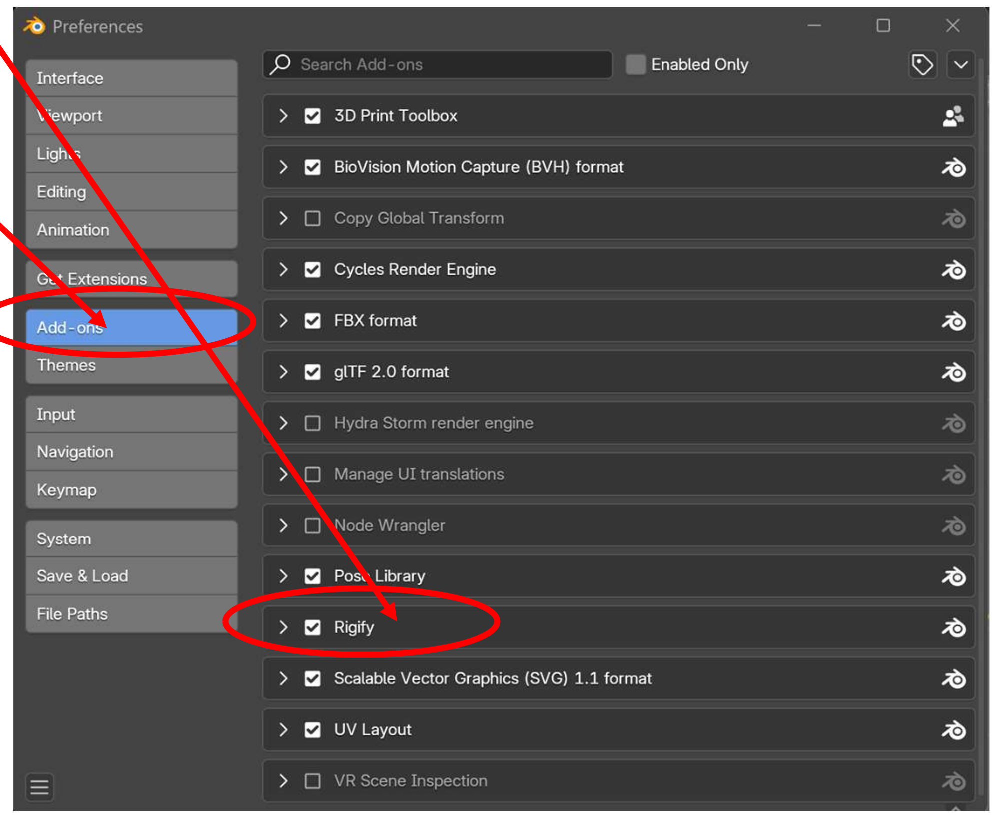
This is from the travelling exhibit *The Science Behind Pixar*. If you ever see that it is coming to a science museum near you, be sure to go see it!

The Rigify Blender Add-on

If you are interested in rigging a human or an animal, there is a great Blender Add-on called **Rigify** that will setup the rigs for you. To enable Rigify:

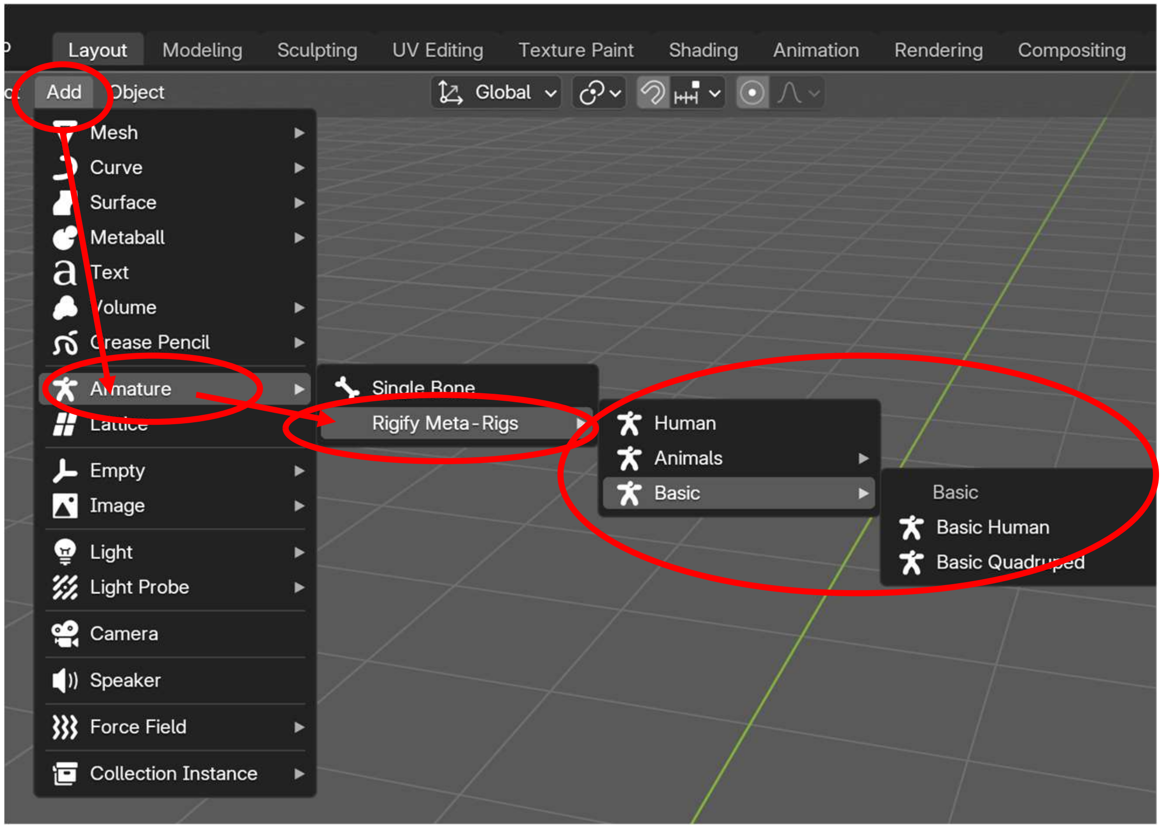
1. Go to **Edit** → **Preferences**
2. Click on **Add-ons**
3. Scroll down until you see **Rigify**, then click its checkbox

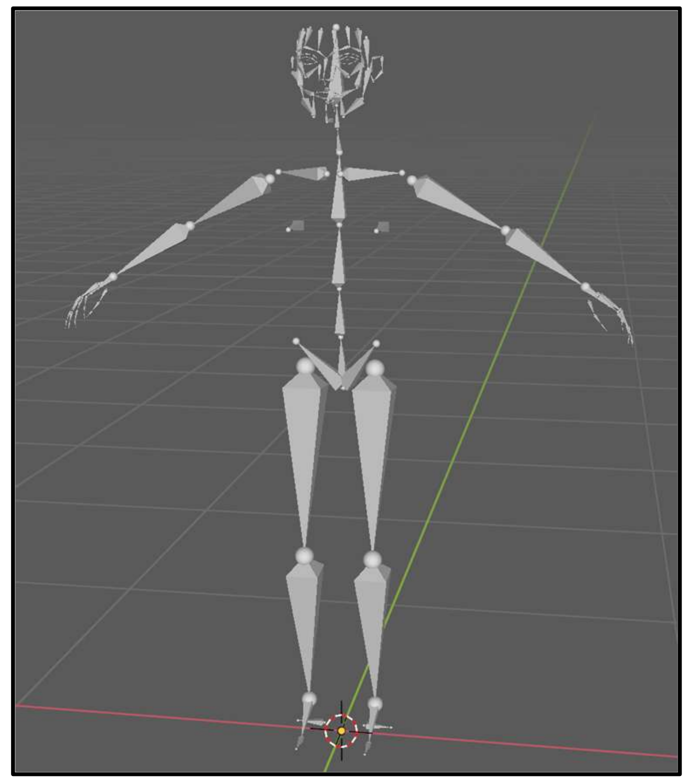




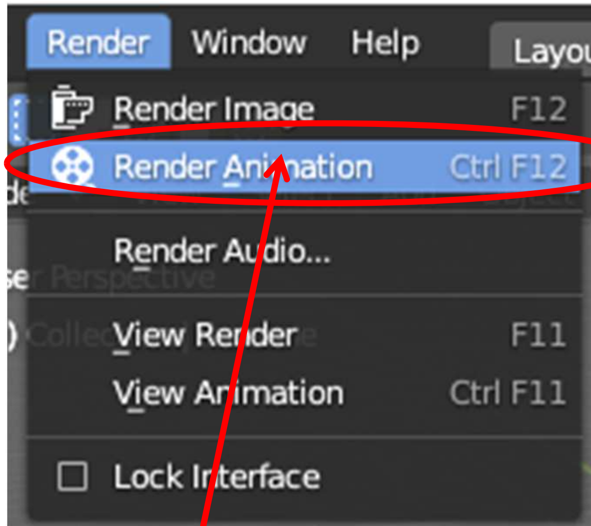
The Rigify Blender Add-on

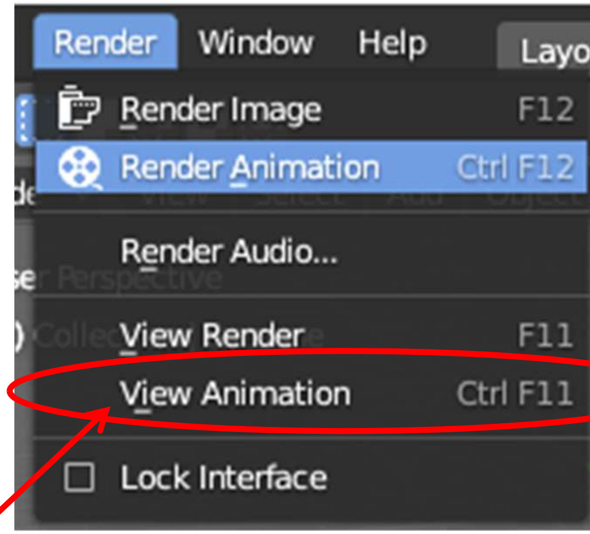
To bring in a rig, **LMB → Add → Armature → Rigify Meta-Rigs → , , ,**





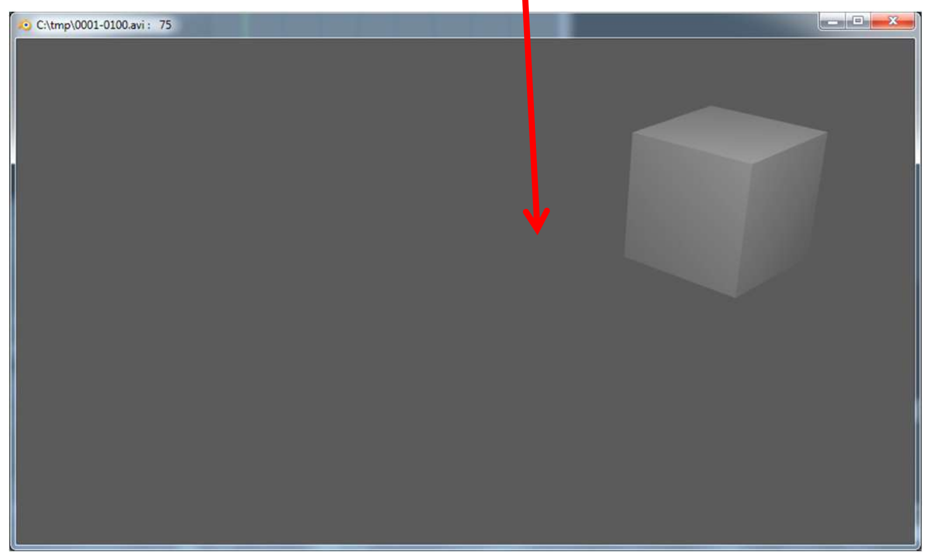
Rendering an Animation





This kicks off the rendering of all your animation frames in order

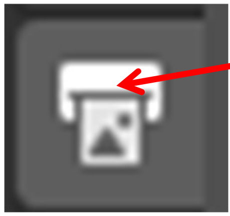
This brings up a separate window and plays back your animation.



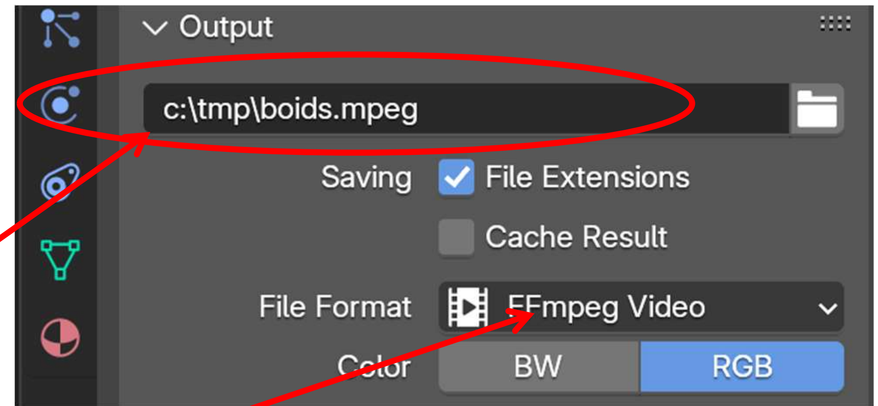
Hint: if this is just a test render, and you have lots of time-consuming visual effects going on, you might cut down the resolution and/or the number of rendered frames to speed things up.

Rendering an Animation to a File

First, go to **Output Properties**



Before saving the animation rendering, you need to specify the file name to put the animation into. In my case, this was:



C:\tmp\boids

and the type of file format that it is to have

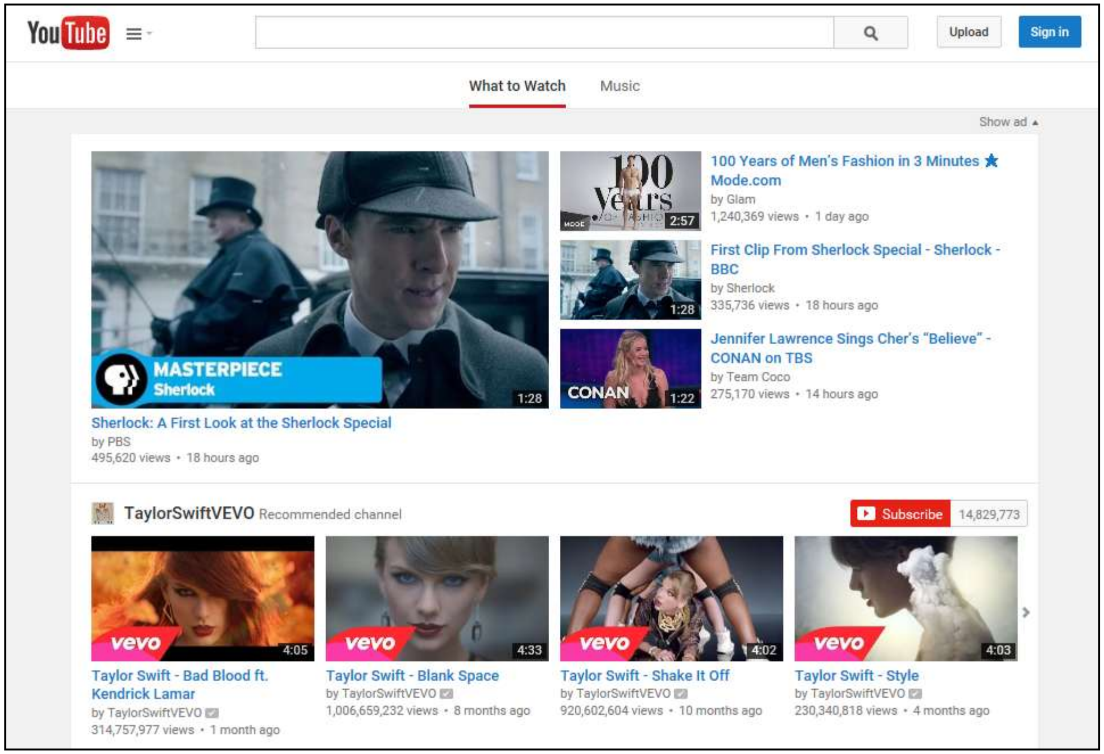
Then select **Render Animation**. In my case, this rendered 300 frames of a boids animation and placed the result in a file called:

C:\tmp\boids.0001-0300.mkv

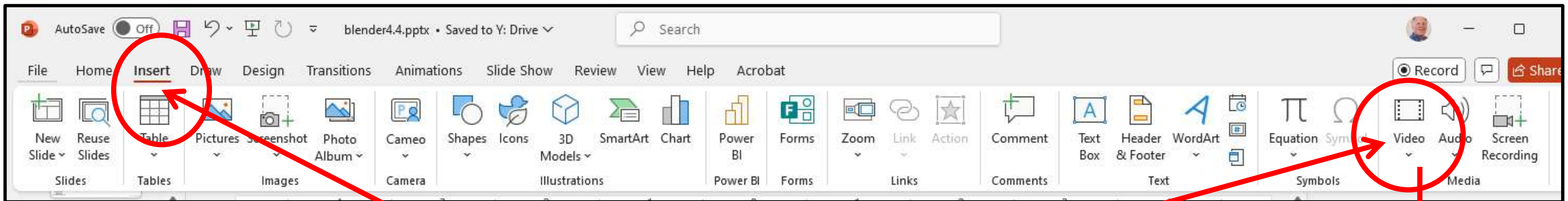
that was 1.3 MB in size.

