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Dr.Babasaheb Ambedkar Open University

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DMA-201
3D Animation

Diploma in Multimedia and Animation (DMA)

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3D Animation

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DMA-201

3D Animation

Block-1: 3D Modelling

Block-2: 3D Shading

Block-3: 3D Animation & Rigging (Practical)

Block-4: 3D Lighting & Rendering (Practical)

Block – 5: 3D Dynamics (Practical)

DMA-201

3D Animation

Block – 1: 3D Modelling

Unit-1 Introduction to 3D space

Introduction

Welcome to Blender, the free and Open Source 3D animation suite. Blender can be used to create 3D visualizations such as still images, video, and real-time interactive video games. Blender is well suited to individuals and small studios that benefit from its unified pipeline and responsive development process. It is a cross-platform and runs on Linux, macOS, and MS-Windows systems with less memory and disk footprint. Its interface uses OpenGL to provide a consistent experience across all supported hardware and platforms.

Key Features

- Blender is a fully integrated 3D content creation suite, offering a broad range of essential tools, including Modelling, Rendering, Animation, Video Editing, VFX, Compositing, Texturing, Rigging, many types of Simulations, and Game Creation.
- Cross platform, with an OpenGL GUI that is uniform on all major platforms (and customizable with Python scripts).
- High-quality 3D architecture enabling fast and efficient creation work-flow.
- Excellent community support from forums and IRC.
- Small executable size, optionally portable.

Title-**Img 1. 1*A rendered image being post-processed.***

Source- blender.org Link-
https://docs.blender.org/manual/en/dev/getting_started/about/introduction.html

Despite everything Blender can do, it remains a tool. Talented artists do not create masterpieces by pressing buttons or manipulating brushes, however, by learning and practicing subjects such as **human anatomy, composition, lighting, animation principles.**

3D Content Creation Software such as Blender has the added technical complexity and jargon associated with the underlying technologies. Terms like UV maps, Materials, Shaders, Meshes, and “Sub surf” are the mediums of the digital artist, and understanding them, even broadly, will help you to use Blender to its best. As this is a 3D based software, the navigation and the working pattern are very different unlike any other 2D based software. In this Unit, you will learn about the Interface of the software.

Outcomes

Upon completion of this unit you will be able to:

- Interface and customize elements as the Info Editor (Top), a large 3D View, TimeLine(Bottom), Outliner (Top right), properties Editor (Bottom right) etc.
- Experience the Navigation within the 3D space using different Transformation tools and the creation of basic meshes (objects) in Blender
- Use Transformation tools in Blender
- Manage Navigation in Space
- Create Basic Primitives
- Work on the Interface
- Create Shortcuts and
- Identify Buttons and Controls

Terminology

Header	:	Header contains various menus and controls based on the current mode.
Menu	:	Menu offers tools to navigate in 3D space.
Mode	:	3D view has several modes used for editing different kinds of data.
Viewport shading	:	Allows you to change the way objects are displayed in the viewport.
Transform Manipulator:	:	These handy selectors allow you to rotate or move objects by grabbing (clicking with your mouse) their controls and moving your mouse in the axis.
Snap	:	Controls the snapping tools that help with transforming and modelling objects.
Tool Shelf	:	Tool shelf is a context-sensitive region containing tools depending on

the current mode.

Properties Region : Properties Region contains properties of the active object and selected objects.

Grid Floor : The grey squares forming a floor mark the zero height of the world.

Orbit : Rotate the view around the point of interest.

Roll : Rotate the viewport camera around its local Z axis in 15° discrete steps.

Introduction to 3D view

3D View is used to interact with 3D scene for a variety of purposes, such as modeling, animation, texture painting, etc.

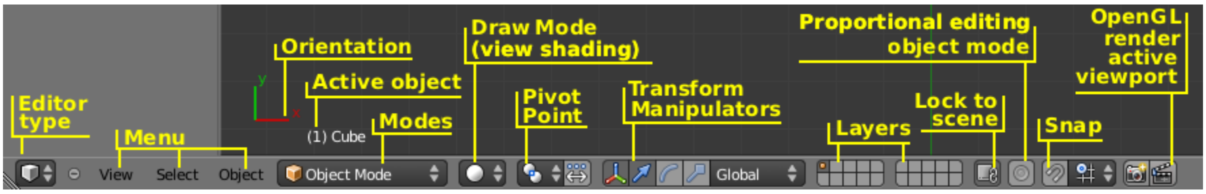
Main Region

One region, which is always visible, is known as the Main Region and is the most prominent part of the editor.

Each editor has a specific purpose, so the main region and the availability of additional regions are different between editors.

Header

The header contains various menus and controls based on the current mode.



Title-Img 1. 2. 3D View header Attribution

Attribution- Source- blender.org

Link-https://docs.blender.org/manual/en/dev/editors/3dview/introduction.html

Menus

View This menu offers tools to navigate in 3D space.

Select Contains tools for selecting objects.

Add Gives a list of different objects types that can be added to a scene.

Object This menu appears when in Object Mode. It contains tools to edit objects. In edit mode, it will change to the appropriate menu with editing tools.

Controls Modes The 3D view has several modes used for editing different kinds of data:

Object Mode The default mode, available for all object types, as it is dedicated to *object data-block editing*

Edit Mode A mode available for all renderable object types, as it is dedicated to their *"shape" Object*

Pose Mode An armature only mode, dedicated to *armature posing*.

Sculpt Mode A mesh-only mode, that enables Blender's mesh *3D-sculpting tool*.

Particle Edit A mesh-only mode, dedicated to *particle systems*, useful with editable systems (hair).

Arranging the Screen

Blender uses a novel screen-splitting approach to arrange areas. The idea is that you split up the big application window into many number of smaller (but still rectangular) non-overlapping areas. That way, each area is always fully visible, and it is very easy to work in one area and hop over to work in another.

Changing the Size

You can resize areas by dragging their borders with LMB. Simply move your mouse cursor over the border between two areas, until it changes to a double-headed arrow, and then click and drag.

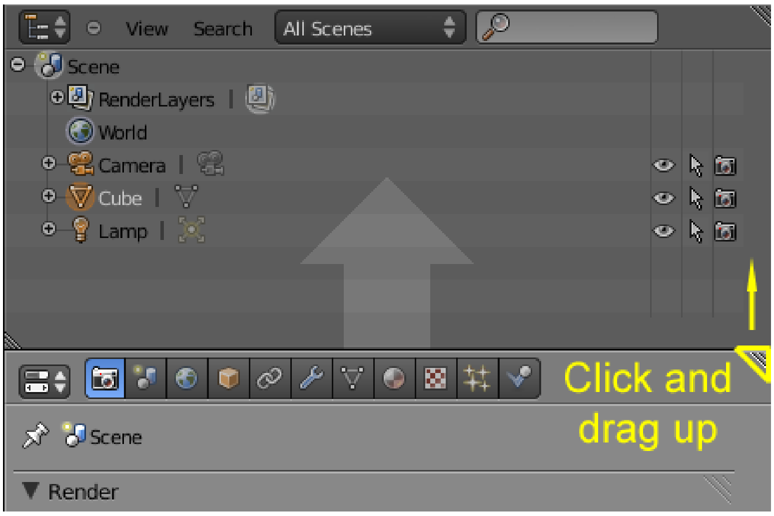
- Splitting and Joining
- Area Split Widget

Title-Img 1. 3. Changing the size **Attribution-**

Source- blender.org

*Link-**https://docs.blender.org/manual/en/dev/interface/window_system/areas.html***

In the upper right and lower left corners of an area are the area split widgets, and they look like a little ridged thumb grip. It bothsplits and combines areas. When you hover over it, your cursor will change to a cross (✛). (Refer Img 1.3) LMB and drag it inward split the area. You define the direction of that border by either dragging horizontally or vertically. In order to join two areas LMB click and drag the area splitter outward. They must be the same dimension (width or height) in the direction you wish to join. This is so that the combined area space results in a rectangle.



Title-Img 1. 3 Properties Editor is being merged "over" the Outliner. **Attribution-Source-** blender.org

Link- ***https://docs.blender.org/manual/en/dev/interface/window_system/areas.html***

The area that was closed gets a dark overlaid with an arrow. Now you can select the area to be closed by moving the mouse over it. **Release the** LMB **to complete the join. If you press** Esc **or** RMB **before releasing the mouse, the operation will be aborted.**

Area Options

RMB on the border opens the Area Options. Split Area Shows an indicator line that lets you select the area and position where to split. Tab switches between vertical/horizontal. Join Areas Shows the join direction overlay. Confirm or cancel works as described above.

Toggle Maximize Area

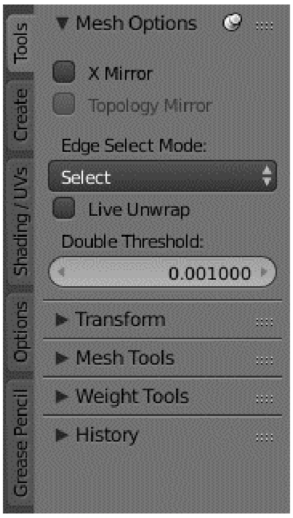
- **Menu: View** ‣ Toggle Maximize Area
- **Hotkey:** Ctrl-Up, Shift-Spacebar

The maximized area fills the whole application window. It contains the Info Editor and the select area. You can maximize an area with the View ‣ Toggle Maximize Area menu entry. To return to normal size use again menu entry, or RMB on the editor's header and select Maximize Area and Tiled Area to return. In the Info Editor header, the Back to Previous button on the right of the menus also returns to tiled areas. A quicker way to achieve this is to use the shortcuts: Shift-Spacebar, Ctrl-Down or Ctrl-Up to toggle between maximized and normal areas.

Tabs & Panels

Tabs

Tabs are overlapping sections in the user-interface. The Tabs header can be vertical (Tool Shelf) or horizontal (Properties Editor, User Preferences). Vertical tabs can be switched with the Wheel within the tab header and Ctrl-Wheel changes tabs from anywhere in the region.



Title-Img 1. 4Tools tab (selected), Create, etc

Source- blender.org

Link- https://docs.blender.org/manual/en/dev/interface/window_system/tabs_panels.html

Title-Img 1. 5 Horizontal tab header Attribution- Source- blender.org

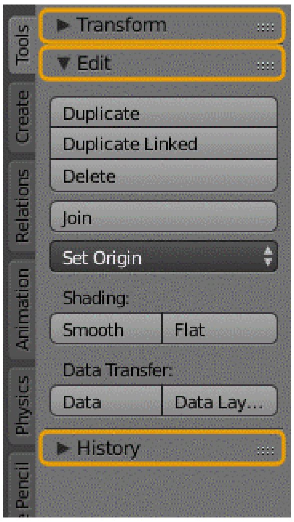
Link- https://docs.blender.org/manual/en/dev/interface/window_system/tabs_panels.html

Panels

The smallest organizational Unit in the user interface is a Panel. Panels can be collapsed to hide its contents. They are used in the Properties Editor, but also for example in the Tool Shelf and the Properties region. In the image on the right there are three panels:

1. Transform
2. Edit
3. History

The Edit panel is expanded and the other two panels are collapsed.



Title-Img 1. 6 Tool Shelf panels. Orange: Panel Headers Attribution-

Source- blender.org

Link- https://docs.blender.org/manual/en/dev/interface/window_system/tabs_panels.html

Collapsing and expanding

A triangle on the left of the title shows the **expanded (▼)** and **collapsed (►)** state of the panel.

- A click with the LMB on the panel header expands or collapses it.
- Pressing A expand/collapses the panel under the mouse pointer.
- A **Ctrl-LMB** click on the header of a specific panel will collapse all other panels and make this the only expanded one.
- Dragging with **LMB** over the headers will expand or collapse many at once.