Importing an Animation into YouTube

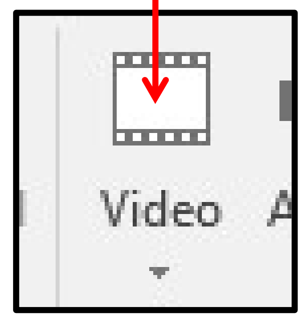
YouTube accepts videos in **MPEG** formats



Importing an Animation into PowerPoint

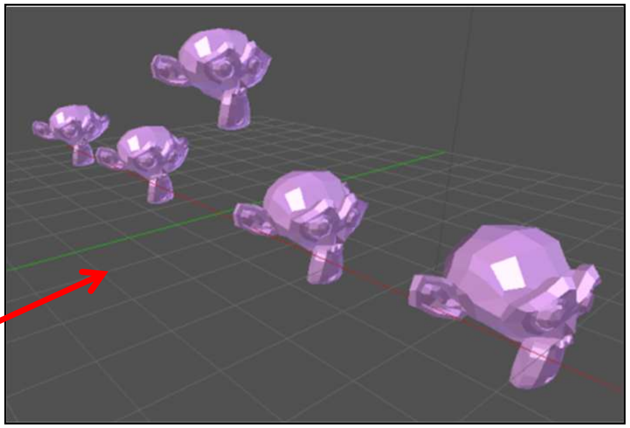


Insert → Video



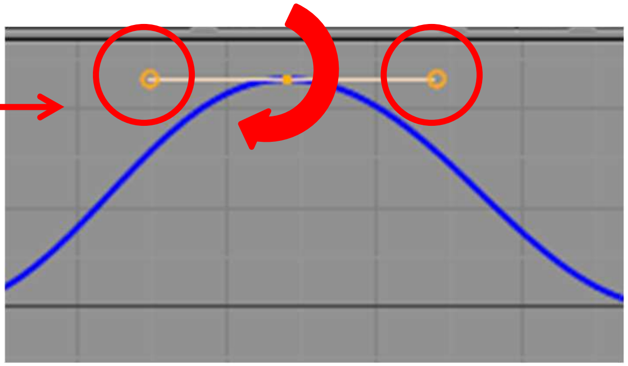
Animation Tricks

1. In this example, we added the first keyframe, then the last keyframe, then three keyframes in the middle. Sometimes it is easiest to work that way. Other times it is easier to add them in sequential order.



2. Sometimes it is easier if you initially add a bunch of duplications of the object in various positions to get a feel for the motion, edit those positions as you see fit, and then use them as keyframe positions.

3. Extending from each keyframe dot is a line. That line can be twisted to change the slope of the curve at that keyframe. Select the dots at the end of that line and move them.



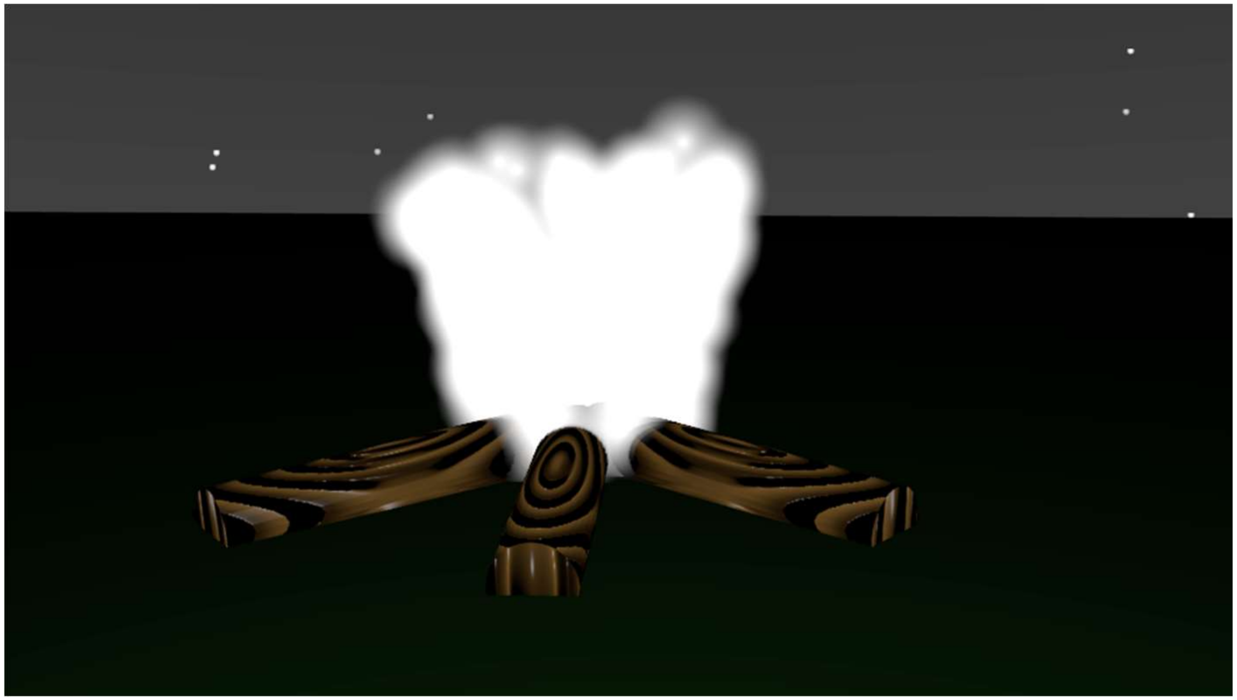
4. The Camera position and the Lamps can be animated too. For each, define an Empty object, force the Camera or Lamp to follow it (it's one of the Constraints), then animate the Empty. Be sure to give the Empty a descriptive name – all Empties look alike.

John Lasseter's Principles of Animation

1. ***Squash and Stretch*** -- Defining the rigidity and mass of an object by distorting its shape during an action.
2. ***Timing*** -- Spacing actions to define the weight and size of objects and the personality of characters.
3. ***Anticipation*** -- The preparation for an action.
4. ***Staging*** -- Presenting an idea so that it is unmistakably clear.
5. ***Follow Through and Overlapping Action*** – The termination of an action and establishing its relationship to the next action.
6. ***Straight Ahead Action and Pose-To-Pose Action*** -- The two contrasting approaches to the creation of movement.
7. ***Slow In and Out*** -- The spacing of the inbetween frames to achieve subtlety of timing and movement.
8. ***Arcs*** -- The visual path of action for natural movement.
9. ***Exaggeration*** -- Accentuating the essence of an idea via the design and the action.
10. ***Secondary Action*** -- The action of an object resulting from another action,
11. ***Appeal*** .-- Creating a design or an action that the audience enjoys watching.

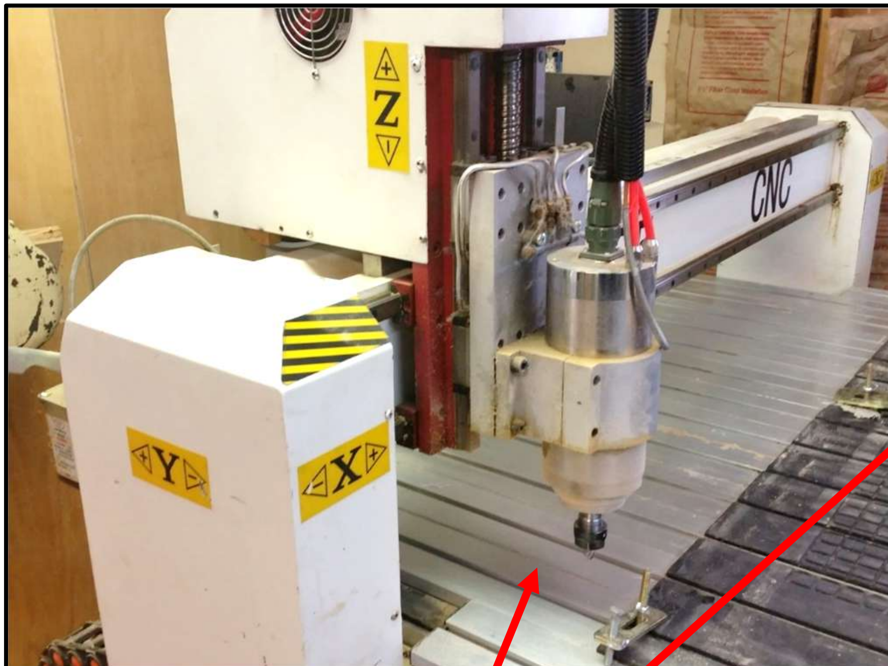
John Lasseter, "Principles of Traditional Animation Applied to 3D Computer Animation Computer Graphics", *Computer Graphics*, Volume 21, Number 4, July 1987.

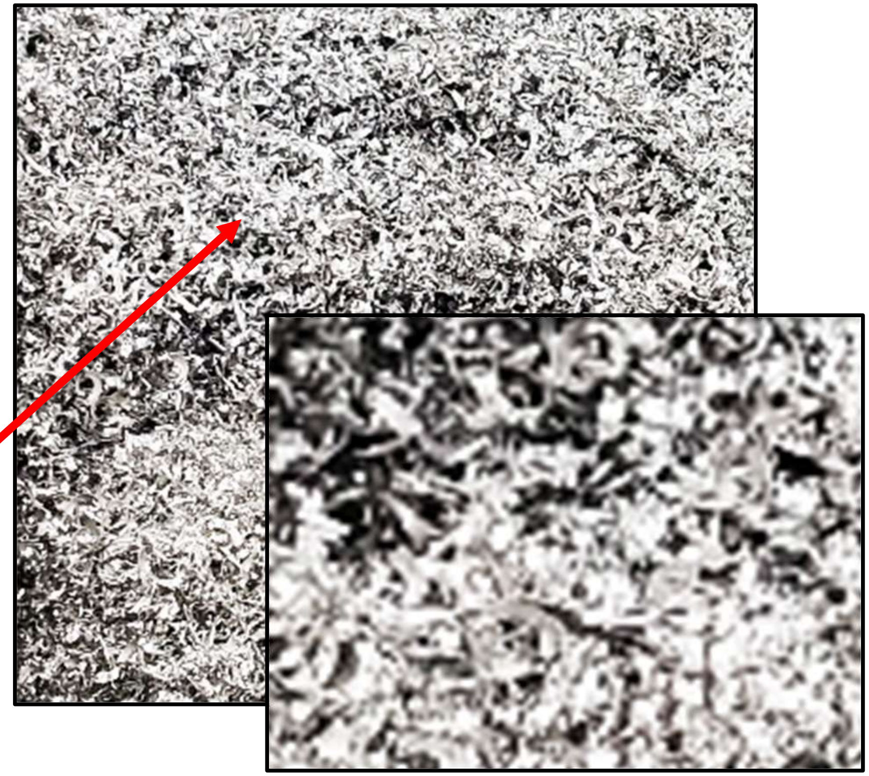
14. 3D Printing



Oregon State University
Computer Graphics

In the Beginning, Manufacturing was "Subtractive"

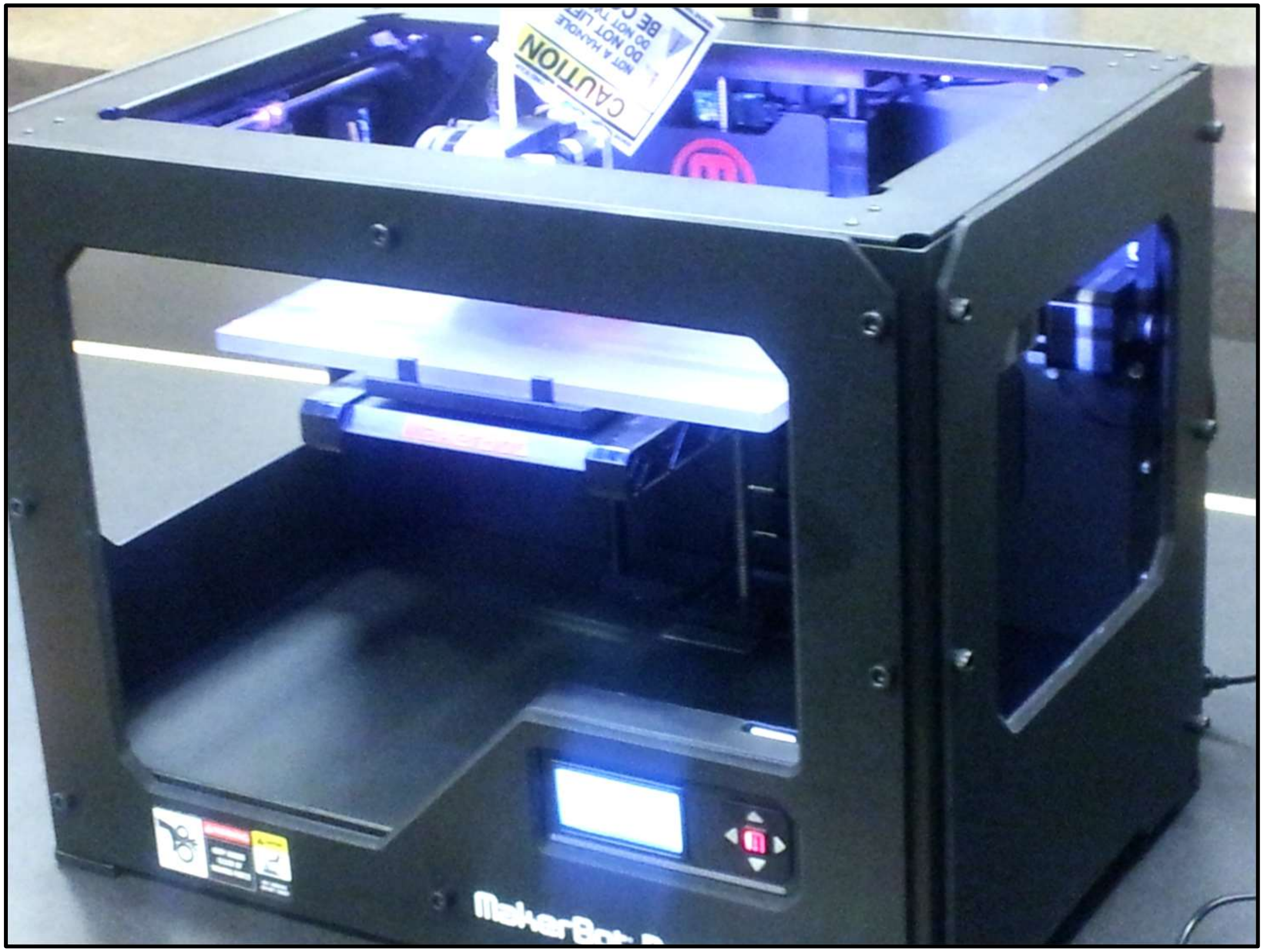




1. The whirling drill bit follows a 3D path
2. Chips of metal (or wood or wax) fly
3. A block of metal becomes a part

3D Printing is Additive

“3D Printing” is defined by some sort of “additive” process. The current trend in desktop 3D Printing consists mostly of systems that deposit layers of molten plastic:



Examples of 3D Printing

Portland's Laika uses Color 3D Printing for Stop-motion Movies

Kubo and the Two Strings

The 3D Printing Geometry File

3D Printers are fed a file called an “STL File”, which lists all the triangles in the object. Blender (as well as all CAD systems) can produce this type of file for you.

```
solid

 facet normal   0.00   0.00   -1.00
  outer loop
   vertex   -2.000000   -2.000000   0.250000
   vertex   -1.980000   -1.980000   0.250000
   vertex   -1.980000   -2.000000   0.250000
  endloop
 endfacet

 facet normal   0.00   0.00   -1.00
  outer loop
   vertex   -2.000000   -2.000000   0.250000
   vertex   -2.000000   -1.980000   0.250000
   vertex   -1.980000   -1.980000   0.250000
  endloop
 endfacet

     . . .

endsolid
```

In this particular file, these coordinates were in units of inches.

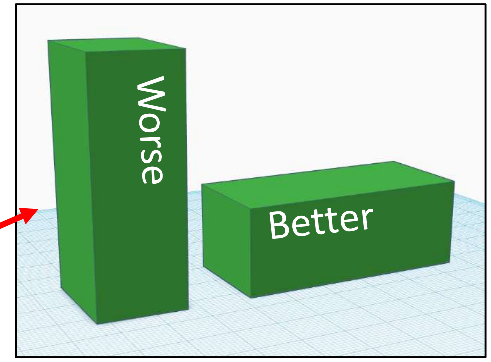
Some 3D Printers still use **inches**, but most now use **millimeters**.

Check! It matters!

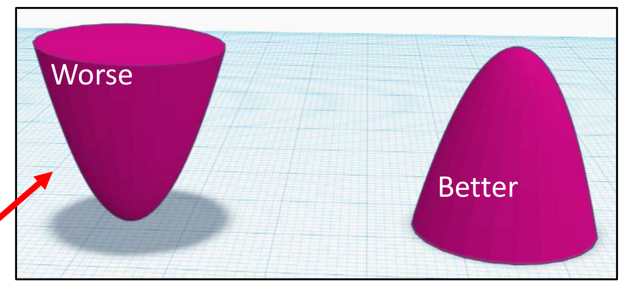
Note: there are 25.4 mm/inch

Advice on 3D Printing

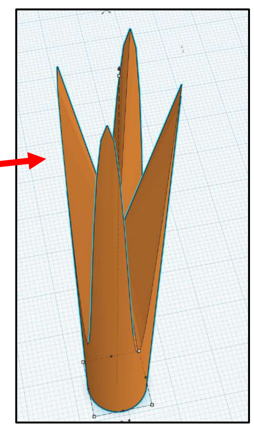
Don’t make the part too big – it will take a long time to 3D print. It's nice if you can fit several models in a single run.



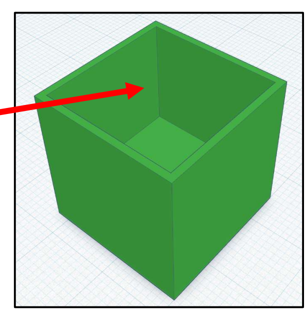
Try to rotate the part so the smallest dimension is vertical. It’s stronger that way, and it builds faster.



The 3D Printer will like it better if the part gets smaller as it goes up, not the other way around.



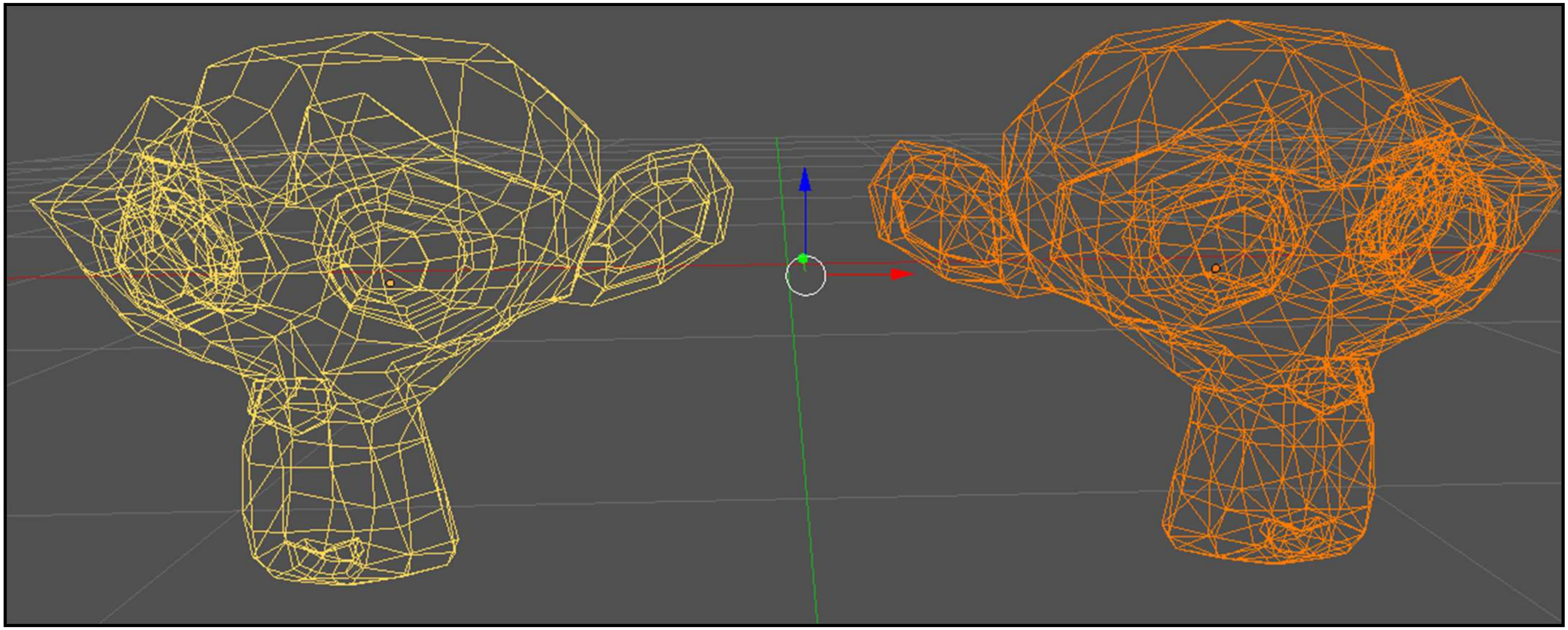
Don’t design the part with long, thin edges. They will likely snap right off.



Don’t make walls too thin – they might break.

Object Rules for 3D Printing

Rule #1: The object must be a mesh and ***consist only of triangles***.

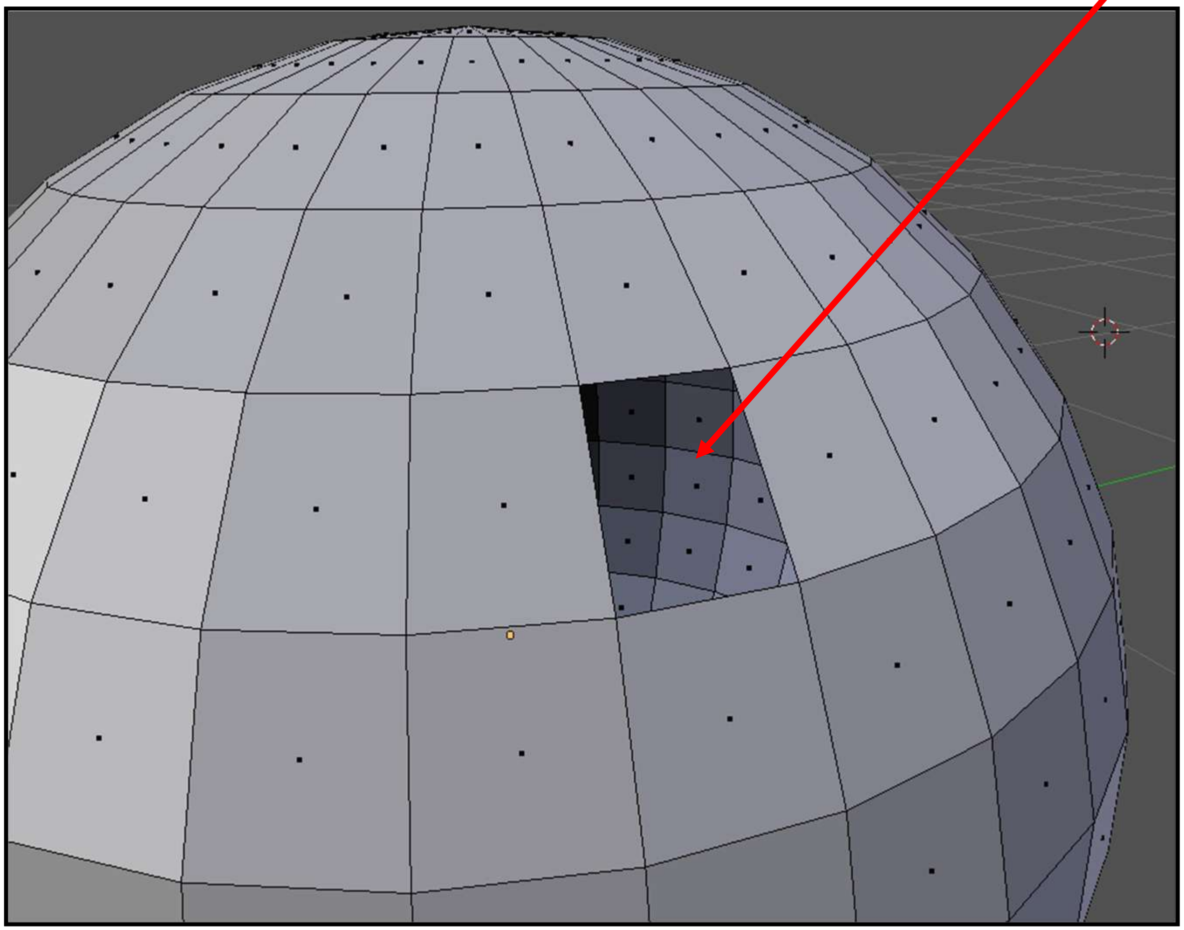


1. Select the mesh object
2. **Modifiers→Add Modifier→Generate→Triangulate →Apply**

RMB→Convert To→Mesh to turn a Meta object or 3D Text into a mesh first

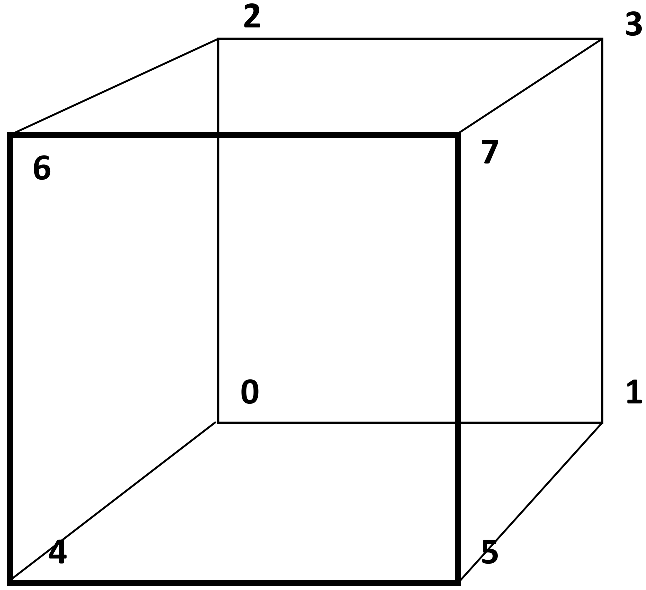
Object Rules for 3D Printing

Rule #2: The object must be a legal solid. It must have a definite inside and a definite outside. It can't have any missing face pieces.



The Simplified Euler's Formula* for Legal Solids

*sometimes called the Euler-Poincaré formula

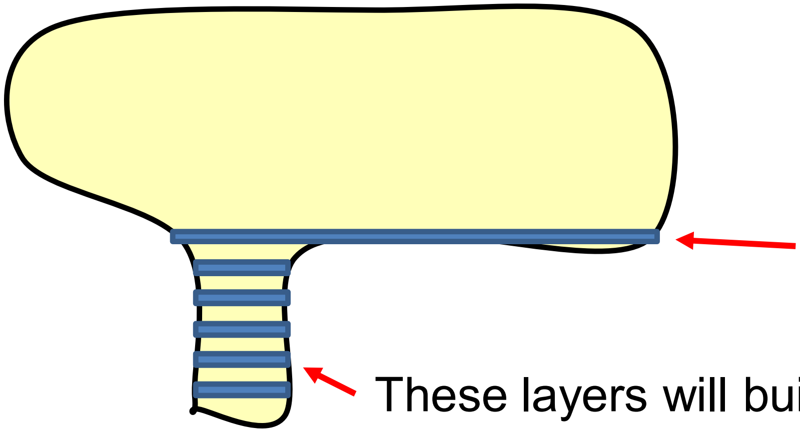


F – E + V = 2

F	**Faces**
E	**Edges**
V	**Vertices**

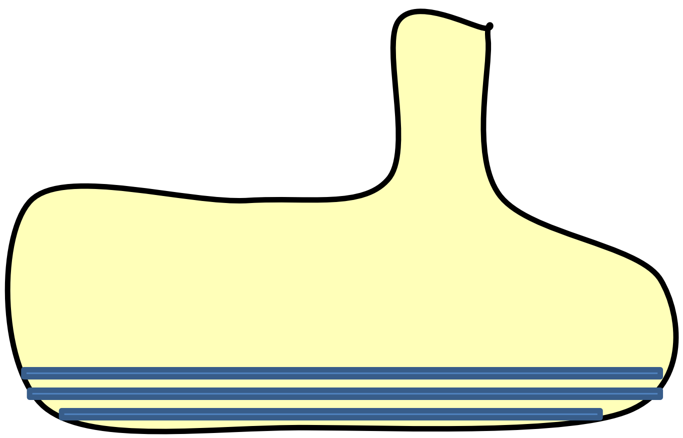
For a cube, 6 – 12 + 8 = 2 √

Watch Out for Overhangs!



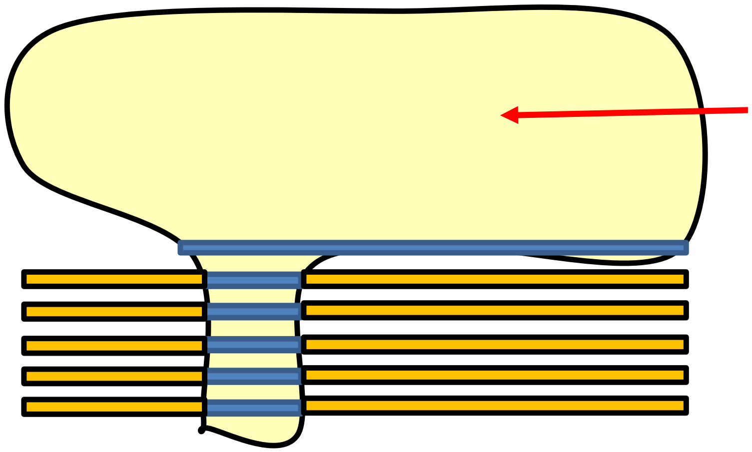
This layer will fall to the plate

These layers will build fine

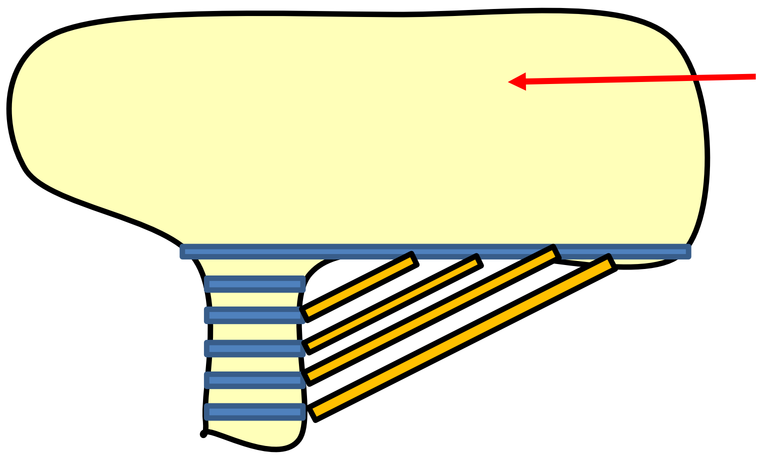


Note that if you build it upside-down, it will probably work fine

Watch Out for Overhangs!