Panel Position

You can change the position of a panel within its region by clicking and dragging it with the LMB on the grip widget (::::) in the upper right corner.

Pinned Panel Often it is desirable to view panels from different tabs at the same time. This has been solved by making panels pinnable. A pinned panel remains visible regardless of which tab has been selected. You can pin a panel by Shift clicking its header, or by RMB clicking on the header and choosing Pin in the context menu. In the image shown to the right, is an example of the Mesh Options pinned in the tools tab.

Zoom

The zoom factor of a whole region with panels can be changed by Ctrl-MMB clicking and moving the mouse anywhere within that region or use the Numpad Plus and Numpad Minus to zoom in and out the contents. Pressing Home (Show All) will reset the zooming at the screen/panel focused by the mouse pointer.

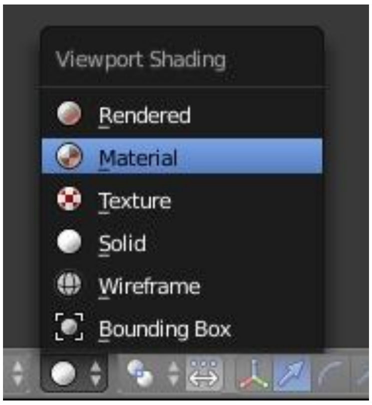
Alignment

The alignment of the panels in the Properties Editor can be changed between vertical and horizontal. To do this, click with RMB somewhere within the main region of the Properties Editor and choose either Horizontal or Vertical from the appearing menu. Keep in mind though that the panels are optimized for vertical alignment.

Viewport Shading

It allows you to change the way objects are displayed in the Viewport.

Header: Viewport Shading



Title-Img 1. 7The Viewport Shading menu Attribution- Source- blender.org

Link- https://docs.blender.org/manual/en/dev/editors/3dview/properties/shading.html

Bounding Box

Only shows rectangular boxes that outline an object's size and shape.

Wireframe

Objects appear as a mesh of lines representing the edges of faces and surfaces.

Solid

The default drawing mode using solid coloured surfaces and simple lighting.

Textured

Shows meshes with an image applied using the mesh's active UV Map. For Cycles materials, the image is the last one selected in the Node Editor. For other render engine's, the UV Map's applied face texture will be shown.

Material

A fast approximation of the applied material.

Rendered

An accurate representation using the selected Render Engine and lit with the visible scene lights.

Keyboard Shortcut

- Shortcuts Switches between Wireframe and Solid draw modes. Z
- Switches between the current and Rendered draw modes. Shift-Z
- Switches between Solid and Textured draw modes. Alt-Z

Except for Rendered, these shading modes are not dependent on light sources in the scene. Instead they use a simple default lighting adjusted by the Solid OpenGL Lights controls on the System tab of the User Preferences editor.

The viewport shading controls the appearance of all objects in a scene, but this can be overridden for individual objects using the Display panel in their Object Properties.

3D Space Navigation

Navigating in 3D space is done with the use of both mouse movement and keyboard shortcuts. To be able to work in the three-dimensional space that Blender uses, you must be able to change your viewpoint as well as the viewing direction of the scene. While describing 3D View editor, most of the other editors have similar functions. For example, it is possible to translate and zoom in the UV/Image editor.

Orbit

- **Mode**: All modes

- **Menu**: View ‣ Navigation ‣ Orbit

- **Hotkey**: MMB, Numpad2, Numpad4, Numpad6, Numpad8, Ctrl-Alt-Wheel

Rotate the view around the point of interest. Click and drag MMB on the viewport’s area. If you start in the middle of the area and move up and down or left and right, the view is rotated around the middle of the area.

To change the viewing angle in discrete steps, use Numpad8 and Numpad2 (which correspond to vertical MMB dragging, from any viewpoint), or use Numpad4 and Numpad6 (or Ctrl-Alt-Wheel) to rotate the scene around the global Z axis from your current point of view. Finally, Numpad9 switches to the opposite side of the view.

Alternatively, if the Emulate 3 button mouse option is select in the User Preferences you can press and hold Alt while dragging LMB in the viewport’s area.

Roll

- Mode: All modes
- Menu: View ‣ Navigation ‣ Roll
- Hotkey: Shift-Numpad4, Shift-Numpad6, Ctrl-Shift-Wheel
  Rotate the viewport camera around its local Z axis in 15° discrete steps.

Panning

- Mode: All modes
- Menu: View ‣ Navigation ‣ Pan
- Hotkey: Shift-MMB, Ctrl-Numpad2, Ctrl-Numpad4, Ctrl-Numpad6, Ctrl-Numpad8

Move the view up, down, left and right. To pan the view, hold down Shift and drag MMB in the 3D View. For discrete steps, use the hotkeys Ctrl-Numpad8, Ctrl-Numpad2, Ctrl-Numpad4 and Ctrl-Numpad6 as with orbiting (note: you can replace Ctrl by Shift). For those without a middle mouse button, you can hold Shift-Alt while dragging with LMB.

Zooming

- Mode: All modes
- Menu: View ‣ Navigation ‣ Zoom
- Hotkey: Ctrl-MMB, Wheel, Numpad Plus, Numpad Minus

Move the camera forwards and backwards. You can zoom in and out by holding down Ctrl and dragging MMB. The hotkeys are Numpad Plus and Numpad Minus. The View ‣ Navigation sub-menu holds these functions too as well. Refer to the 3D View’s View menu image above for more information. If you have a wheel mouse, you can zoom by rotating the Wheel.

Zoom Border

- Mode: All modes
- Menu: View ‣ Zoom Border
- Hotkey: Shift-B

The Zoom Border tool allows you to specify a rectangular region and zoom in so that the region fills the 3D View. You can access this through the View menu, or the shortcut Shift-B, then LMB click and drag a rectangle to zoom into. Alternatively you can zoom out using the MMB.

Dolly Zoom

- Mode: All modes
- Hotkey: Ctrl-Shift-MMB

In most cases its sufficient to zoom the view to get a closer look at something, however, you may notice that at a certain point you cannot zoom any closer. This is because, Blender stores a view-point that's used for orbiting and zooming. It works well in many cases, however sometimes you want to move the view-point to a different place. This is what Dolly supports, allowing you to transport the view from one place to another. You can dolly back and forth by holding down Ctrl-Shift and dragging MMB.

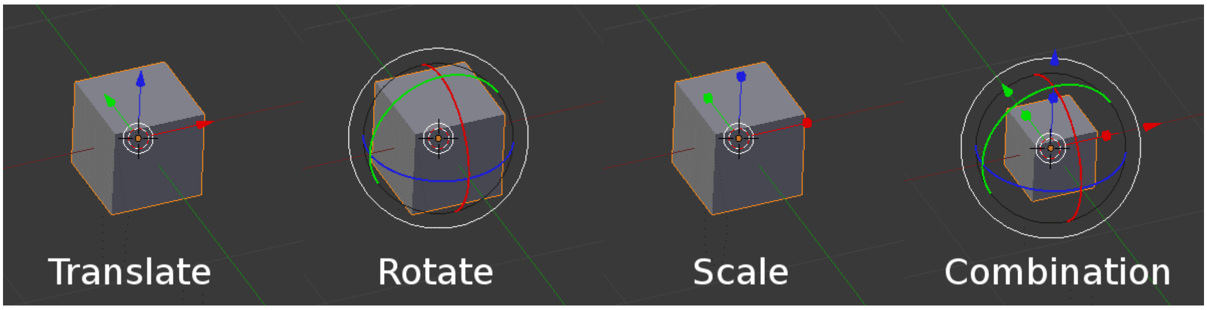
Transform Manipulators

These handy selectors allow you to rotate or move objects by grabbing (clicking with your mouse) their controls and moving your mouse in the axis.

Title-Img 1. 8 Transform Manipulators **Attribution-**
Source- blender.org
Link-https://docs.blender.org/manual/en/dev/editors/3dview/object/editing/transform/control/manipulators.html

- Mode: Object and Edit Modes
- Menu:
- Hotkey: Ctrl-Spacebar

The Transformation manipulator widgets allow mouse controlled translation, rotation and scaling in the 3D View. There is a separate manipulator for each operation. Each manipulator can be used separately or in combination with the others.



Title-**Img 1. 9 The different Manipulators** Attribution-

Source- **blender.org**

Link-

https://docs.blender.org/manual/en/dev/editors/3dview/object/editing/transform/control/manipulators.html

Header Controls

Manipulators can be accessed through the header of the 3D View.

Axis : Enable/disable the manipulators Ctrl-Spacebar.

Manipulators: Toggles each of the manipulators. Clicking with Shift-LMB on multiple manipulator icons will combine the manipulators.

Arrow: Translation.

Arc: Rotation.

Box: Scale.

Basic Transformations

Grab/Move

- **Mode**: Object Mode, Edit Mode, and Pose Mode
- **Panel:** Tool Shelf ‣ Tools ‣ Transform ‣ Translate
- **Menu:** Object type ‣ Transform ‣ Grab/Move
- **Hotkey:** G

In Object Mode, the grab/move option lets you translate (move) objects. Translation means changing location of objects. It also lets you translate any elements that make up the object within the 3D space of the active 3D View. Pressing G activates "Grab/Move" transformation mode. The selected object or element then moves freely according to the mouse pointer's location and camera.

You can also move an object by clicking and holding RMB on the object to move it. To confirm the action, press LMB.

Rotate

- Mode: Object and Edit Modes
- Panel: Tool Shelf ‣ Tools ‣ Transform ‣ Rotate
- Menu: Object/Mesh/Curve/Surface ‣ Transform ‣ Rotate
- Hotkey: R

Rotation is also known as a spin, twist, orbit, pivot, revolve, or roll and involves changing the orientation of elements (vertices, edge, face, Object etc.) around one or more axes or the Pivot Point

Scale

- Mode: Object and Edit Modes
- Panel: Tool Shelf ‣ Tools ‣ Transform ‣ Scale
- Menu: Object/Mesh/Curve/Surface ‣ Transform ‣ Scale
- Hotkey: S

Scaling means changing proportions of objects. Pressing S will enter the Scale transformation mode where the selected element is scaled inward or outward according to the mouse pointer's location. The element's scale will increase as the mouse pointer is moved away from the Pivot Point and decrease as the pointer is moved towards it. If the mouse pointer crosses from the original side of the Pivot Point to the opposite side, the scale will continue in the negative direction and flip the element.

Title-Img 1. 10 Basic scale usage

Source- blender.org

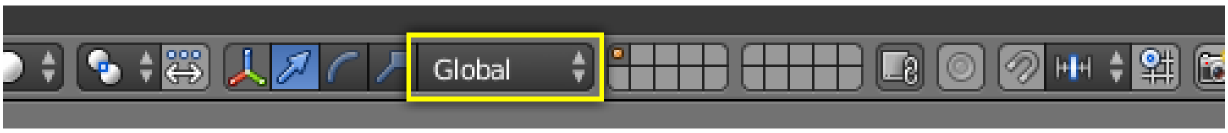
Link- https://docs.blender.org/manual/en/dev/editors/3dview/object/editing/transform/basics.html

From left to right, the panels show: the original Object, a scaled down Object, a scaled-up Object and a scale-flipped Object.

Transform Orientations

- Mode: Object and Edit Modes
- Panel: Properties region ‣ Transform Orientations
- Hotkey: Alt-Spacebar

Orientations affect the behaviour of Transformations: Location, Rotation, and Scale. You will see an effect on 3D Manipulator (the widget in the centre of the selection), as well as on transformation constraints (like axis locking). This means that, when you press G-X, it will constrain to the global X-axis, but if you press G-X-X it will constrain to your Transform Orientations X-axis.