Some 3D printers handle this by leaving unused material in place to support the overhangs



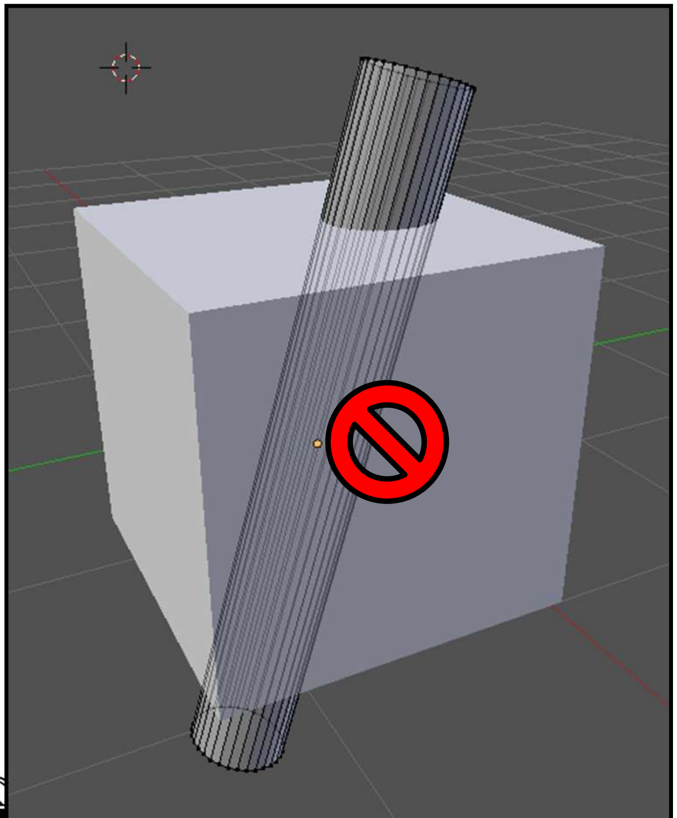
Some 3D printers handle this by using software to add “support structures” to the overhangs

Some 3D printers handle this better than others… ☺

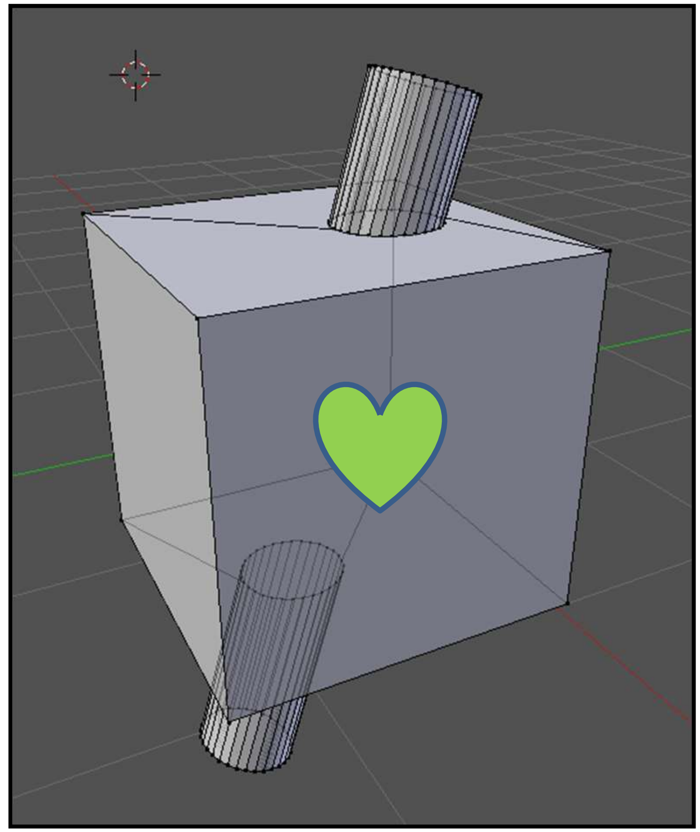
http://twistedsifter.com/2013/08/when-3d-printing-goes-wrong/

Object Rules for 3D Printing

Rule #3: You can't make a new object by simply overlapping two objects in 3D. If you want both shapes together, do a Boolean union on them so that they become one complete object.



Overlapped in 3D

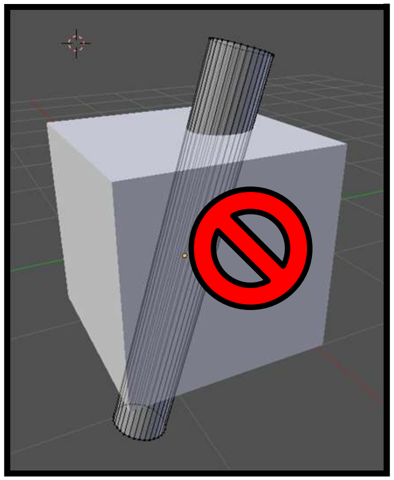


Boolean union

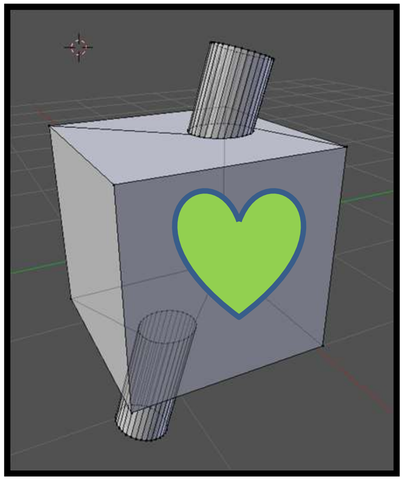
What Happens if You Do Overlap Objects?

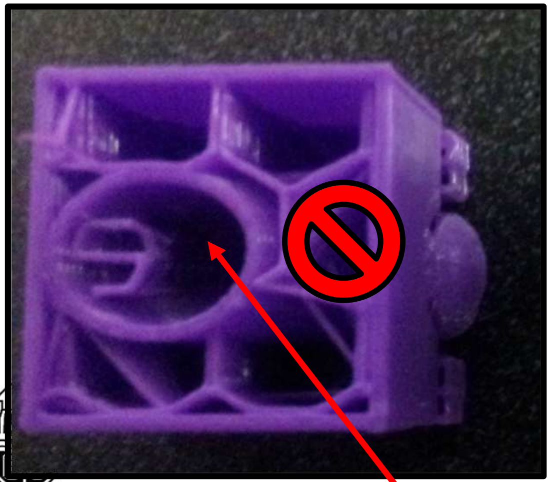
Here's what one of the 3D Printers in the OSU Library did:

Overlapped in 3D



Boolean union

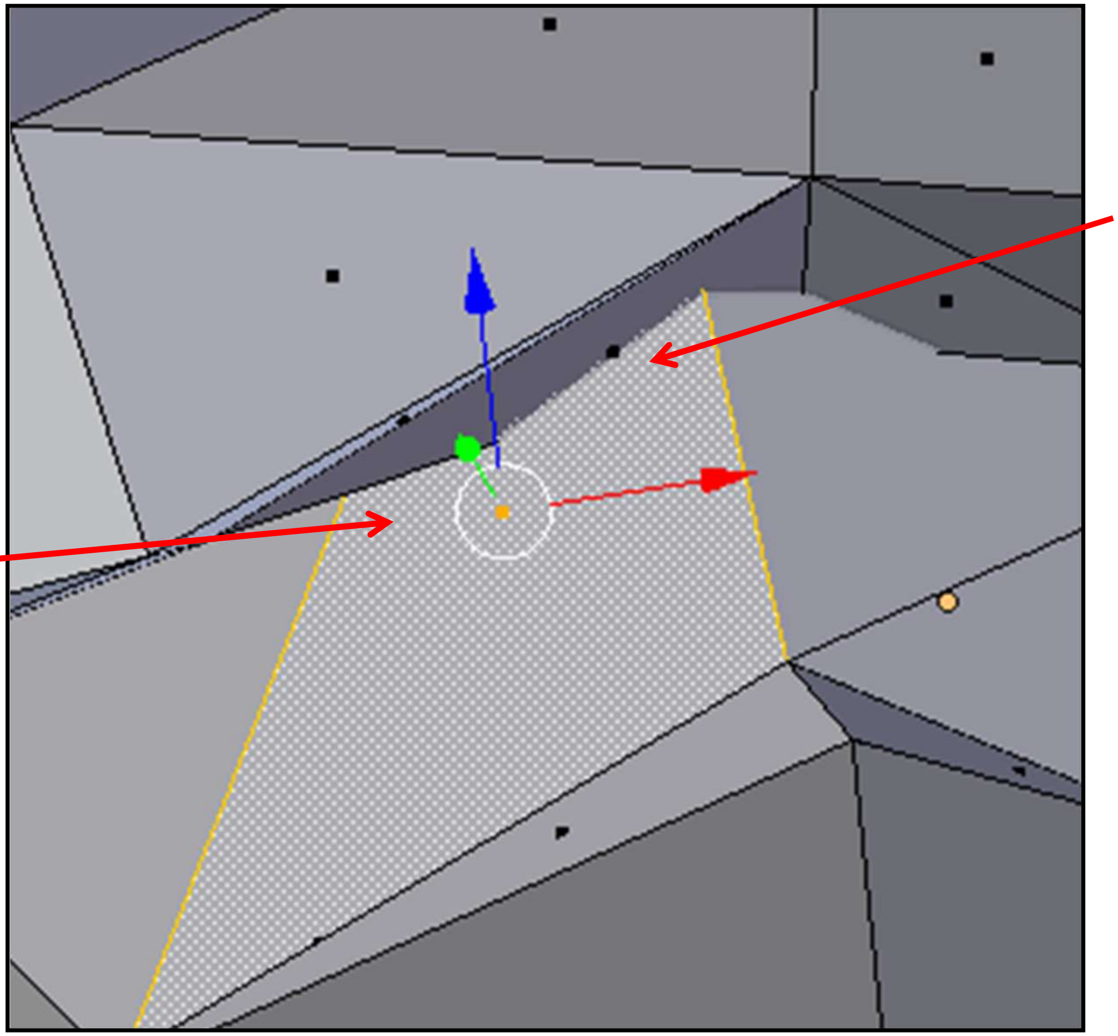




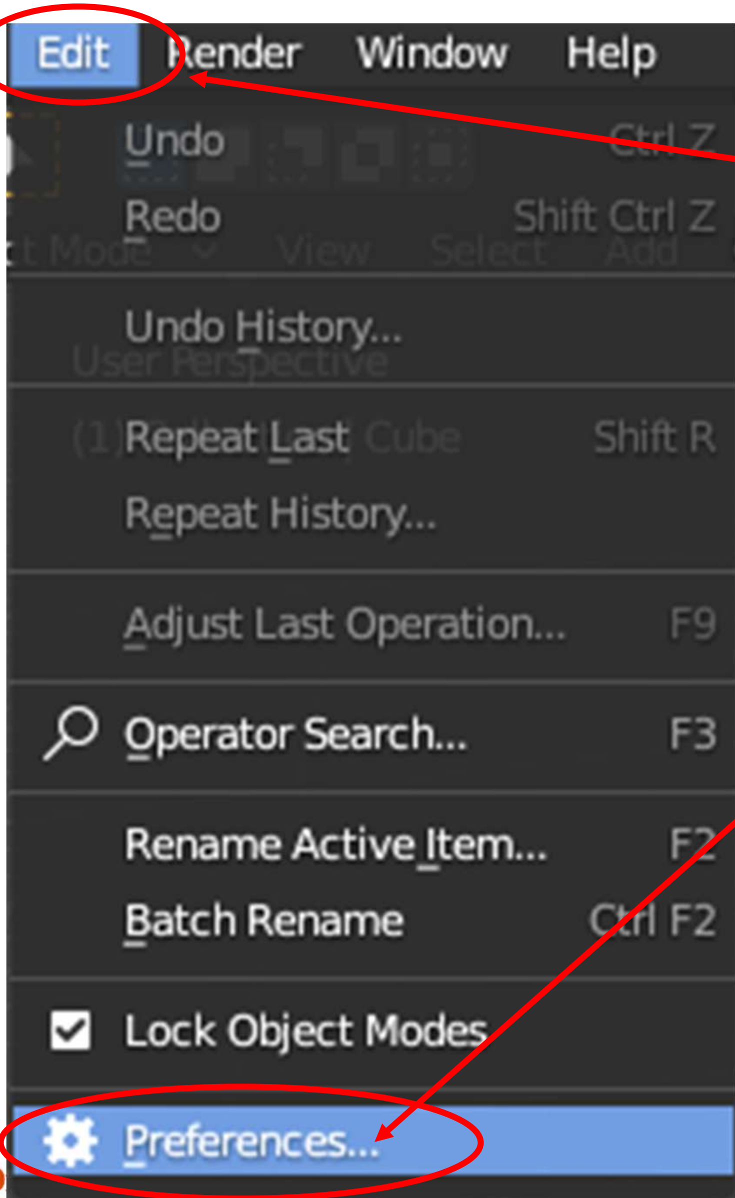
Not bad – it could have been lots worse …

Object Rules for 3D Printing

Rule #4: Each edge in the mesh must bound **2 and only 2** triangles (this is known as the Vertex-to-Vertex Rule). If this is not true, then your model has cracks in it.