Title-Img 1. 11Transform Orientations selector **Attribution-**

Source- blender.org

Link- https://docs.blender.org/manual/en/dev/editors/3dview/object/editing/transform/control/orientations.html
The Orientations options can be set through the Orientation selector in 3D View header, with Alt-Spacebar, or in the Transform Orientations panel in the Properties region.

Orientations Global

The manipulator matches the global axis. When using the Global orientation, the orientation's XYZ matches world's XYZ axis. When this mode is selected, the local coordinates of the object are subjected to the Global coordinates. This is good to place objects in the scene. To constrain an axis, press G and the desired axis. To constrain to a local axis, press the desired axis two times. The difference between Global and Local, is more noticeable when you have an object in which the origin is not located at the exact center of the object, and does not match the Global coordinates.

Local

The manipulator matches the object axis.

Notice that, here, the Manipulator is at a slight tilt (it is most visible on the object's Y-axis, the green arrow). This is due to our 15° rotation of the object. This demonstrates the difference between local coordinates and global coordinates. If we had rotated the object 90° along its X-axis, we would see that the object's "Up" is the world's "Forward" – or the object's Z-axis would now be the world's Y-axis. This orientation influences many parts of the interface, so it is important to understand the distinction.

Normal

The Z-axis of the manipulator will match the normal vector of the selection.

In Object Mode, this is equivalent to Local Orientation, in Edit Mode, it becomes more interesting.

As you see, the light blue lines indicate the faces' normals, and the darker blue lines indicate the vertex normals (these were turned on in the N Properties region under Mesh Display ‣ Normals ‣ Face and Vertex). Selecting any given face will cause our Manipulator's Z-axis to align with that normal. The same goes for Vertex Select Mode. Edge Select is different – A selected Edge has the Z-axis aligned with it (so you will have to look at the Manipulator widget to determine the direction of X and Y). If you select several elements, it will orient towards the average of those normals.

A notable example of how this is useful is in Vertex Select Mode: Pick a vertex and then do G, Z, Z to tug it away from the mesh and shove it into the mesh. To make this even more useful, select a nearby vertex and press Shift-R to repeat the same movement – except along that second vertex's normal instead.

Gimbal

Uses a Gimbal behaviour that can be changed depending on the current Rotation Mode.

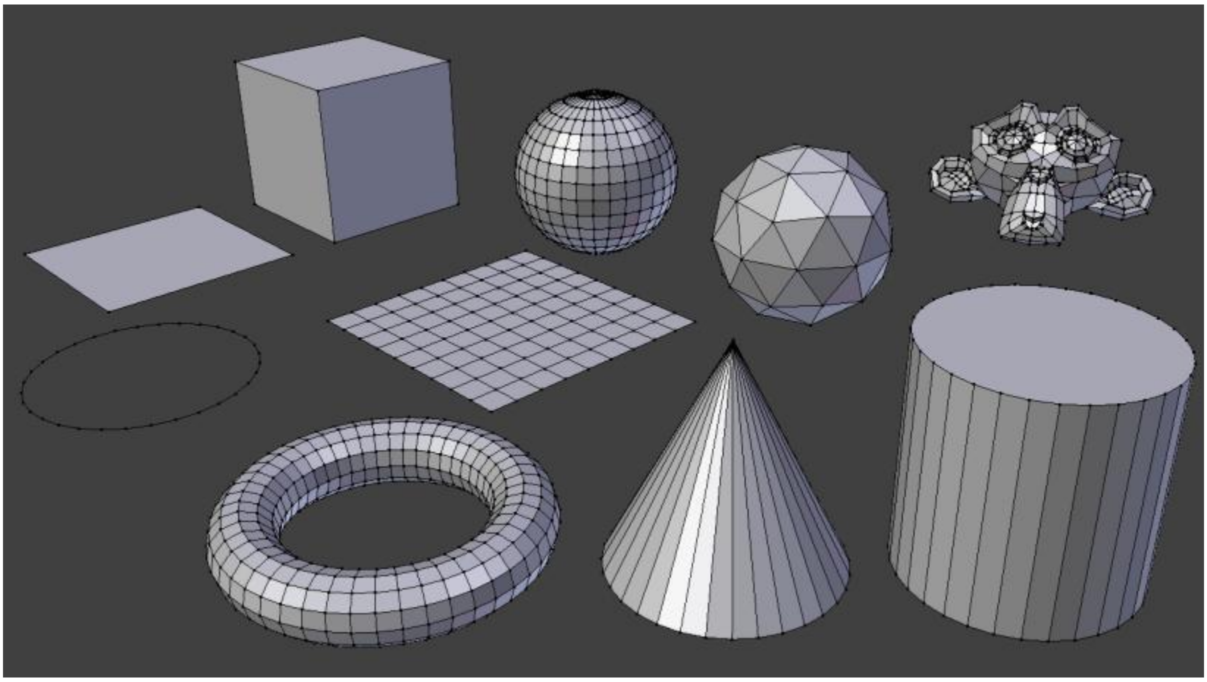
Creating Basic Primitives

- Mode: Object Mode and Edit Mode
- Panel: Tool Shelf ‣ Create ‣ Add Primitive/Mesh
- Menu: Add ‣ Mesh
- Hotkey: Shift-A

A common object type used in a 3D scene is a Mesh. Blender comes with several "primitive" mesh shapes that you can start modelling from. You can also add primitives in Edit Mode at the 3D cursor. If the created object can be removed by hitting delete key.

Undo Hotkey: Ctrl-Z

Redo Hotkey: Ctrl-Shift-Z



Title-Img 1. 12 Blender's standard primitives **Attribution-**
Source- blender.org
Link- https://docs.blender.org/manual/en/dev/modeling/meshes/primitives.html

Unit summary

In this Unit, you have learnt what is 3D Interface and how to

- Work effectively and navigate in 3D space within Blender to manage the work flow
- Customize the user interface to limit the tools and option required for the user in Blender.
- Use Hot keys
- Identify buttons and controls
- Interact with 3D scene using 3D View for a variety of purposes, such as modeling, animation, texture painting, etc.
- Use the Info Editor at the top, a large 3D View, TimeLine at the bottom, Outliner at the top right, properties Editor at the bottom right etc.

After learning this Unit, you can download the Open Source Software available on the internet for free of cost to practice the possibilities of creating 3D Interface.

Assignment

- Create a Dining Table with a table lamp using the basic primitives.

Assessment

- Explain 3D Navigation in Blender
- Define Primitives.
- Write a brief note on Transform Manipulator.
- Describe the types of Viewport Shading.
- Write a brief note on Track Panel.
- How are the splitting and arranging widgets used?

Fill in the Blanks

1. _______________ allows you to change the way objects are displayed in the viewport.
2. ______________ tool is used to rotate the view around the point of interest.
3. Pressing _______________expand/collapses the panel under the mouse pointer.
4. In _______________ mode, objects appear as a mesh of lines representing the edges of faces and surfaces.
5. The_____________ short cut can be used to grab and move object.

Resources

While studying this Unit, you can browse the internet links for online tutorials and several books and training DVDs available in theBlender Storeand on theBlender Cloud.

- wiki.blender.org
- archive.org
- www.blender.org
- docs.blender.org

Unit-2 Introduction to Modeling

Introduction

In this Unit, you will learn about the important Tools, which support the work flow in Modelling and the many ways of Selecting an Object, Duplicating, Mirroring, etc. Common use of Mirroring is to model Half an Object, duplicate it and then use the mirror transform to create a reversed version to complete the model. You will also learn how to organize 3D scenes by using Layers, as it often becomes exponentially more confusing as they grow more complex. Sometimes the artist also needs precise control over how individual Objects are lit, and does not want lights for one Object to affect nearby Objects.

Outcomes

Upon completion of this unit you will be able to:

- Draw with Selection Tools
- Select, duplicate and mirror an Object
- Create Multiple Objects with Mirror and Duplicate
- Edit Pivot Point
- Use Snap Tool
- Organize 3D Scenes using Layers

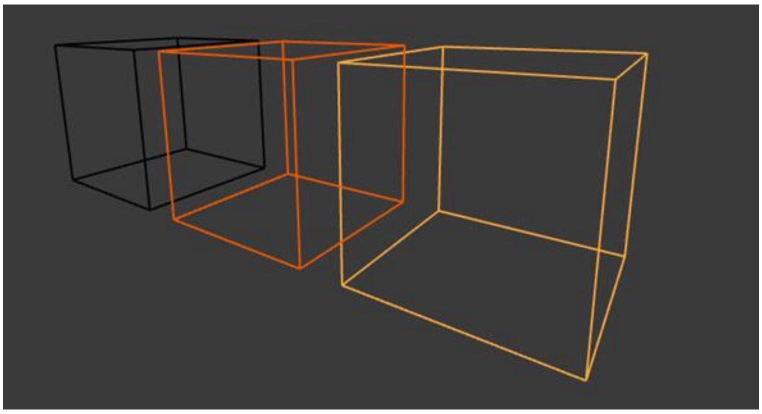
Terminology

Active Object	In Object Mode, the last (de)selected item is called the "Active Object"
Point selection	Selecting the Object in the viewport with a RMB.
Border select	With Border Select, you can draw a rectangle while holding down LMB.
Lasso select	Lasso select is used to draw a dotted line around the pivot point of the Objects, in Object Mode.
Circle select	Circle Select is used to move with dotted circle through Objects with LMB.
Mirror	Mirroring an Object or Mesh selection will create a reversed version of the selection.
Duplicate	This will create a visually-identical copy of the selected Object(s).
Edge Ring	In Edge select mode, holding Ctrl-Alt while selecting an edge selects a sequence of edges that are not connected.

Selection grid	**to**	Snaps the currently selected Object(s) to the nearest grid point.
Cursor Selected	**to**	Moves the cursor to the centre of the selected Object(s).
Layers		Objects can be placed into one or more “layers” using Object layers.
Cursor center	**to**	Moves the cursor to the center of the grid.

Work Flow of Modeling

Object Selection Selections and the Active Object Blender distinguishes between **two different states of selection**:



Title- Img 2. 1 Unselected Object in black, selected Object in orange, and active Object in yellow.

Source-Blender.org

Link-https://docs.blender.org/manual/en/dev/editors/3dview/object/select ing/introduction.html

- In **Object Mode,** the last (de)selected item is called the “**Active Object**” and is outlined in **yellow** (the others are orange). There is exactly one active Object at any time (even when nothing is selected).
- Many actions in Blender use the active Object as a reference (for example linking operations). If you already have a selection and need to make a different Object the active one, simply re-select it with **Shift-RMB.**
- All other selected Objects are just selected. You can select any number of Objects.

Point Selection

- The simplest form of Object selection consists of using **RMB** on it.
- To add to the selection, use **Shift-RMB** on more Objects.
- If the Objects are **overlapping** in the view, you can use **Alt-RMB** to cycle through possible choices.
- If you want to add to a selection this way, then the shortcut becomes **Shift-Alt-MB.**
- **To activate** an Object that is already selected, click **Shift- RMB** on it.
- To deselect an active Object, click **Shift-RMB** one time and hence, two clicks if the Object is not active. Note that this only works if there are no other Objects under the mouse. Otherwise it just adds those to the selection. There appears to be no workaround for this bug.

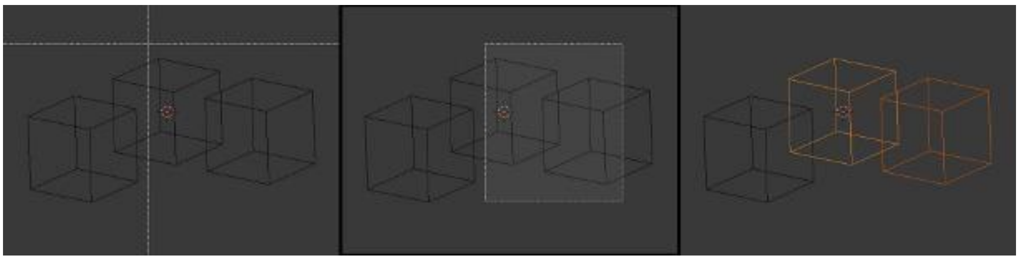
Border Selection

- **Mode**: Object Mode and Edit Mode
- **Menu**: Select ‣ Border Select
- **Hotkey**: B

With Border Select you draw a rectangle while holding down **LMB**. Any Object that lies even partially within this rectangle becomes selected.

- For deselecting Objects, use **MMB** or Border Select again with holding **Shift.**
- To cancel the selection use **RMB.**

Example



Title-Img 2. 2 Border selecting in three steps

Source-Blender.org

Link-*http://blender-manual- i18n.readthedocs.io/ja/latest/modeling/objects/selecting.html*

Border Select has been activated in the first image and is indicated by showing a **dottedcross-haircursor**. In the second image, the selection region is being chosen by drawing a **rectangle** with the **LMB**. The rectangle is only covering two cubes. Finally, in the third image, the selection is completed by releasing **LMB.**

Notice in the third image, the bright color of left-most selected cube. This means it is the "**Active Object**", the last selected Object prior to using the **Border Select** tool.

Lasso Select

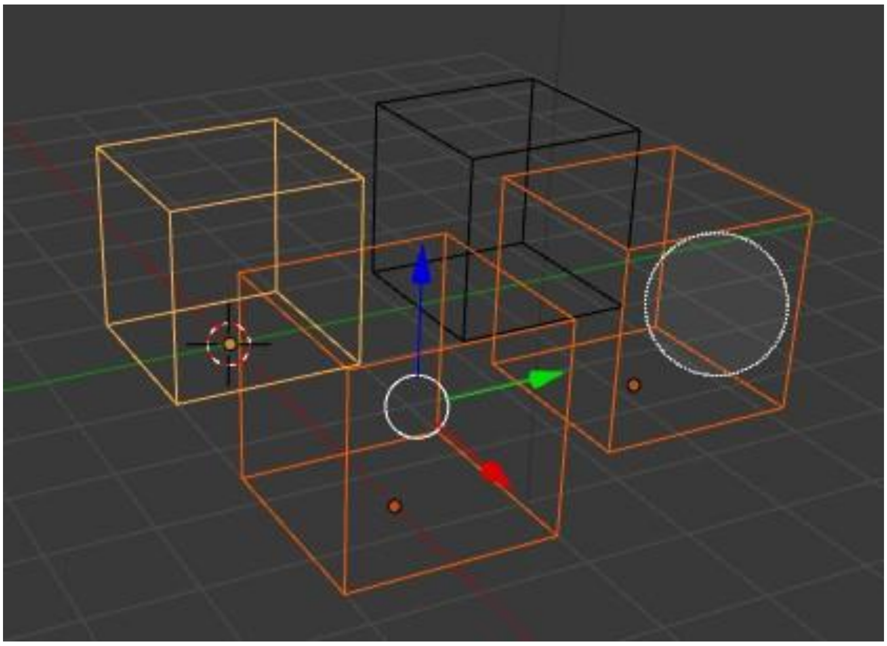
- **Mode**: Object Mode and Edit Mode
- **Menu**: no entry in the menu
- **Hotkey**: Ctrl-LMB

Lasso select is used by **drawing a dotted line** around the pivot point of the Objects, in Object Mode.

Circle Select

- **Mode:** Object Mode and Edit Mode
- **Menu:** Select ‣ Circle Select
- **Hotkey:** C

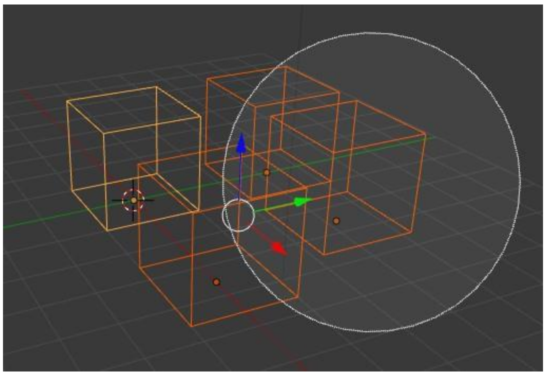
Circle Select is used by moving with **dotted circle** through Objects with **LMB**. You can select any Object by touching of circle area. It is possible to dynamically change the diameter of circle by scrolling **MMB** as seen in Img 2.3 and Img 2.4. Deselection is under the same principle - **MMB**. To cancel the selection use **RMB** or key Esc.



Title- Img 2. 3 Circle selection

Source-Blender.org

Link-*https://wiki.blender.org/index.php/Doc%3A2.6/Manual/Modeling/Objects/Selecting*



Title-Img 2. 4 with huge circle

Source-Blender.org

Link-*https://wiki.blender.org/index.php/Doc%3A2.6/Manual/Modeling/Objects/Selecting*

Menu Selection

The selection methods described above are the **most common**. There are also many more options accessible through the Select menu of the 3D View.

Select Grouped

- **Mode**: Object Mode

- **Menu**: Select ‣ Grouped
- **Hotkey**: Shift-G

There are **two ways** to organize the Objects in relation to one another.

1. Parenting
2. Simple grouping

Select Grouped uses the Active Object as a base to select all others.

Title-Img 2. **5** Select Grouped menu

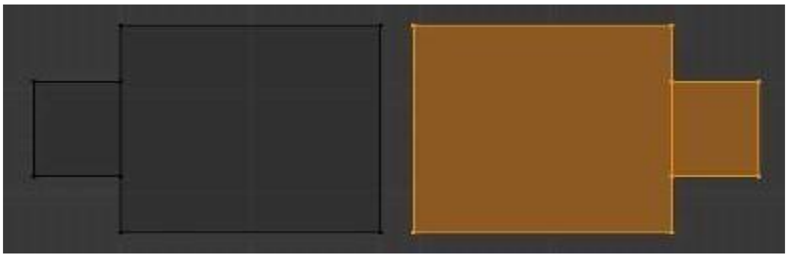
Source-wiki.Blender.org

Link-*https://wiki.blender.org/index.php/File:25-Manual-Object-Selection-Grouped.png*

Mirror Object

- **Mode:** Object and Edit Modes
- **Menu:** Object/Mesh ‣ Mirror
- **Hotkey:** Ctrl-M

Mirroring an Object or **Mesh selection** will create a reversed version of the selection. The position of the mirrored version of the selection is determined by the **Pivot Point**. A common use of mirroring is to **model half an Object**, duplicate it and then use the **mirror transform** to create a reversed version to complete the model.



Title- Img 2. 6 Mirroring a Selection

Source-Blender.org

Link- *https://docs.blender.org/manual/en/dev/editors/3dview/object/editing/transform/mirr or.html*

Duplicate Object

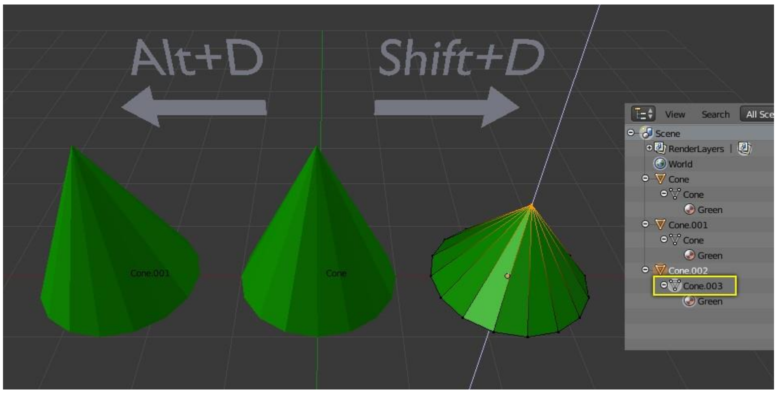
This will create a **visually-identical cop**y of the selected Object(s). The copy is created at the same position as the original Object and you are automatically placed in **Grab mode**.

This copy is a new Object, which shares some data-blocks with the original Object (by default, all the Materials, Textures, and F-Curves), but which has copied others, like the mesh, for example. Therefore, this form of duplication is sometimes called "**shallow link**", because not all data- blocks are shared; some of them are "**hard copied**"!

- **Mode**: Edit and Object Modes
- **Menu**: Object ‣ Duplicate
- **Hotkey**: Shift-D

This will create a visually-identical copy of the selected Object(s). The copy is created at the same position as the original Object and you are automatically placed in **Grab mode**. See the example below (Img 2.7).

Examples



Title-Img 2. **7** The MeshCone.006 of Object Cone.002 is being edited.

Source-Blender.org

Link- *https://docs.blender.org/manual/en/dev/editors/3dview/object/editing/duplica tion.html*

The mesh's unique data-block ID name is highlighted in the Outliner.

The cone in the middle has been

(1) link duplicated to the left and

(2) duplicated to the right.

The **duplicated right cone** is being edited; the original cone in the middle remains unchanged. The **Mesh data** has been **copied not linked**.

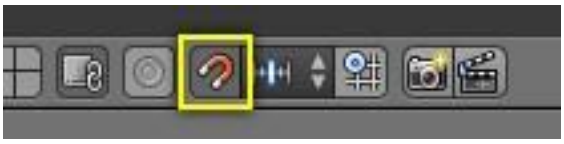
Likewise, if the right cone is edited in Object mode, the original cone remains unchanged. The new Objects transform properties or data-block is a **copy, not linked**.

When the right cone was duplicated, it inherited the material of the middle cone. The material properties were **linked, not copied**.

Snapping

- **Mode**: Object and Edit Mode
- **Hotkey**: Shift-S

Transform Snapping



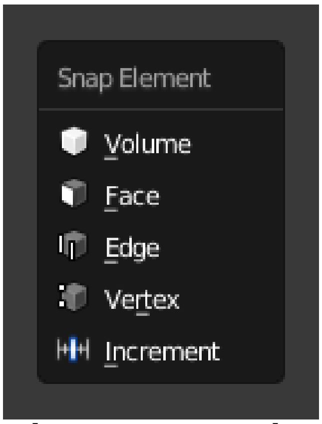
Title-Img 2. 8 Magnet icon in the 3D View header (red when enabled)

Source-Blender.org

Link- *https://docs.blender.org/manual/en/dev/editors/3dview/object/editing/transform/cont rol/snap.html*

The ability to snap Objects and Mesh element to various types of scene elements during a transformation is available by toggling the magnet icon (which will turn red) in the 3D View's header buttons**.**

Snap Element



Title-Img 2. 9 Snap Element menu

Source-Blender.org

Link- *https://docs.blender.org/manual/en/dev/editors/3dview/object/editing/transform/cont rol/snap.html*

Volume

Snaps to regions within the volume of the first Object found below the mouse cursor. Unlike the other options, this one controls the depth (i.e. Z-coordinates in current view space) of the transformed element. By toggling the button that appears to the right of the snap target menu (Refer Img 2.10), target Objects will be considered as whole, when determining the volume center.

Face

Snap to the surfaces of faces in Mesh Objects. It is useful for retopologizing the surface of the geometry.