Installing the Blender 3D Printing Extension

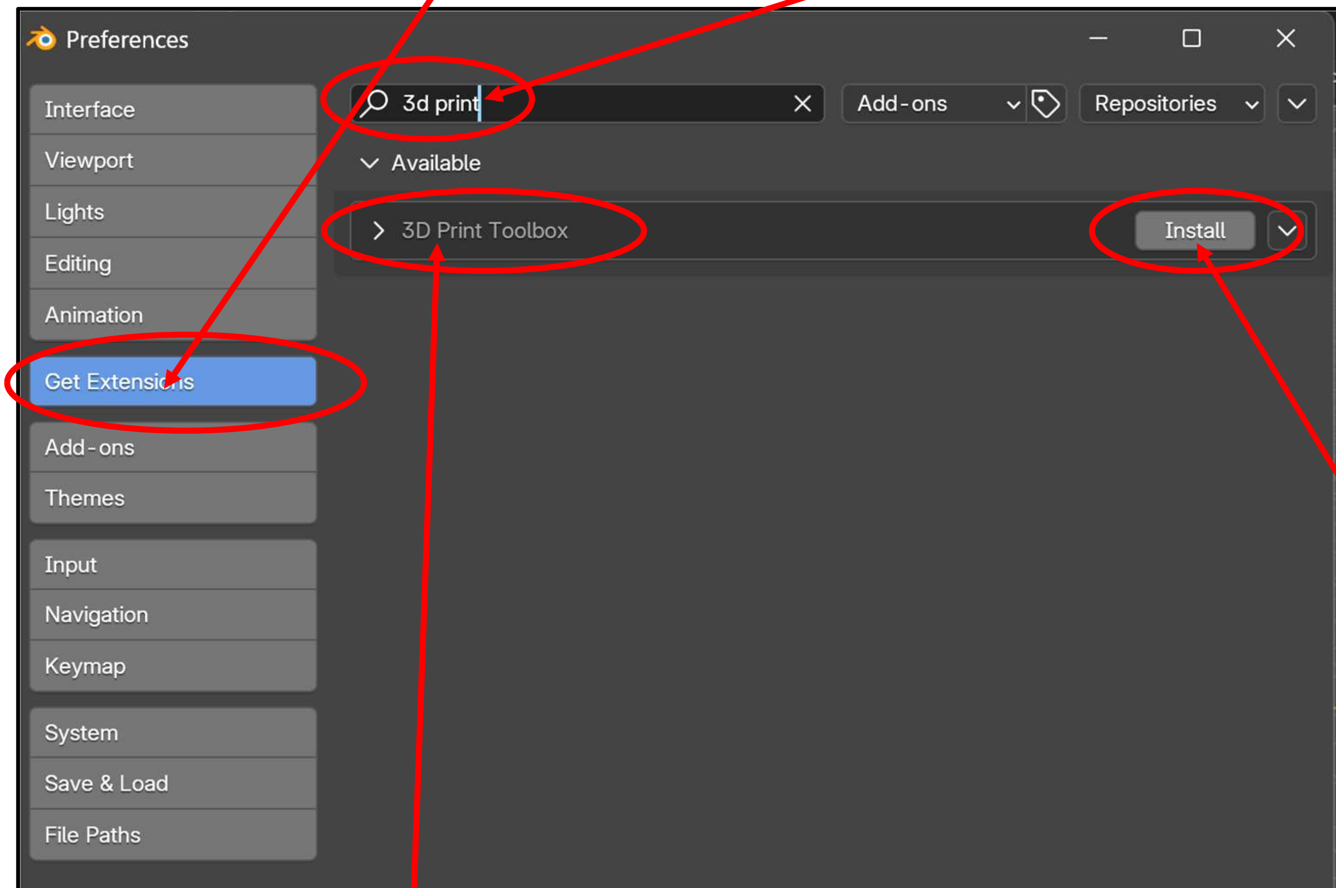


1. Select **Edit → Preferences**

Installing the Blender 3D Printing Extension

2. Click on **Get Extensions**

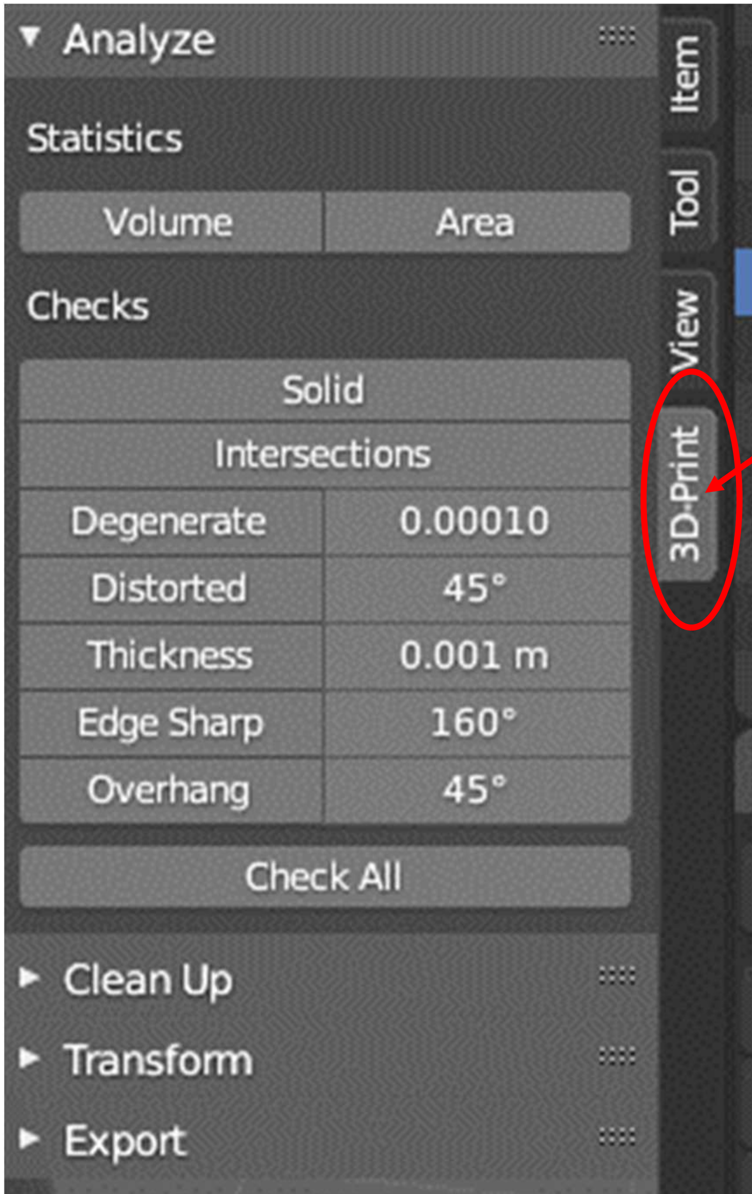
3. Type *3d print* into the search box



4. You should see **3D Print Toolbox** show up here

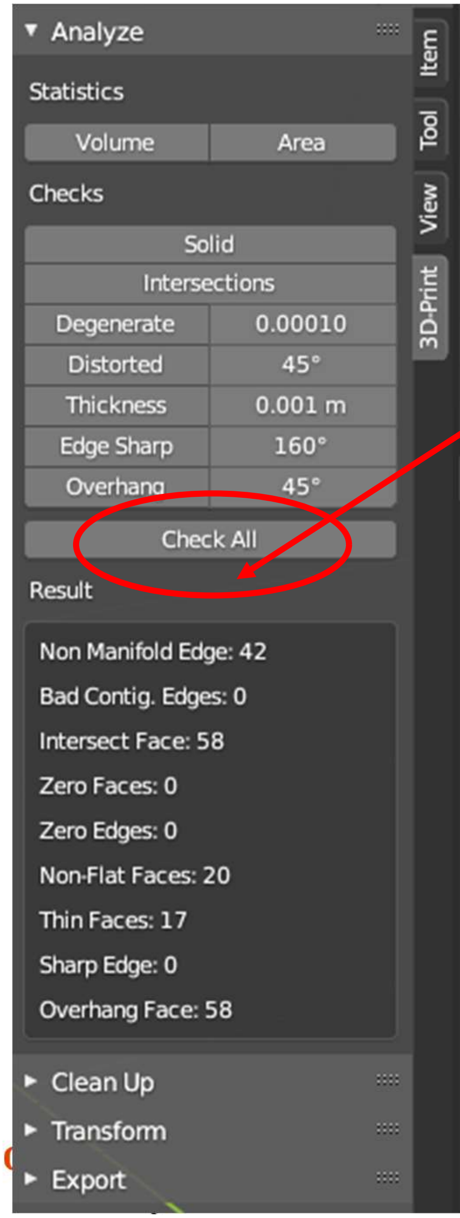
5. Click on **Install**

Using the Blender 3D Printing Toolbox Extension

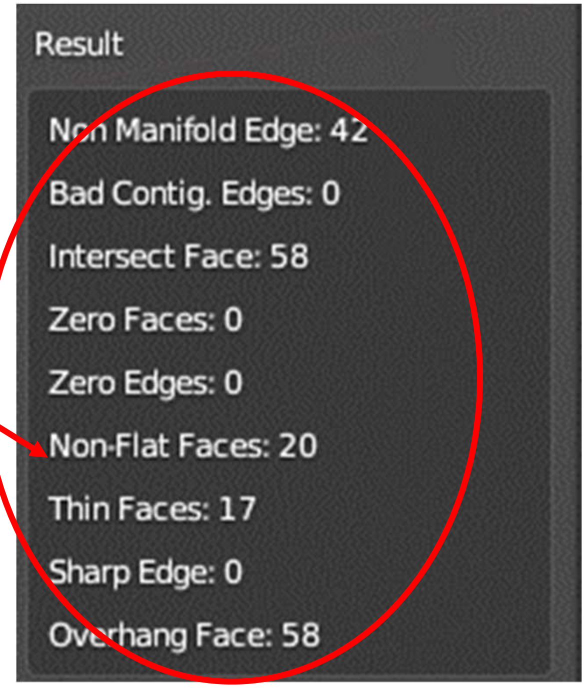


Hit the **'n'** key to see the sidebar menu.
The **3D Print Toolbox** will be a tab like this.

Using the Blender 3D Printing Toolbox Extension



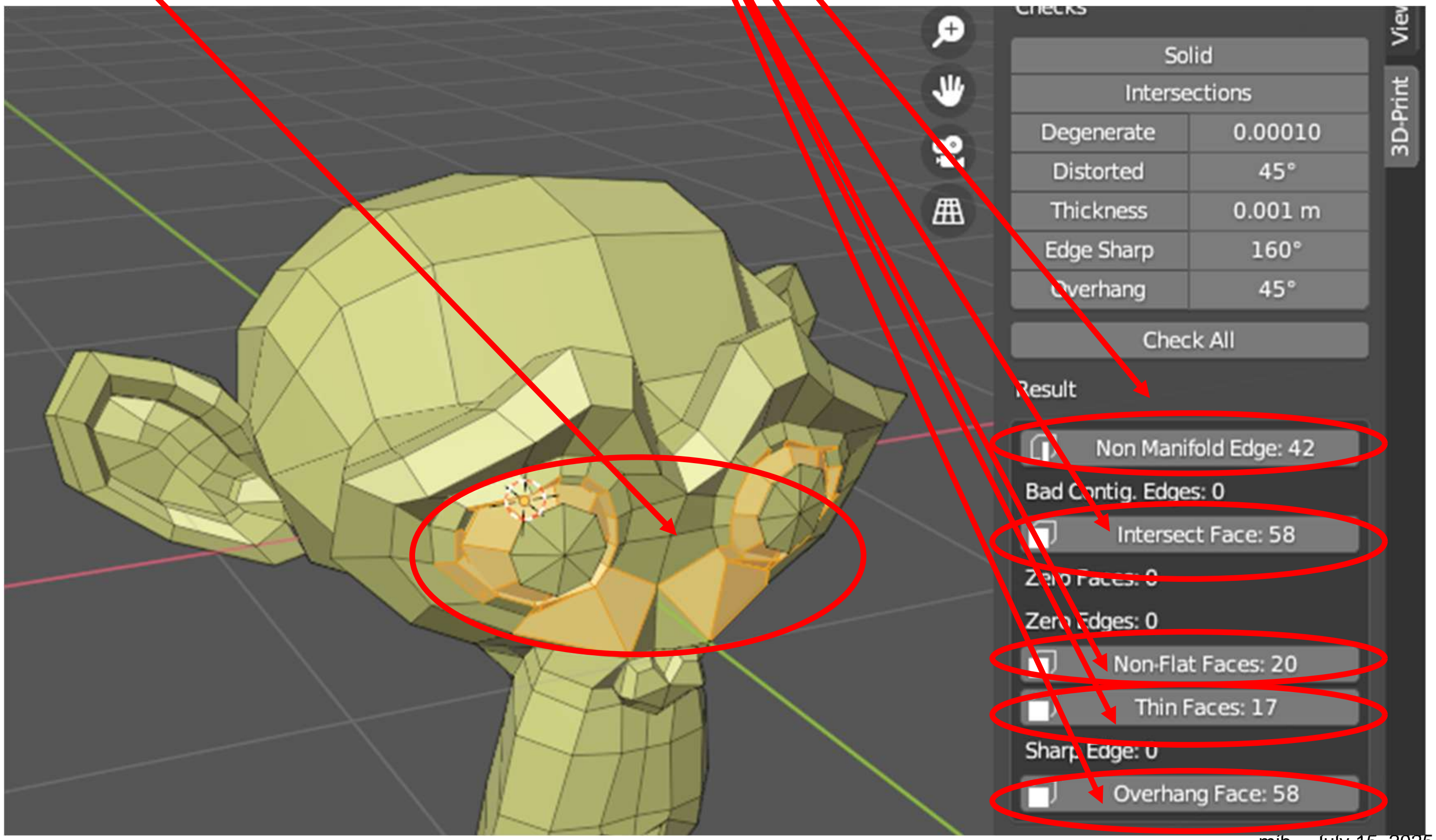
Selecting your object and then clicking on **Check All** will give you this nice list of problems Blender thinks you will have if you try to 3D Print this object



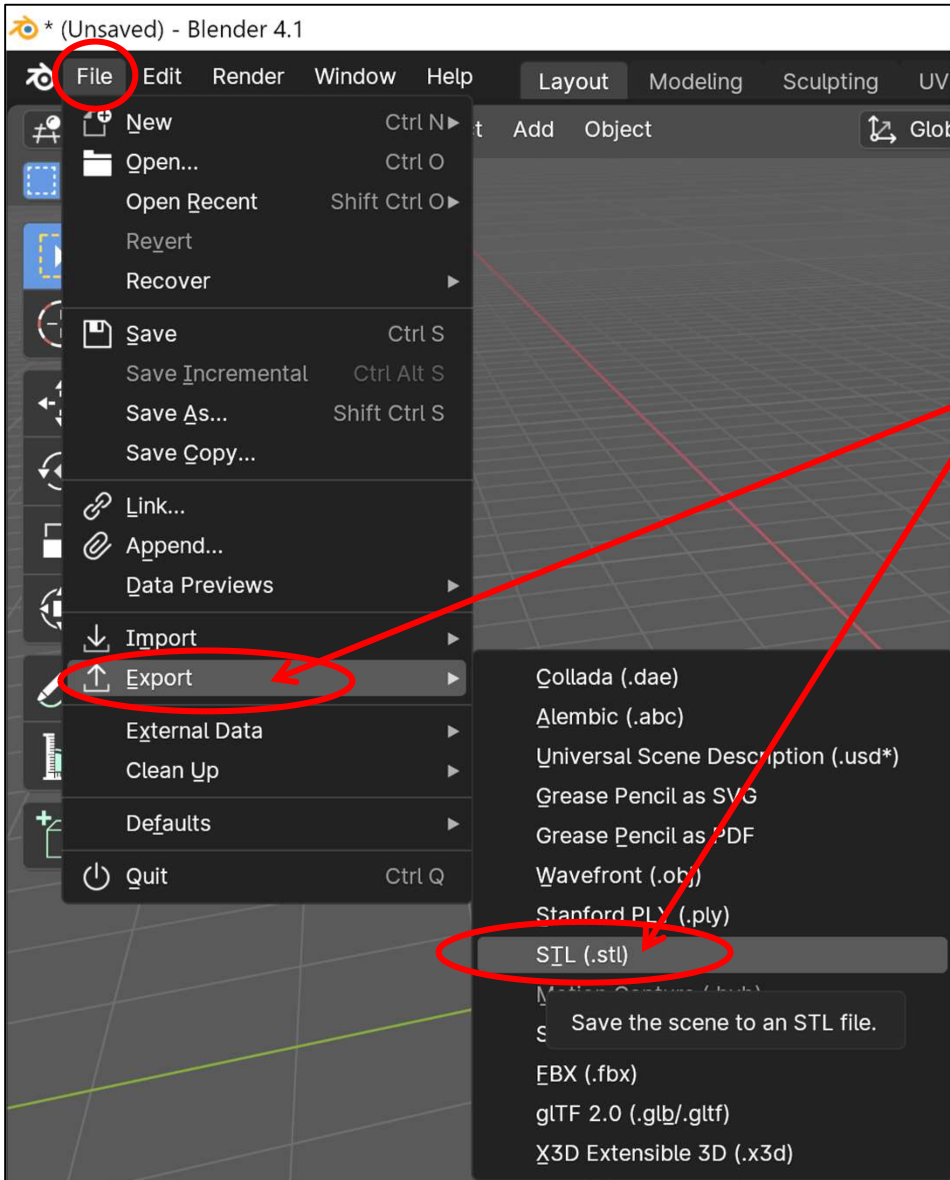
Selecting **Clean Up → Make Manifold** can try to fix some of the problems

The Blender 3D Printing Toolbox Add-on

Tab over to **Edit Mode**.
Click in an empty area to unselect everything.
Then click in all the places that show problems.
Blender will light up the object in the places that provoked that problem, giving you a chance to fix them.



Output for 3D Printing



To **export** an STL file for 3D Printing:

1. Use the Triangulate modifier to be sure all polygons in your object are triangles
2. Select the object you want to export
3. **File → Export → Stl (.stl)**
4. Navigate to where you want to save the file
5. Give it a filename that ends in .stl
6. Click **Export STL**

.stl is the most common 3D printing file format

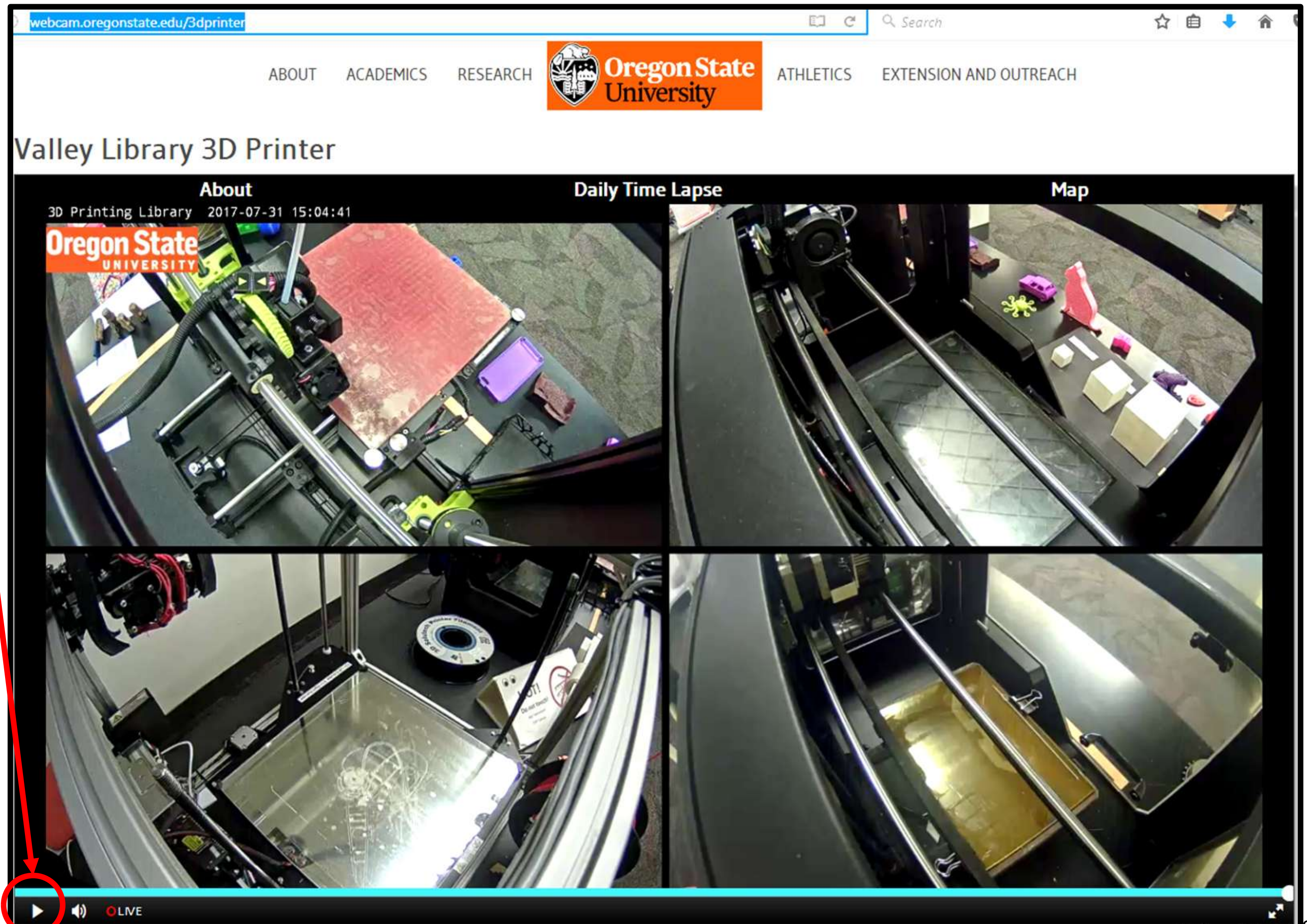
"STL" stands for **Stereolithography**

The word "stereolithography" comes from the Greek words for "3D" and "writing".

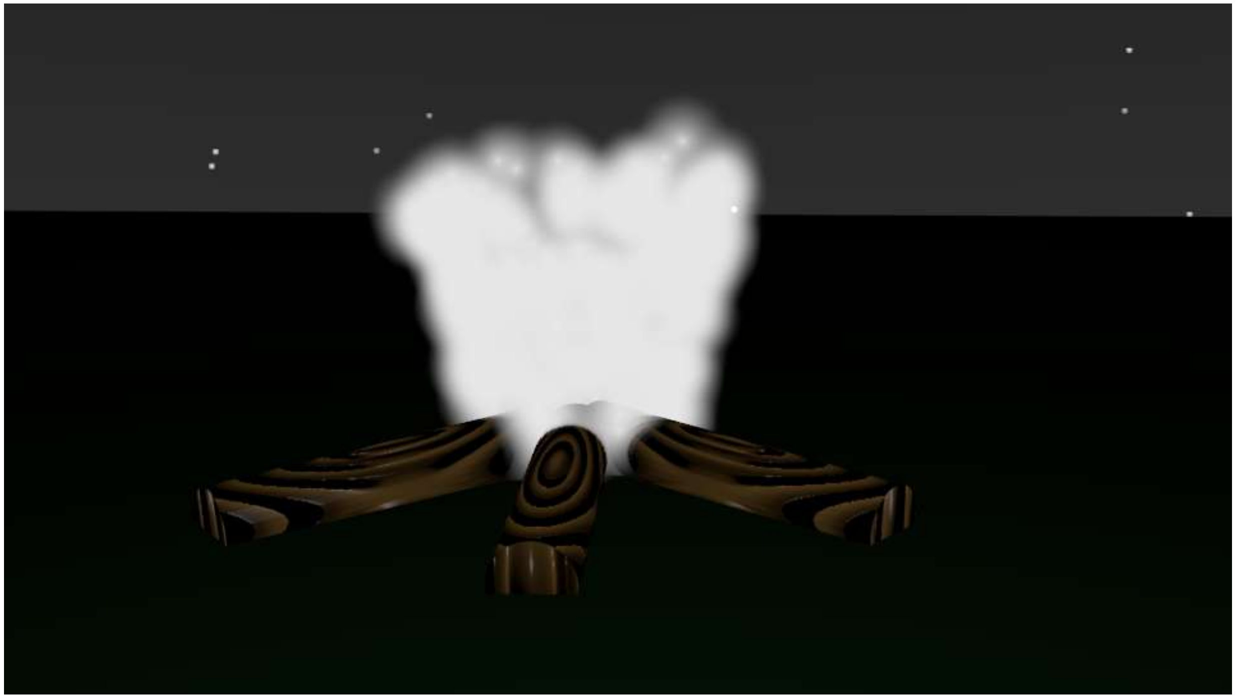
Want to see 3D Printing in Action?

Oregon State University's library has 3D Printers for use by OSU students.
To see them via webcam, go to: http://webcam.oregonstate.edu/3dprinter

Click here to see the live, streaming view.

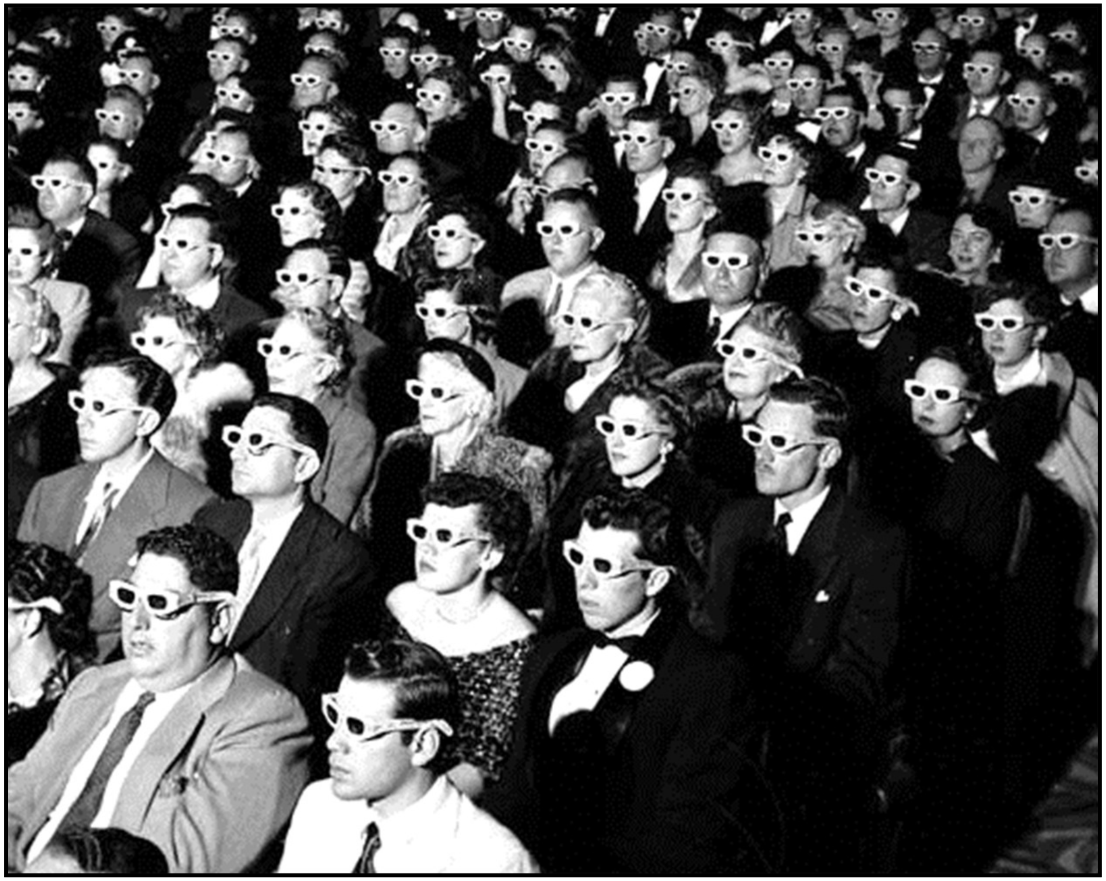


15. Stereographics



Oregon State University
Computer Graphics

Stereoscopy is not new – it's been in common use since the 1950s



Life Magazine

But, with virtual reality and 3D movies being so popular, stereoscopy has made a big comeback. And, you can get at it through Blender!

For more information on stereoscopy, see: https://en.wikipedia.org/wiki/Stereoscopy

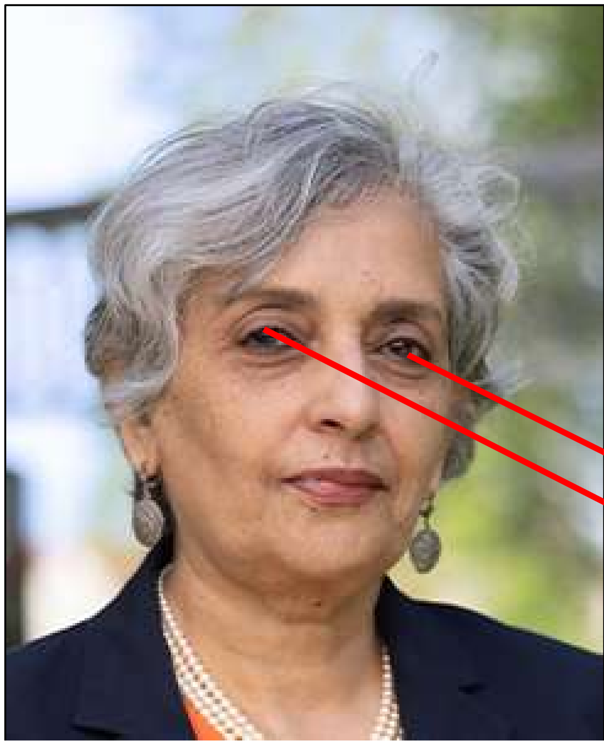
And even longer than that in stills

Newport Maritime Museum

Portland Art Museum's Ansel Adams Exhibit

We Humans have Binocular Vision

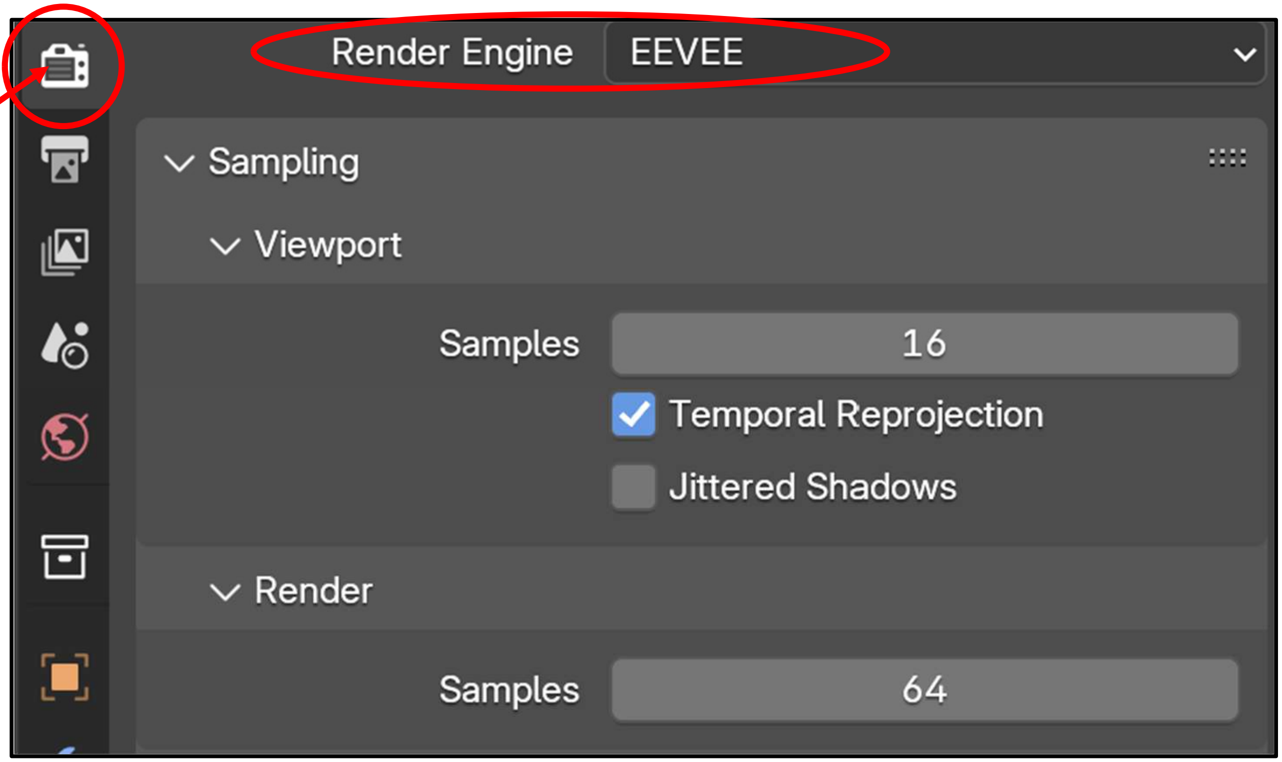
In everyday living, part of our perception of depth comes from the slight horizontal difference in how our two eyes see the world around us. This is known as *binocular vision*. We care about this because computer graphics can simulate that slight viewing difference and thus create the binocular viewing of a computer-generated scene.



OSU's 16th President Dr. Jayathi Murthy

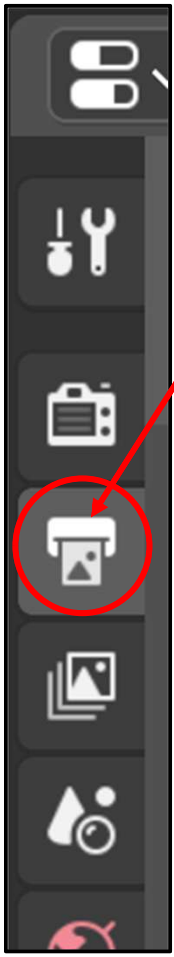
Step #1a – Be Sure You are Using the Eevee Renderer, not Cycles

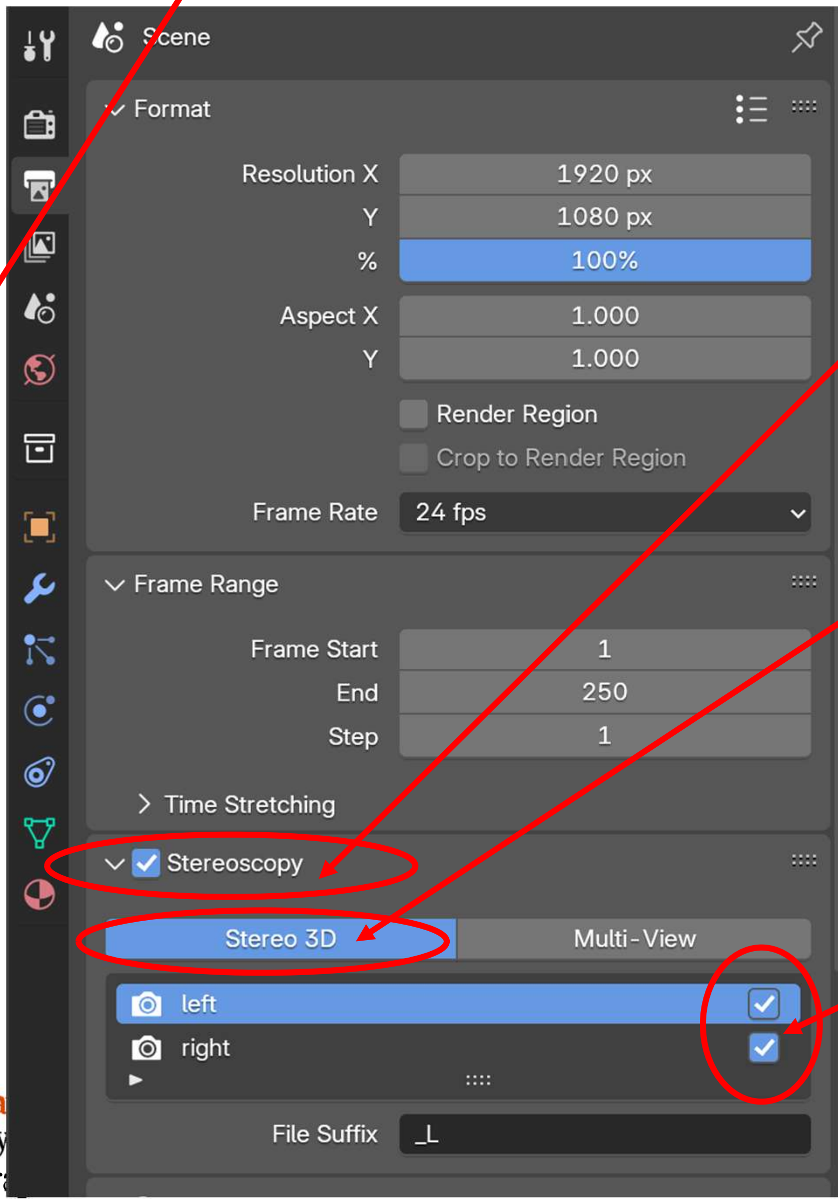
Open the **Render Properties** menu



Step #1b – Turn the Stereographics On

Open the **Output Properties** menu



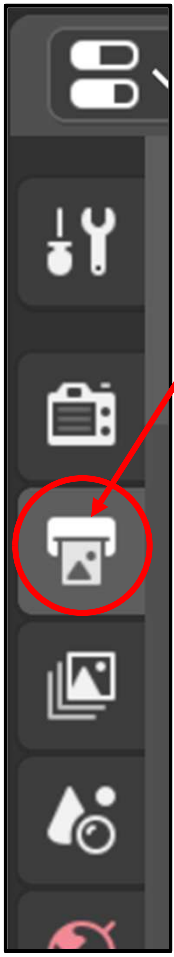


Enable the **Stereoscopy** checkbox and open the menu

Select **Stereo 3D**.