Edge

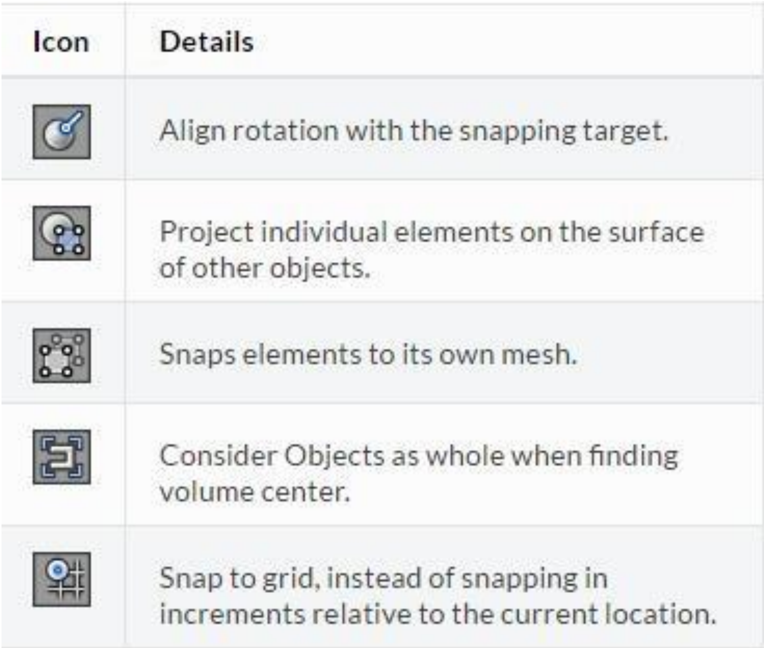
Snap to edges of Mesh Objects.

Vertex

Snap to vertices of Mesh Objects.

Increment

Snap to grid points. When in Orthographic view, the snapping increment changes depending on zoom level.



Icon	Details
	Align rotation with the snapping target.
	Project individual elements on the surface of other objects.
	Snaps elements to its own mesh.
	Consider Objects as whole when finding volume center.
	Snap to grid, instead of snapping in increments relative to the current location.

Title-Img 2. 10 Various Snap Option

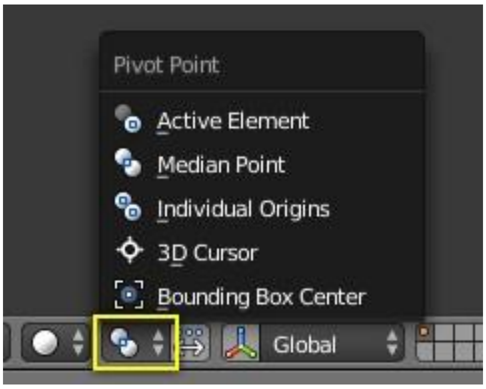
Source-Blender.org

Link- *https://docs.blender.org/manual/en/dev/editors/3dview/object/editing/transform/cont rol/snap.html*

Pivot Points

Origin of the 3D model, which is therefore not the physical center of gravity of the Object, but rather the **pivot point** that will identify the location coordinates of the Object in 3D space, and in toward which operations (such as rotation and scaling of the entire Object) will be carried out, in Object Mode.

- **Mode**: Object Mode and Edit Mode
- **Menu**: Drop list in the header of the 3D View

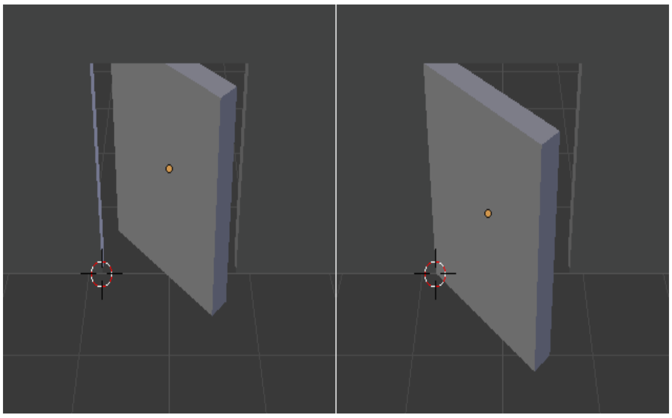


Title-Img 2. 11 Pivot Point modes

3D Cursor

- **Mode:** Object Mode and Edit Mode
- **Menu:** Select from the icon in the 3D View header.
- **Hotkey: .**

The 3D cursor is the most **intuitive of the pivot points**. With the 3D cursor selected as the active pivot point (from either the Editors Header or via.), simply position the 3D cursor and then do the required transformation. All **rotation and scaling** transformations will now be done relative to the location of the 3D cursor. The image below shows the difference when rotating an Object **around the median** point (left) and **around the 3D cursor** (right).



Title- Img 2. 12 Rotation around the 3D cursor compared to the median point.

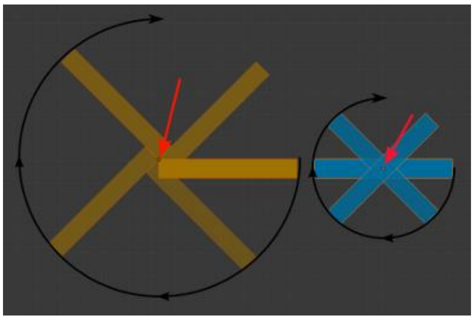
Attribution- Source-Blender.org

Link*https://docs.blender.org/manual/en/dev/editors/3dview/object/editing/transform/control/pivot_point/3d_cursor.html*

Individual Origins

- **Mode**: Object Mode and Edit Mode
- **Menu**: Select from the pivot-icon icon in the 3D View header.
- **Hotkey**: Ctrl-.

In Object Mode



Title-Img 2. 13 Rotation around individual origins.

Source-Blender.org

Link-

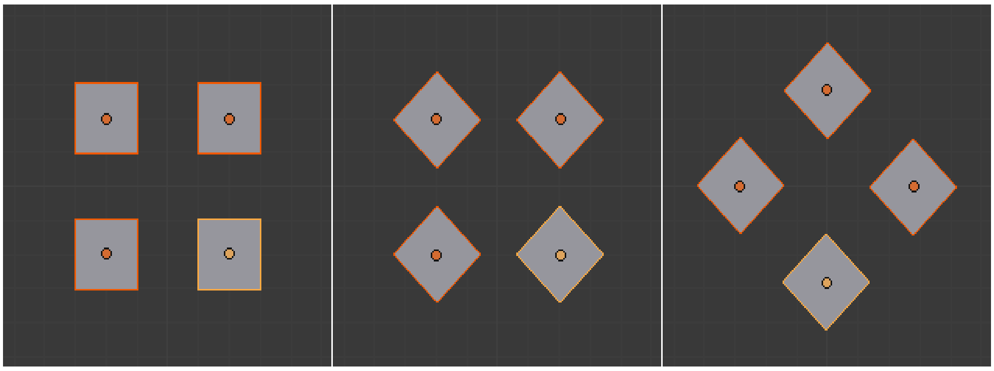
https://docs.blender.org/manual/en/dev/editors/3dview/object/editing/transform/control/pivot_point/individual_origins.html?highlight=rotation%20around%20individual%20 origins

The **Origin of an Object** is shown in the 3D View by a **small orange circle**. This is highlighted in the image to the right by **the red arrow**. The origin tells Blender the relative position of that Object in 3D space. What you see in the 3D View (vertices, edges etc.) is what makes up the Object.

While the Origin is equivalent to the center of the Object, it does not have to be located in the center of the Mesh. This means that an Object can have its center located on one end of the Mesh or even completely outside the mesh. For example, the orange rectangle in the image has its Origin located on the far left of the mesh.

Now let us examine: Rotation around the individual origins:

- The **blue rectangle** has its Origin located in the center of the mesh, while the orange rectangle has its Origin located on the left-hand side.
- When the **Pivot Point** is set to Individual Origins, the center of each Object (indicated by the red arrow) remains in place while the Object rotates around it in the path shown by the black arrow.

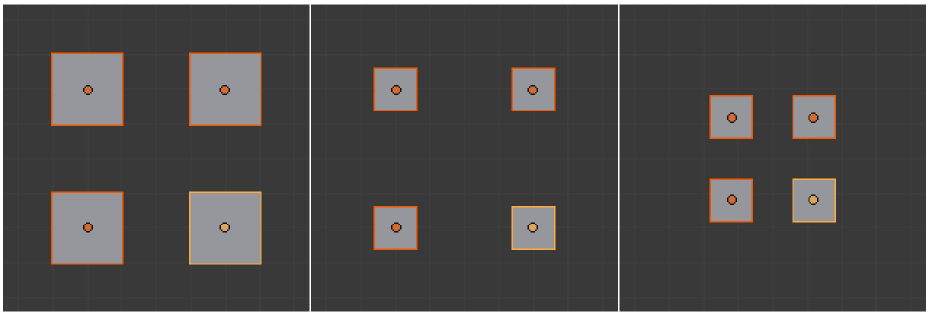


Title-Img 2. 14 Rotation around individual origins (middle) compared to the median point (right)

Source-Blender.org

Link-

https://docs.blender.org/manual/en/dev/editors/3dview/object/editing/transform/control/pivot_point/individual_origins.html



Title-Img 2. 15 Scaling around individual origins (middle) compared to the median point (right).

Source-Blender.org

Link- *https://docs.blender.org/manual/en/dev/editors/3dview/object/editing/transform/control/pivot_point/individual_origins.html*

Working with Layers

3D scenes often become exponentially more confusing as they grow more complex. Sometimes the artist also needs precise control over how individual Objects are lit, and does not want lights for one Object to affect nearby Objects. For this and other reasons below, Objects can be placed into one or more "**layers**". Using Object layers, you can:

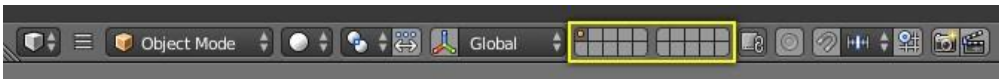
Selectively display Objects from certain layers in your 3D View, by selecting those layers in the 3D View header. This allows you to speed up interface redrawing, reduce virtual-world clutter, and help improve your workflow.

Mode: Object Mode

- **Panel:** Object ‣ Relations
- **Menu:** Object ‣ Move to Layer...
- **Hotkey:** M

Viewing layers

Blender provides **twenty layers** whose visibility can be toggled with the small unlabelled buttons in the header (Refer Img 2.16, 3D View layer buttons). To select a single layer, click the appropriate button with **LMB**; to select more than one, use **Shift-LMB** - doing this on an already active layer will deselect it.



Title-Img 2. 16 3D View layer buttons.

Source-Blender.org

Link- https://docs.blender.org/manual/en/dev/editors/3dview/object/properties/rela tions/layers.html

To select layers via the keyboard,

- **Step 1:** press **1 to 0** (on the main area of the keyboard) for layers 1 through 10 (the top row of buttons), and
- **Step 2: Alt-1** to **Alt-0** for layers 11 through 20 (the bottom row). Use Shift for multiple (de)selection works for these shortcuts too.

You can select or deselect all Scene Layer buttons at once by pressing **\.**

Locking to the scene

By default, the lock button directly to the right of the layer buttons is enabled. This means that changes to the viewed layers affect all other 3D Views locked to the scene

Multiple Layers

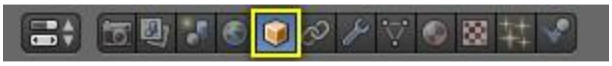
An Object can exist on **multiple layers**. For example, a lamp that only lights Objects on a shared layer could "be" on layers **1, 2, and 3.** An Object on layers **3 and 4** would be lit, whereas an Object on **layers 4 and 5** would not. There are many places where layer-specific effects come into play, especially lights and particles.