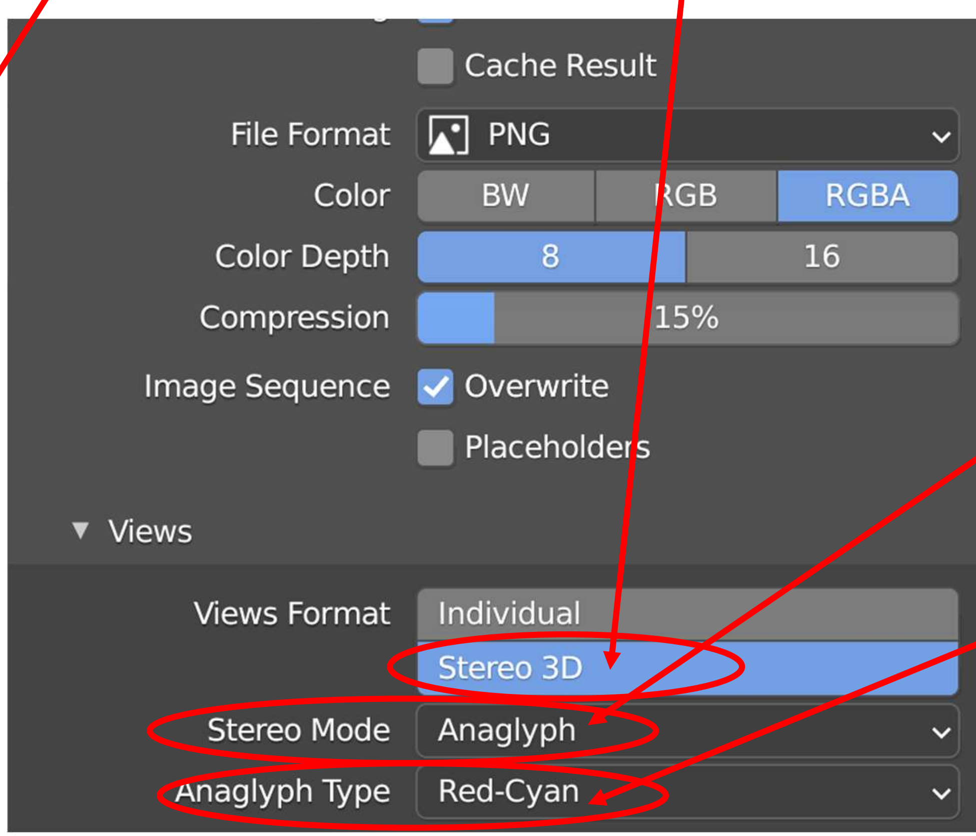
Be sure these are both checked

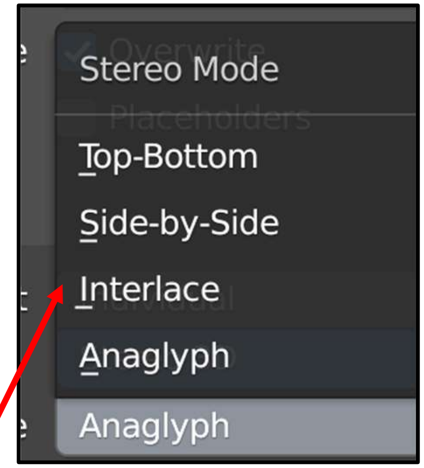
Step #1c – Turn the Stereographics On



While *still* in the **Output Properties** menu …

Click on **Stereo 3D**.

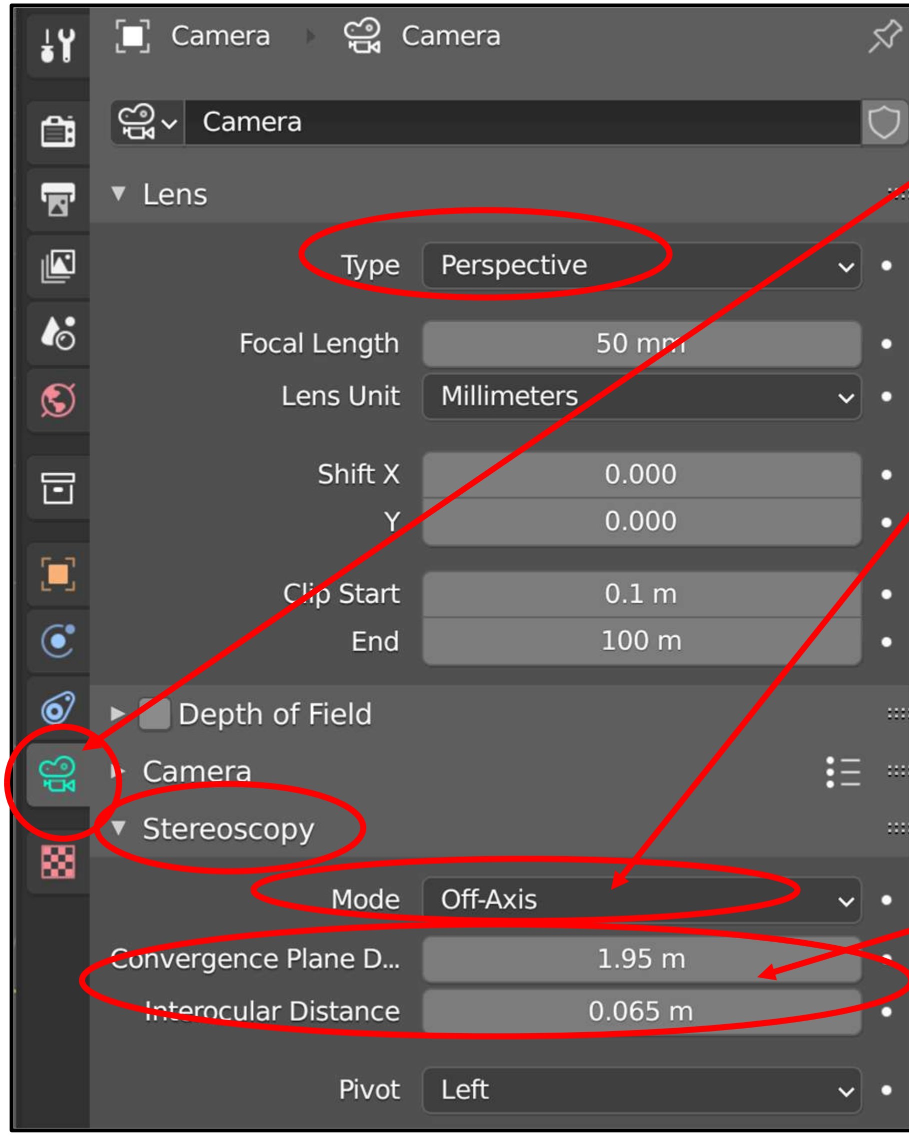




Pick one of these here

Red-Cyan is good here if you picked Anaglyph before. On the screen, the display will always be a Red-Cyan anaglyph. This menu controls how it will be drawn when you write a file after a **Render**.

Step #2 – Set the Stereo Cameras

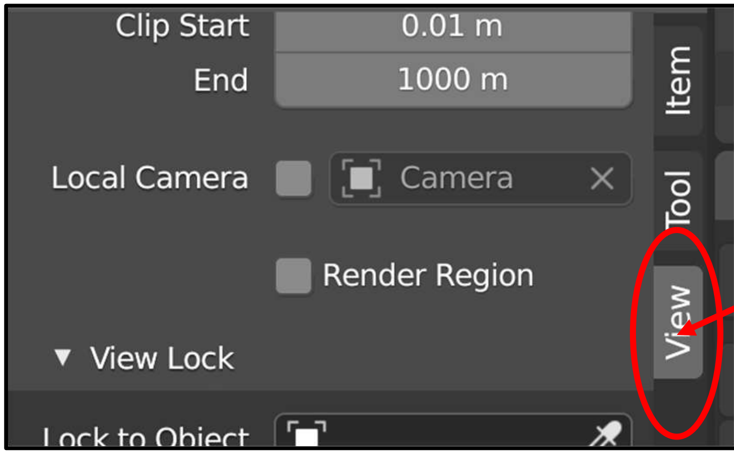


Select your **Camera** (in the scene or in the Outliner) and then open the **Camera Data** menu

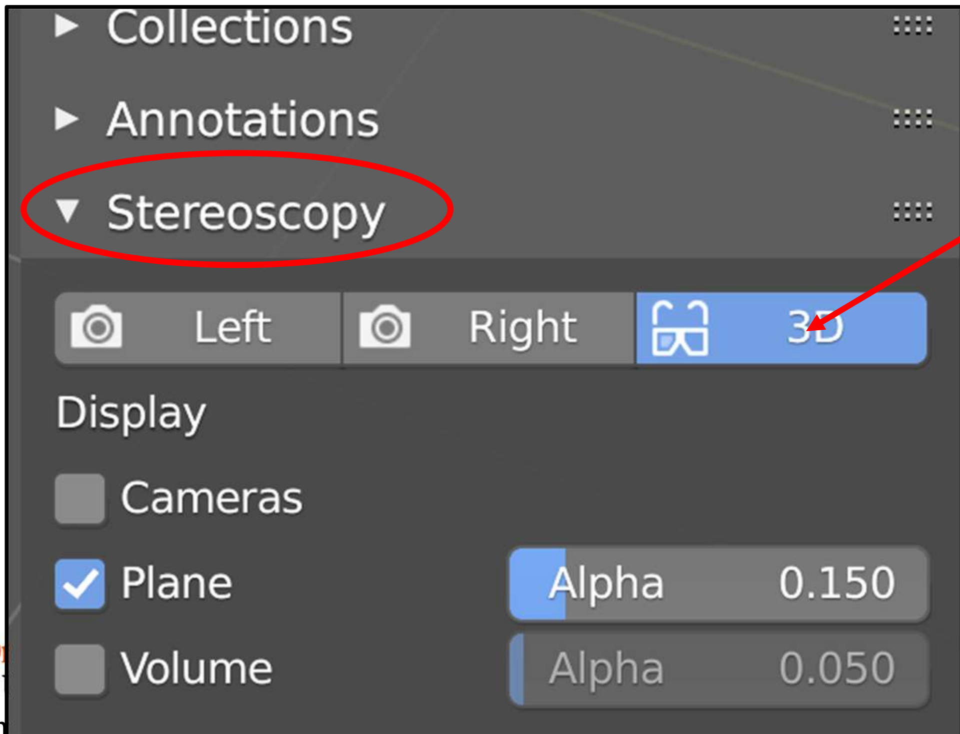
Any of these will work well. I'm kind of partial to **Off-Axis** or **Tow-In**.

These are interesting to experiment with. They control how deep the stereo focuses and how easy the stereo images are to converge.

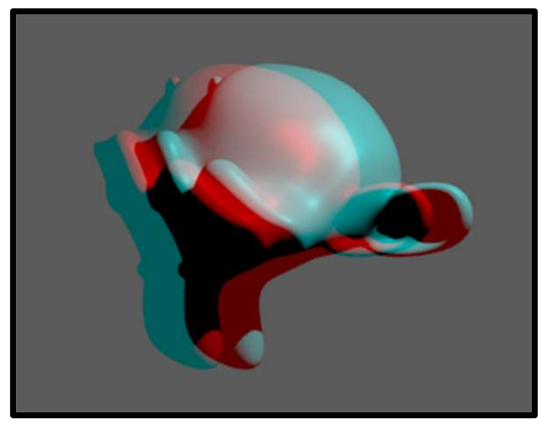
Step #3 – Tell the Renderer to Produce both a Left and Right View



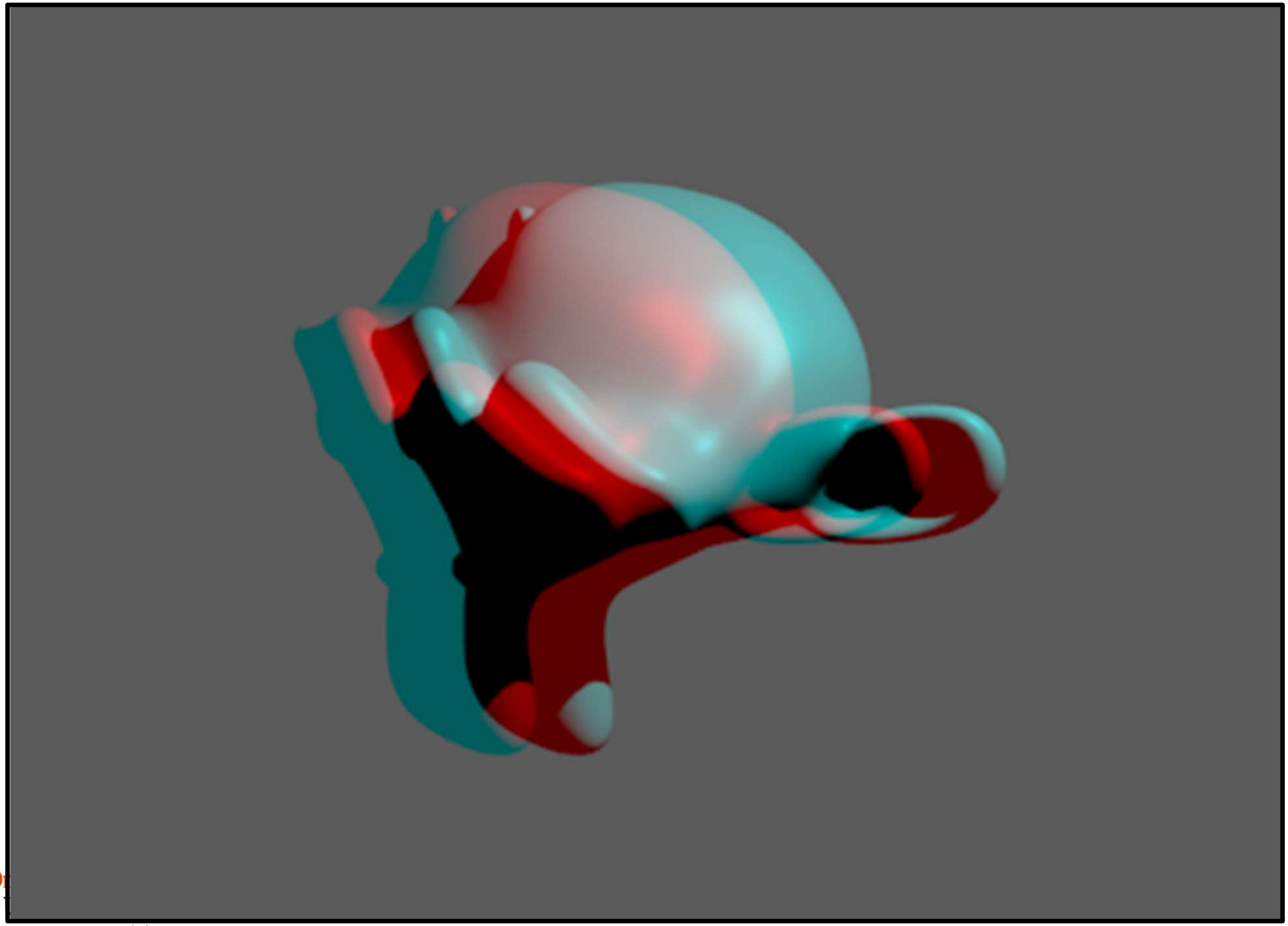
Open the **Object Properties** menu (hit **'n'** on the keyboard) and click on the **View** tab



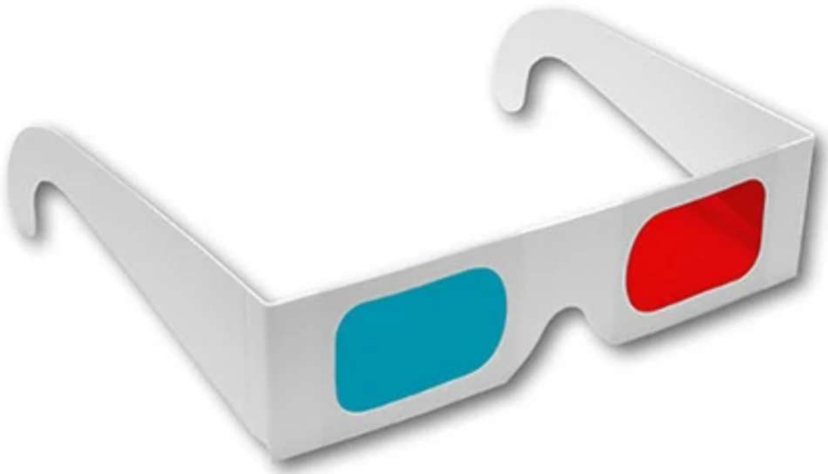
This tells the Renderer to produce both a left and right view, and to make a red-cyan stereopair from them



Step #4 – Render → Render Image



Red-Cyan Glasses



No, they are not *red-blue* glasses!
No, they are not *red-green* glasses!
They are ***red-cyan*** glasses!