Moving Objects between layers

Title-Img 2. 17 Layer selection. Source-Blender.org

Link- https://docs.blender.org/manual/en/dev/editors/3dview/object/properties/relations/la yers.html

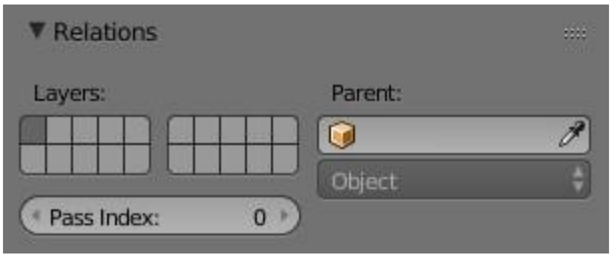
To move selected Objects to a different layer, press **M** and then select the layer you want from the pop-up menu. Objects can also be on **more than one layer** at a time. To have an Object on multiple layers, hold **Shift** while clicking.



Title-Img 2. 18 Selection in the Object tab Source-Blender.org

Link- https://docs.blender.org/manual/en/dev/editors/3dview/object/properties/relations/la yers.html

Another way to view or change a selected Object layer is via the Relations panel, in the Object tab.



Title-Img 2. 19 Layers in Object tab, Relations panel. Source-Blender.org

Link- https://docs.blender.org/manual/en/dev/editors/3dview/object/properties/relations/la yers.html

You will then see the layer buttons in the Relations panel – as before – the Object can be displayed on more than one layer by clicking **Shift- LMB**.

Objects in Blender

The geometry of a scene is constructed from one or more Objects. These Objects can range from lamps to light your scene, **basic 2D and 3D shapes** to fill it with models, armatures to animate those models, to cameras to take pictures or video of it all.

Object Types

Mesh

Meshes are Objects composed of Polygonal Faces, Edges and/or Vertices, and can be edited extensively with Blender's Mesh editing tools.

Curve

Curves are mathematically defined Objects which can be manipulated with control handles or control points (instead of vertices), to manage their length and curvature.

Surface

Surfaces are patches that are also manipulated with control points. These are useful for simple rounded forms and organic landscapes.

Metaball

Meta Objects (or Metaballs) are Objects formed by a mathematical function (with no control points or vertices) defining the 3D volume in which the Object exists. Metal Objects have a liquid-like quality, where when two or more Metaballs are brought together, they merge by smoothly rounding out the connection, appearing as one unified Object.

Text

Text Objects create a two-dimensional representation of a string of characters.

Armature

Armatures are used for rigging 3D models in order to make them poseable and animateable.

Lattice

Lattices are non-renderable wireframes, commonly used for taking additional control over other Objects with help of the Lattice Modifier.

Empty

Empties are null Objects that are simple visual transform nodes that do not render. They are useful

for controlling the position or movement of other Objects.

Speaker

Speaker brings to scene source of sound.

Camera

This is the virtual camera that is used to determine what appears in the render.

Lamp

These are used to place light sources in the scene.

Force Field

Force Fields are used in physical simulations. They give simulations external forces, creating movement, and are represented in the 3D View editor as small control Objects.

Group Instance

Let's you select from a list of existing Object groups. Once selected, an Empty Object will be created, with an instance of the selected group (group duplication active).

Objects

The geometry of a scene is constructed from one or more Objects. These Objects can range from lamps to light your scene, basic 2D and 3D shapes to fill it with models, armatures to animate those models, to cameras to take pictures or video of it all.

Unit Summary

In this Unit, you have learnt how to

- Work with 3D modelling using various options
- Channelize your work flow that helps you to bring down the complexities of the software.
- Create basic Objects, selection, duplication and mirroring Objects
- Load the Objects to layers to ensure an organised way of handling complex scenes.
- Create Object with the knowledge of the pivot
- Manipulate the pivot using various options to develop more complicated duplication of Objects.
- Arrange the Object precisely using one of the most important features of the software "snap" which gives us more flexibility.

After learning this Unit, you can download the Open Source Software available on the internet for free of cost to practice the possibilities of creating 3D Objects

Assignment

- Create "**House model**" with proper interiors using the basic primitives looking at the given image.

No need to add colors to the model. (you can do it after learning the texturing unit)The total length of the video should be **2-5 minutes.**

Assessment

1. Explain the various Selection Modes in Blender.
2. Describe the Method of Duplication and Mirror.
3. Describe the Uses of Layers.
4. Why do we need Snap Tool, explain?
5. Write a brief note on the Object Types in Blender.
6. Explain any three types of Snap Options.

Fill in the Blanks

1. In Object Mode, the last (de)selected item is called the_____.
2. The simplest form of Object Selection consists of using ____on it.
3. The____icon is used to Snap Objects and Mesh element to several types of scene elements.
4. _______will identify the location coordinates of the Object in 3D space.
5. Circle Select is used by moving with dotted circle through Objects with _____.

Resources

While studying this Unit, you can browse the internet links for tutorials and several books and training DVDs available in the Blender Store and on the Blender Cloud.

- wiki.blender.org
- archive.org
- www.blender.org
- docs.blender.org

Unit-3 Inorganic Modeling

Introduction

Curves and Surfaces are very important for Modeling.

Curves and Surfaces are types of **Blender Objects**. They are expressed by mathematical functions rather than a series of points. Using the specific features of both **Bezier** and **NURBs curves,** you will create a model in 3D, and explore how they are computed behind the scenes than how they appear from a modeler's perspective.

Bezier curves are generally more intuitive because they start and end at the control points that you set, but **NURBs curves** are more efficient for the computer to calculate when there are many twists and turns in a curve.

Curves are **2D objects**, and Surfaces are their **3D extension**. Note however, that in Blender, you only have **NURBS Surfaces, no Bezier**. Even though curves and Surfaces share the same object type, they are not the same thing; For example, you cannot have in the same object both curves and Surfaces.

In this Unit, you will learn the **usage of Curves and Surfaces** for modeling.

Outcomes

Upon completion of this unit you will be able to:

- Create and work with Curves.
- Edit the Curves using different Modes.
- Working Surface modeling.
- Create Objects using Curves and
- Prepare Curve Deformation and Curve Extrusion

Terminology

Bezier Curve: Adds an open 2D Bezier curve with two control points.

Bezier Circle: Adds a closed, circle-shaped 2D **Bezier curve** (made of four control points).

NURBS Curve: It adds an open 2D **NURBS curve**, with four controls.

NURBS Circle: It adds a closed, circle-shaped 2D NURBS curve (made of eight control points).

Path: It adds a NURBS open 3D curve made of five aligned control points, with Endpoint knots and the Curve Path setting enabled.

NURBS: Non-Uniform Rational B-Splines.

Extrude: Will extrude the curve along both the positive and negative local Z axes.

Bevel Depth: Changes the size of the bevel.

Subdividing: Curve subdivision simply subdivides all selected segments by adding one or more control points between the selected segments.

Duplication: This command duplicates the selected control points, along with the curve segments implicitly selected (if any).

Separating Curves: Curve objects that are made of multiple distinct, curves can be separated into their own objects by selecting the desired segments.

Fill: Fill determines the way a Curve is displayed when it is bevelled.

Introduction to Curves and Surfaces Curves

Bézier Curves

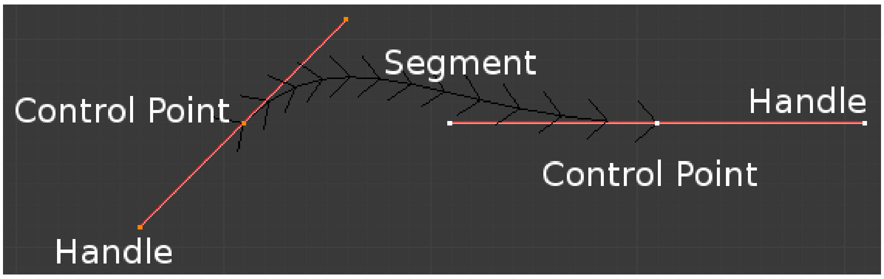
The main elements used in editing Bezier Curves are the **Control Points and Handles**.

Control Points

A Segment (the actual Curve) is found between **two Control Points**.

In the image below (Img 3.1), the Control Points can be found in the **middle of the pink line** while the Handles comprise the **extensions** from the Control Point.

By default, the arrows on the Segment represent the **direction** and **relative speed** and direction of movement Objects will have when moving along the curve. This can be altered by defining a custom **F- Curve**.



Title-Img 3. 1 Bezier Curve in Edit Mode.

Source-Blender.org

Link-http://blender-manual- i18n.readthedocs.io/ja/latest/modeling/curves/introduction.html?highlight=Bezier%20Curve%20in%20Edit%20Mode.

Editing Bézier Curves

A Bézier curve can be edited by moving the locations of the Control Points and Handles:

- **Step 1:** Add a Curve by Shift-A to bring up the Add menu, followed by

  Curve ‣ Beziers.

- **Step 2:** Press Tab to enter Edit Mode.
- **Step 3:** Select one of the Control Points and move it around. Use LMB to confirm the new location of the Control Point, or use RMB to cancel.
- **Step 4:** Now select one of the Handles and move it around. Notice how this change the curvature of the curve.

To add more Control Points:

- **Step 1:** Select at least two adjacent Control Points.
- **Step 2:** Press **W** and select Subdivide.

Optionally, you can press **F6** immediately after the subdivision to modify the number of subdivisions

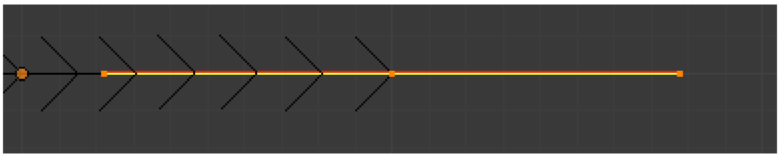
Handles

There are **Four Bézier Curve Handle types**. They can be accessed by pressing **V** and selecting from the list that appears, or by pressing the appropriate **hotkey** combination. Handles can be rotated, moved, scaled and shrunk/fattened like any vertex in a Mesh.

Bézier Curve Handle Types

1. Automatic V-A

This handle has a completely automatic length and direction which is set by Blender to ensure the **smoothest result**. These handles convert to **Aligned handles** when moved.



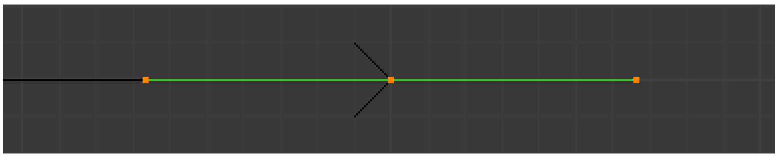
Title-Img 3. 2 Bezier handle type.

Source-

Link-*[http://blender-manual- i18n.readthedocs.io/ja/latest/modeling/curves/introduction.html?highlight=Bezier%20Curve%20in%20Edit%20Mode.](http://blender-manual-i18n.readthedocs.io/ja/latest/modeling/curves/introduction.html?highlight=Bezier%20Curve%20in%20Edit%20Mode)*

2. Vector V-V

Both parts of a handle always point to the previous handle or the next handle which allows you to create curves or sections thereof made of straight lines or with sharp corners. Vector handles convert to **free handles** when moved.



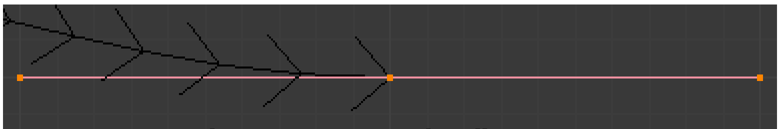
Title-Img 3. 3 Bezier handle type.

Source-Blender.org

Link-*[http://blender-manual- i18n.readthedocs.io/ja/latest/modeling/curves/introduction.html?highlight=Bezier%20C](http://blender-manual-i18n.readthedocs.io/ja/latest/modeling/curves/introduction.html?highlight=Bezier%20Curve%20in%20Edit%20Mode)* urve%20in%20Edit%20Mode**.**

3. Aligned V-L

These handles always lie in a **straight line**, and give a continuous curve without sharp angles.



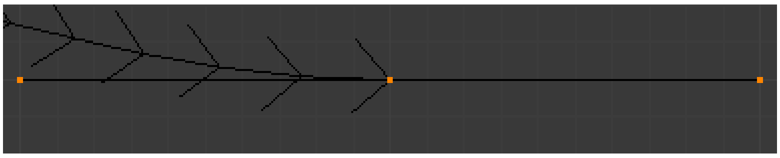
Title-Img 3. 4 Bezier handle type.

Source-Blender.org

Link-*[http://blender-manual- i18n.readthedocs.io/ja/latest/modeling/curves/introduction.html?highlight=Bezier%20Curve%20in%20Edit%20Mode.](http://blender-manual-i18n.readthedocs.io/ja/latest/modeling/curves/introduction.html?highlight=Bezier%20Curve%20in%20Edit%20Mode)*

4. Free V-F

The handles are **independent** of each other.



Title-Img 3. 5 Bezier handle type.

Source-Blender.org

Link-*[http://blender-manual- i18n.readthedocs.io/ja/latest/modeling/curves/introduction.html?highlight=Bezier%20Curve%20in%20Edit%20Mode.](http://blender-manual-i18n.readthedocs.io/ja/latest/modeling/curves/introduction.html?highlight=Bezier%20Curve%20in%20Edit%20Mode)*

Additionally, the **V-T shortcut** can be used to toggle between Free and Aligned handle types.

NURBS Curves

One of the major differences between Bézier Objects and NURBS Objects is that Bézier Curves are approximations.

For example, a Bézier circle **approximates a circle**, whereas a NURBS circle is an **exact circle**.In practice, many of the Bézier curve operations discussed above apply to NURBS curves in the same manner. The following text will concentrate only on those aspects that are unique to NURBS curves.

Editing NURBS Curve

A NURBS Curve is edited by moving the location of the Control Points:

- **Step 1:** Place a Curve by **Shift-A** to bring up the Add menu, followed by Curve ‣ NURBS curve.
- **Step 2:** Press Tab to enter Edit Mode.
- **Step 3:** Select one of the Control Points and move it around. Use LMB to confirm the new location of the Control Point, or use RMB to cancel.

To add additional Control Points

- **Step 1:** select both the Control Points
- **Step 2:** press **W** and
- **Step 3:** select Subdivide.
- **Step 4:** Press **F6** immediately after to determine how many subdivisions to make.

Transform Tools

Deforming Tool

- **Mode**: Edit Mode
- **Menu**: Curve ‣ Transform

The **Shear, Warp and Push/Pull transform tools** are described in the Transformations sections. The two other tools, **Tilt and Shrink/Fatten Radius** are related to **Curve Extrusion**.

Smoothing Tool

- **Mode**: Edit Mode
- **Hotkey**: W ‣ smooth

Curve smoothing is available through the specials menu. For Bézier curves, this smoothing operation **reduces the distance** between the selected control point/s and their neighbors, while keeping the neighbors anchored. **Does not affect** control point tangents.

Mirror Tool

- **Mode**: Edit Mode
- **Menu**: Curve ‣ Mirror
- **Hotkey**: Ctrl-M

The Mirror tool is also available, behaving exactly as with **Mesh vertices**. **Set Bézier**

Handle Type

- **Mode**: Edit Mode
- **Panel**: Curve Tools ‣ Handles
- **Menu**: Curve ‣ Control Points ‣ Set Handle Type
- **Hotkey**: V

Handle types are a **property of Bézier curves** that can be used to alter features of the curve. For example, switching to Vector handles can be used to create curves with **sharp corners**. Read the Bézier curves page for more details.

Extending Curves

- **Mode**: Edit Mode
- **Menu**: Curve ‣ Extrude
- **Hotkey**: Ctrl-LMB, E

Once a curve is created you can add **new segments** (in fact, new control points defining new segments), either by extruding, or placing new handles with **Ctrl-LMB**. Each new segment is added to one end of the curve. The Bézier curve can only be extend at the endpoints. **Ctrl-LMB** on inner control points will make unconnected duplicates.

Subdivision

- **Mode**: Edit Mode
- **Panel**: Curve Tools
- **Menu**: Surface tools ‣ Modeling ‣ Subdivide
- **Hotkey**: W

Curve subdivision simply subdivides all selected segments by adding one or more control points between the selected segments. To control the number of cuts, **press W** to make a single subdivision. Then **press F6** to bring up the Number of Cuts menu.

Duplication

- **Mode**: Edit Mode
- **Menu**: Curve ‣ Duplicate
- **Hotkey**: Shift-D

This command **duplicates** the selected control points, along with the curve segments implicitly selected (if any). The copy is selected and placed in **Grab mode**, so you can move it to another place.

Joining Curve Segments

- **Mode**: Edit Mode
- **Menu**: Curve ‣ Make Segment
- **Hotkey**: F

Two open curves can be **combined into one** by creating a segment between the two curves. To join two separated curves, select one end control point from each curve then **press F**. The two curves are joined by a segment to become a **single curve**.

Separating Curves

- **Mode**: Edit Mode
- **Menu**: Curve ‣ Separate
- **Hotkey**: P

Curve objects that are made of multiple distinct curves can be **separated** into their own objects by selecting the desired segments and **pressing P**. Note, if there is only one curve in a Curve object, pressing P will create a new Curve object with **no control points**.

Deleting Elements

- **Mode**: Edit Mode
- **Menu**: Curve ‣ Delete...

- **Hotkey**: X, Delete
- **Selected: This** will delete the selected control points, without breaking the curve (i.e. the adjacent points will be directly linked, joined, once the intermediary ones are deleted).

- **Segment:** This option is somewhat the opposite to the preceding one, as it will cut the curve, without removing any control points, by erasing one selected segment.

Opening and Closing a Curve

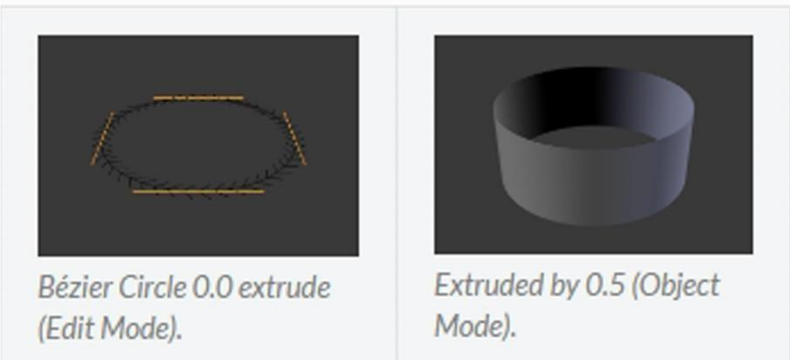
- **Mode**: Edit Mode
- **Menu**: Curve ‣ Toggle Cyclic
- **Hotkey**: Alt-C

This toggles between an open curve and closed curve **(Cyclic**). Only curves with at least one selected control point will be **closed/open**. The shape of the closing segment is based on the **start and end** handles for Bézier curves, and as usual on adjacent control points for **NURBS**. The only time a handle is adjusted after closing is if the handle is an **Auto one**. Open and Closed curves is the same Bézier curve open and closed.

Curve Extrution

- **Mode**: Object or Edit Mode
- **Panel**: Curve and Surface
- **Extrude**

Turns a **one-dimensional curve into a two-dimensional curve** by giving it height. Note that this is not related to **Extrude** used in Mesh edit-mode. With a scale of one, an Extrusion of 0.5 will extrude the **curve 0.5 BU** in both directions, perpendicular to the curves normals.



Title-Img 3. 6 Curve Extrution

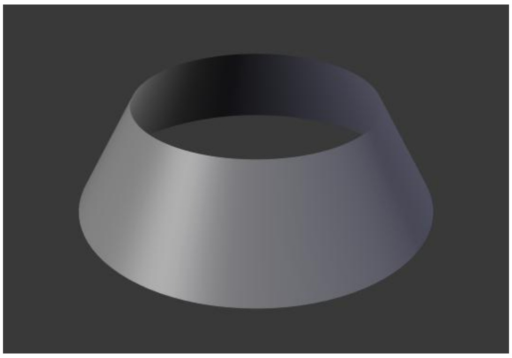
Attribution- Source-Blender.org

Link-*https://easyblend.org/html/modeling/curves/editing/extrude.html*

Tilt This setting controls how the normals **(visualization: arrows)** twist around each control point – so it is only relevant with 3D curves! You set it using the Tilt transform tool in the **T tool shelf**, the **N ‣ transform ‣ Mean tilt**, or **Curve ‣ Transform ‣ Tilt**.

You can also reset it to its default value (i.e. perpendicular to the original curve plane) with **Alt-T**, **Curve ‣ Control Points ‣ Clear Tilt.**

With **NURBS**, the tilt is always smoothly **interpolated**. However, with **Bézier**, you can choose the interpolation algorithm between Linear, Ease, B-Spline, and Cardinal, in the Properties Editor ‣ Object Data ‣ Active Spline ‣ Tilt



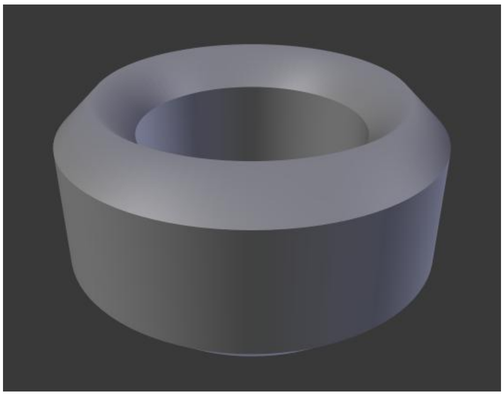
Title-Img 3. 2 30-degree Mean Tilt of all control points.

Source-Blender.org

Link-https://easyblend.org/html/modeling/curves/editing/extrude.html

Bevel Depth

This will add a bevel to the Extrusion. Refer Img 3.8 for its effects... Note that the bevel makes the Extrusion wider and higher. If **set to 0.0**, there is no bevel.



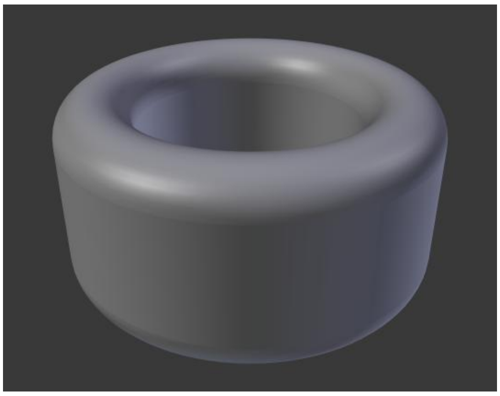
Title-Img 3. 3*Bevel depth of 0.25, fill set to full, zero Mean Tilt.*

Source-Blender.org

Link-https://easyblend.org/html/modeling/curves/editing/extrude.html

Bevel Resolution

It controls the resolution of the bevel created by a Bevel Depth **higher than zero**. If set the to 0 (the default), the bevel is a simple "flat" Surface. Higher values will smooth, round off the bevel, similar to the resolution settings of the curve itself.