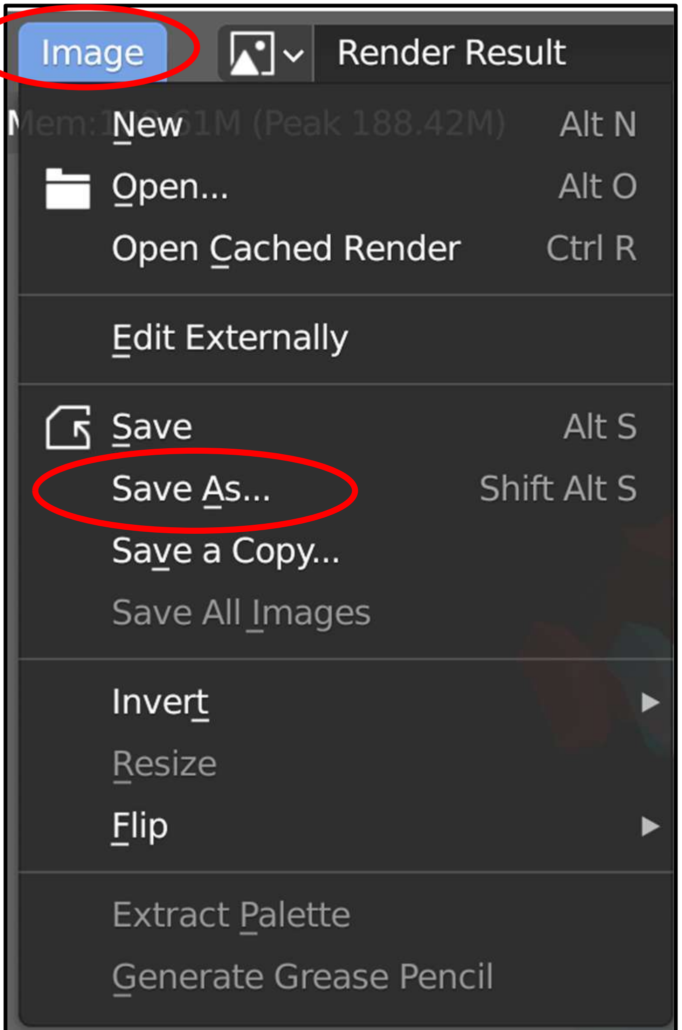
The universal convention is:

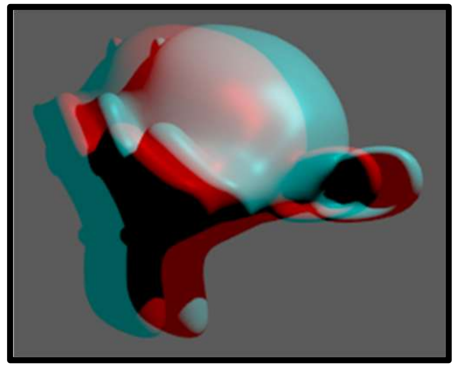
- Red goes over the left eye
- Cyan goes over the right eye

If you want to own your own red-cyan glasses (and who doesn't?) my go-to is:
https://the3dmarket.com/collections/anaglyphic/products/red-cyan

You can also find them on Amazon. Search for ***anaglyph glasses***

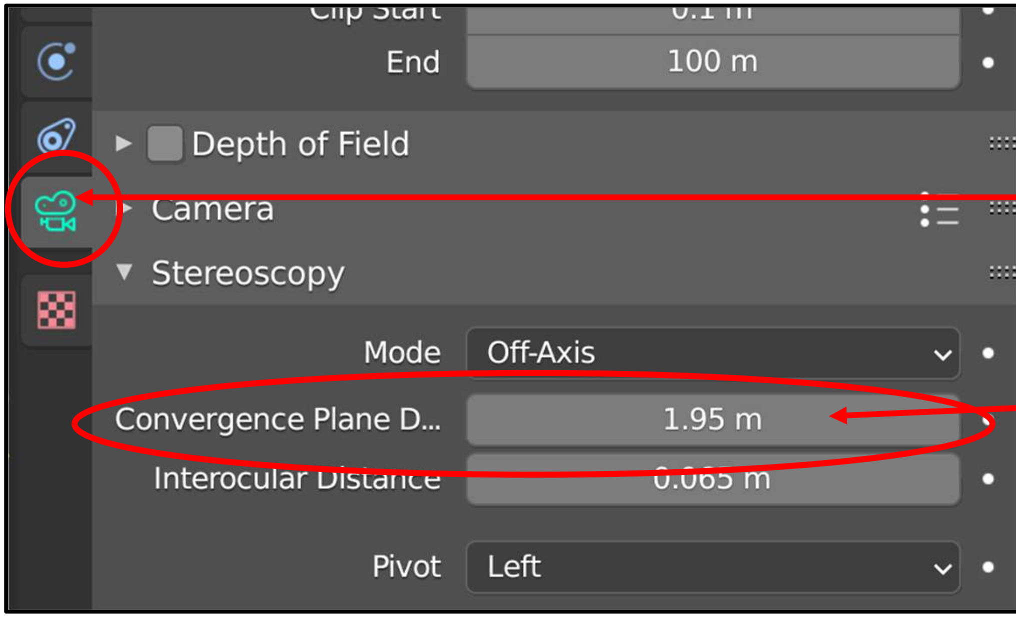
Step #5 – (if you want): From the Render window, write out a Stereographics Image File





This assumes you have already done the other steps

How Deep your Scene Appears to be into and out of the Computer Screen -- Setting the Convergence Plane

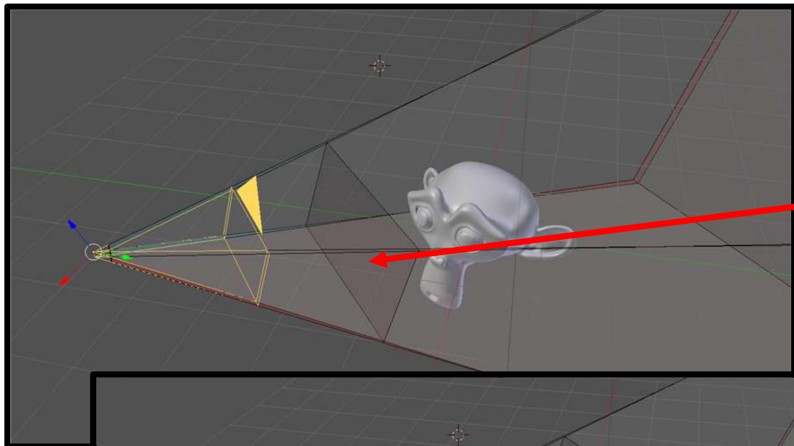


Select your **Camera** (in the scene or in the Outliner) and then open the **Camera Data** menu

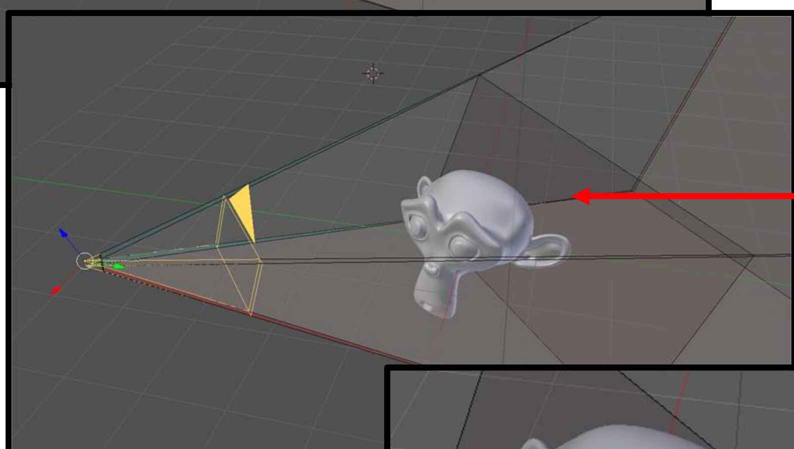
The **Convergence Plane Distance** controls how much the scene appears to exist behind or in front of the display screen. Use a small distance to make the scene look like it is living in the monitor.

Use a larger distance to make the scene look like it is living in the air in front of the monitor. (Don't go too crazy with this – it will look less cool than you are expecting.)

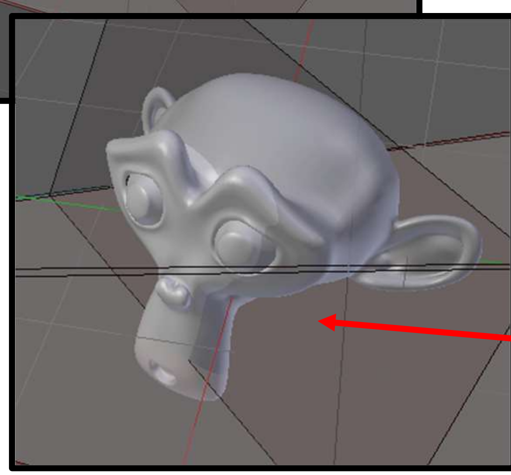
How Deep does the Scene Appear to be into and out of the Computer Screen? Setting the Convergence Plane



The Convergence Plane is in front of the object – the object will appear to be inside the monitor

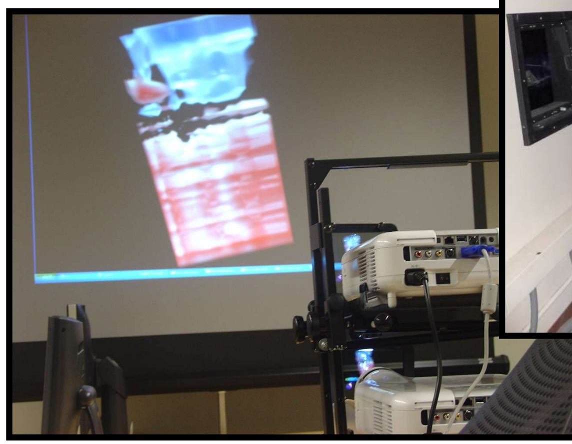


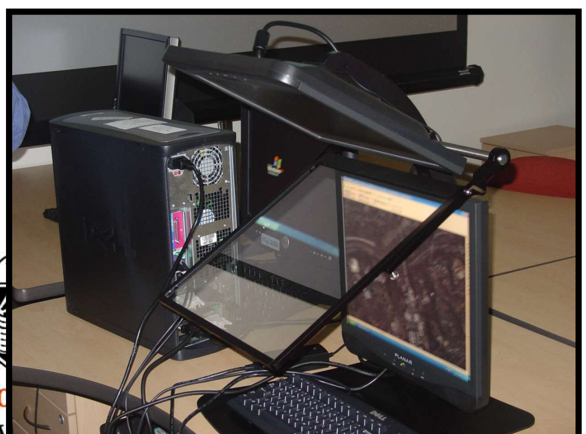
The Convergence Plane is behind the object – the object will appear to be in the air in front of the monitor



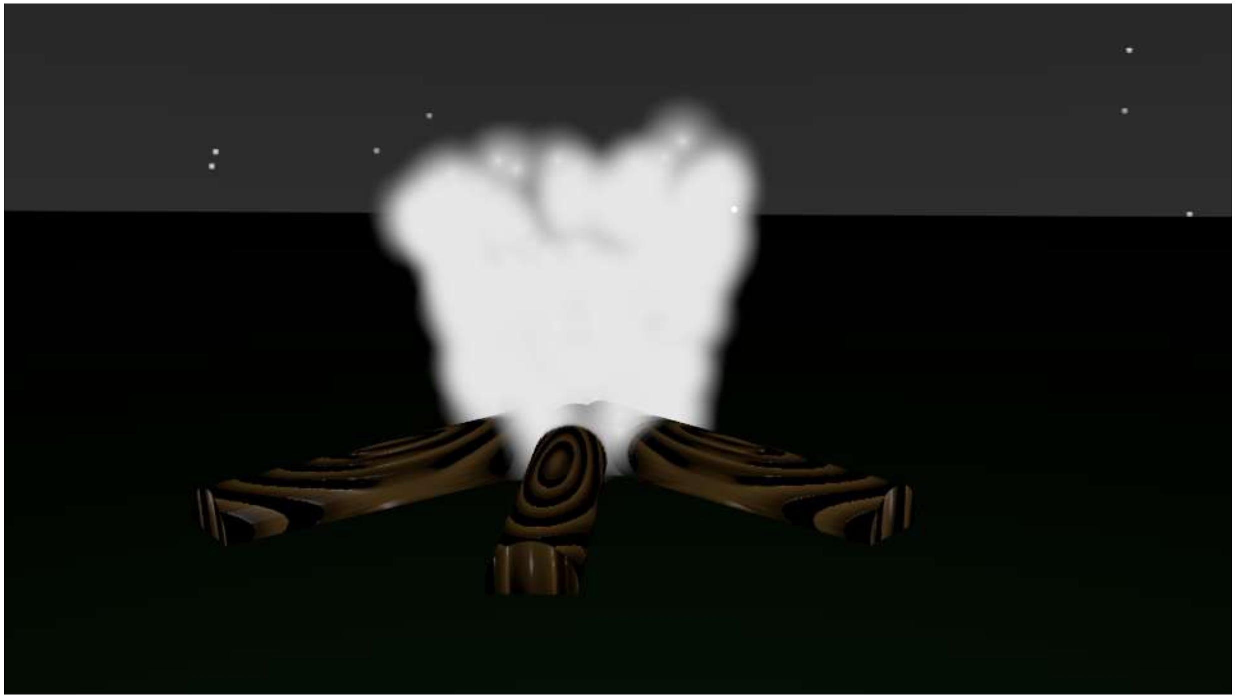
I like placing the Convergence Plane about 1/3 of the way through the object

There are many ways to display the correct view into the correct eye





16. References



Blender References I Like

http://cs.oregonstate.edu/~mjb/blender

http://blender.org

http://blenderkit.com

http://www.blender.org/education-help/

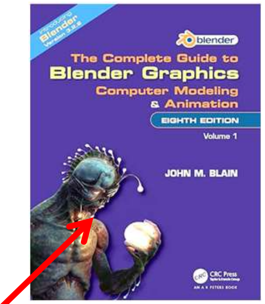
http://www.blenderguru.com/

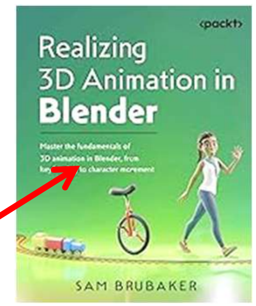
John Blain, *The Complete Guide to Blender Graphics: Computer Modeling and Animation*, Eighth Edition, Volumes 1 and 2, CRC Press, 2023.

Sam Brubaker, *Realizing 3D Animation in Blender*, Packt, 2024.

Jaime Kelley, *3D Character Rigging in Blender*, Packt, 2024.

Ruan Lotter, *Taking Blender to the Next Level*, Packt, 2022.





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Computer Graphics

Getting Free 3D Models and Texture Images

http://polyhaven.com

https://free3d.com

http://www.turbosquid.com/Search/3D-Models/free/obj

https://sketchfab.com/features/free-3d-models

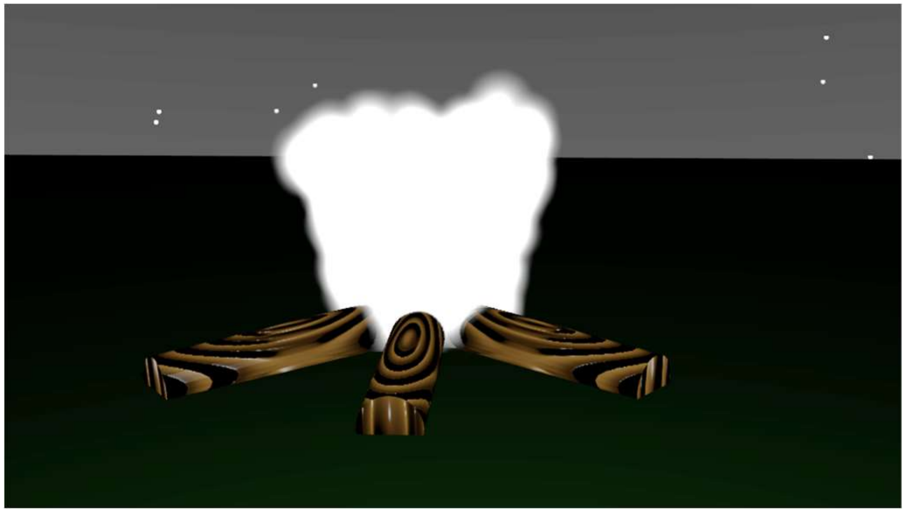
And Finally…

There is no badge for completing the Blender Camp, but if there was, it would probably look like this:*

*Thanks to Microsoft CoPilot for generating this image and thanks to my good friend Andrew Glassner for suggesting the prompts to do it.

Camp Blender

http://cs.oregonstate.edu/~mjb/blender



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