Title-Img 3. 4 *Bevel resolution set to 10.*

Source-Blender.org

Link-https://easyblend.org/html/modeling/curves/editing/extrude.html

Offset

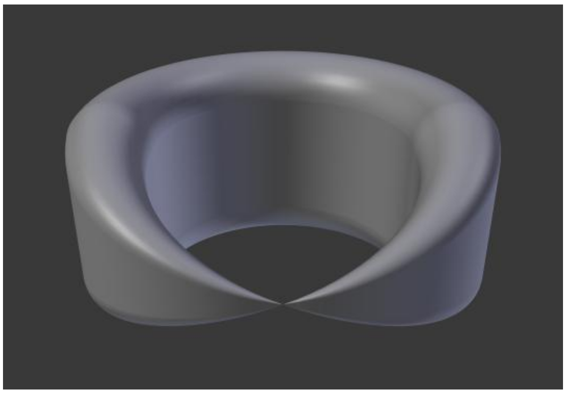
Offset Moves the Extrusion parallel to the curve normal. Almost like scaling

-1 Offset, 0.5 Extrusion, 0.25 Bevel Depth, 10 Bevel resolutions

Radius

The Radius allows you to **directly control** the width of the Extrusion along the "spinal" curve. The Radius of the points is set using the Shrink/Fatten Radius transform tool **Alt-S**, the **Curve ‣ Transform ‣**

Shrink/Fatten Radius, or the **N ‣ transform ‣ Radius**.



Title-Img 3. 5 One control point radius set to zero

Source-Blender.org

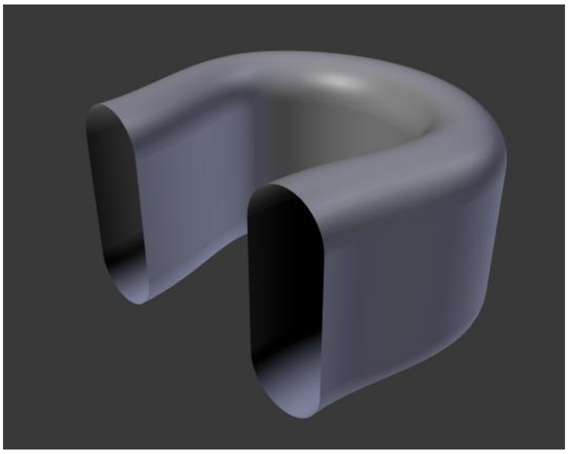
Link-https://easyblend.org/html/modeling/curves/editing/extrude.html

Three Sub-Classes of Curve:

We have **three sub-classes** of results, depending on whether the curve is **open** or **closed** or **3D.**

Open 2D Curve

The Extrusion will create a **“wall” or “ribbon”** following the curve shape. If using a Bevel Depth, the wall becomes a sort of slide or gutter. If your normals are facing the wrong way you can switch their direction as shown here.



Title-Img 3. 6 Open 2D Curve with Alt-C, fill set to none, zero offset, 0.5 Extrusion, 0.25 Bevel Depth, 10 Bevel resolution.

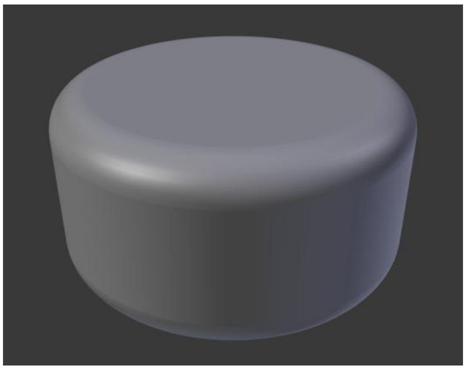
Source-Blender.org

Link-https://docs.blender.org/manual/en/dev/modeling/curves/properties/geometry.html

Closed 2D Curve

This is probably the most useful situation, as it will quickly create a volume, with (by default) two flat and parallel Surfaces filling the two sides of the extruded "wall". You can remove one or both faces by choosing the fill mode: **both, front, back, or none.**

The optional bevel depth will always create a **90 degree** bevels here.



Title-Img 3. 7 *Closed 2D Curve, 0.5 extrude, 0.25 Bevel Depth, 10 Bevel resolution, Fill: Both.*

Source-Blender.org

Link-*https://docs.blender.org/manual/en/dev/modeling/curves/properties/geometry.html*

Advanced Extrution

These Extrusions use **one or two** additional curve objects, to create very complex organic shapes.

To enable this type of Extrusion, you must type a **valid curve object** name in the Bevel Object field of the curve you are going to use as the "spinal column" of your Extrusion. The **"bevel" curve** will control the cross section of the extruded object. Whether the Bevel Object curve is **2D or 3D** has no importance, but if it is closed, it will create a "tube-like" Extrusion; otherwise you will get a sort of gutter or slide object...

The object is extruded along the entire length of all internal curves. By default, the width of the **Extrusion is constant**, but you have two ways to control it,

1. Radius property of control points
2. Taper Object.

Taper Curve

Taper Curve is evaluated along the **local X axis**, using the **local Y axis** for width control. Note also that:

It must be an **open curve**.

The taper is applied independently to all curves of the extruded object.

Only the first curve in a Taper Object is evaluated, even if you have several separated segments.

The scaling starts at the first control-point on the left and moves along the curve to the last control-point on the right.

Negative scaling, (negative local Y on the Taper Curve) is possible as well. However, rendering artifacts may appear.

It might need to increase the curve resolution to see more detail of the taper.

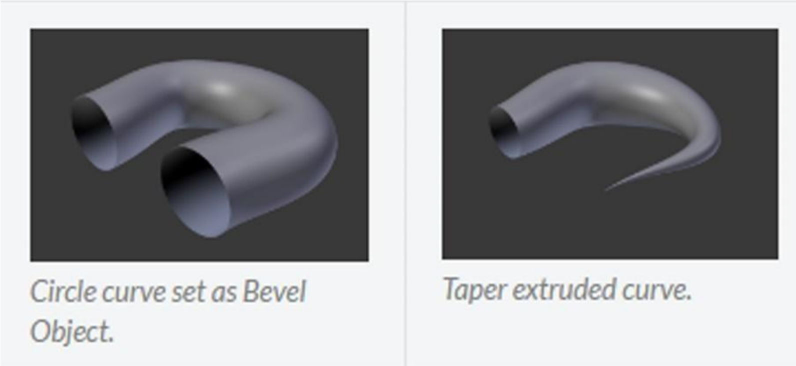
With **closed curves**, the Taper Curve in Taper Object acts along the whole curve (perimeter of the object), not just the length of the object, and varies the Extrusion depth. In these cases, you want the relative height of the Taper Object Taper Curve at both ends to be the same, so that the **cyclic point** (the place where the endpoint of the curve connects to the beginning) is a smooth transition.

Let us taper a simple curve circle extruded object using a Taper Curve.

- **Step 1:** Add a curve,
- **Step 2:** Then exit Edit Mode.
- **Step 3:** Add another one (a closed one, like a circle);
- **Step 4:** Call it “Bevel Curve”,
- **Step 5:** Enter its name in the Bevel Object field of the first curve (Curve and Surface tab). We now have a pipe.
- **Step 6:** Add a third curve while in Object Mode and
- **Step 7:** Call it “Taper Curve”.
- **Step 8:** Adjust the left control-point by raising it up about 5 units.
- **Step 9:** Now return to the Object tab,
- **Step 10:** Edit the first curve’s Taper Object field in the Curve and Surface panel to reference the new Taper Curve which we called “Taper Curve”.

When you hit enter the Taper Curve is applied immediately, with the results shown in Img 3.13 Circle curve set as Bevel Object.

Title-Img 3. 8Taper curve

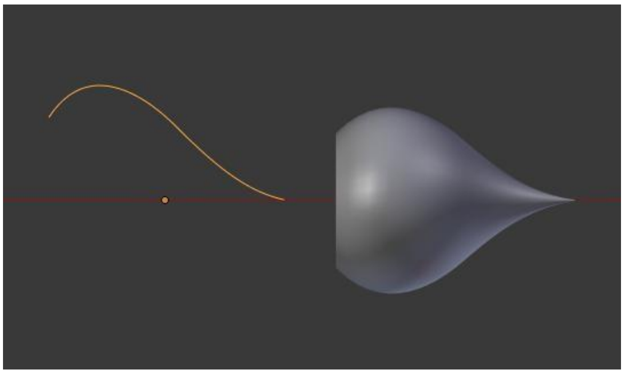


Source-Blender.org

Link-[***https://docs.blender.org/manual/en/dev/modeling/curves/properties/geometry.html***](https://docs.blender.org/manual/en/dev/modeling/curves/properties/geometry.html)

You can see the Taper Curve being applied to the extruded object. Notice how the pipe's volume shrinks to nothing as the Taper Curve goes from left to right. If the Taper Curve went below the local Y axis the pipe's inside would become the outside, which would lead to **rendering artifacts**. Of course, as an artist, that may be what you are looking for!

Taper Examples

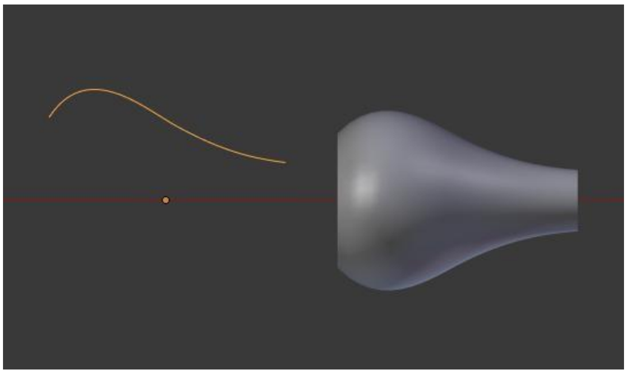


Title-Img 3. 9*Taper example 1.*

Source-Blender.org

Link- [***https://docs.blender.org/manual/en/dev/modeling/curves/properties/geometry.html***](https://docs.blender.org/manual/en/dev/modeling/curves/properties/geometry.html)

In Taper example 1 (Img 3.14), You can clearly see the effect the left Taper Curve has on the right curve object. Here the left Taper Curve is closer to the object center and that results in a smaller curve object to the right.

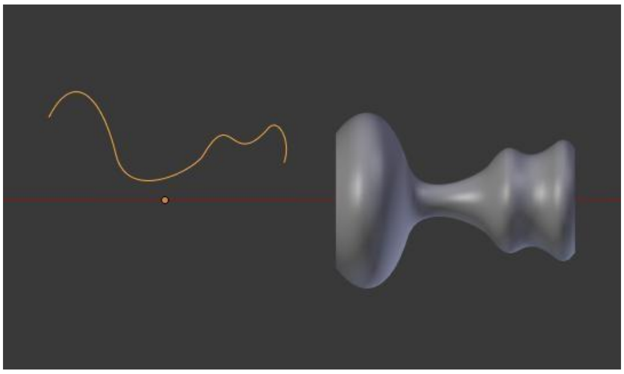


Title-Img 3. 10*Taper example 2.*

Source-Blender.org

Link- ***https://docs.blender.org/manual/en/dev/modeling/curves/properties/geometry.html***

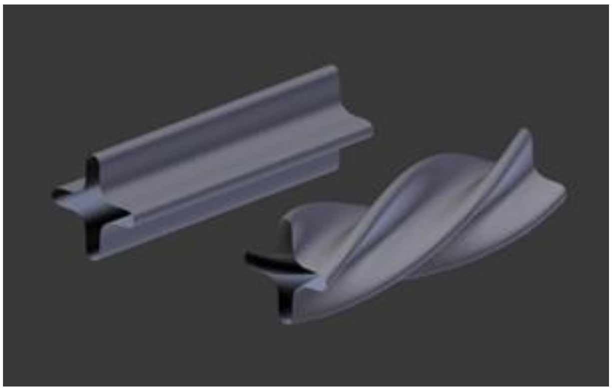
In Taper example 2 (Img 3.15), A control point in the Taper Curve to the left is moved away from the center and that gives a wider result to the curve object on the right.



Title-Img 3. 11 *Taper example 3.*

Source-Blender.org Link-
https://docs.blender.org/manual/en/dev/modeling/curves/properties/geometry.html

In Taper example 3 (Img 3.16), We see the use of a more irregular Taper Curve applied to a curve circle.



Title-Img 3. 12 Bevel Extrusion with Tilt example.

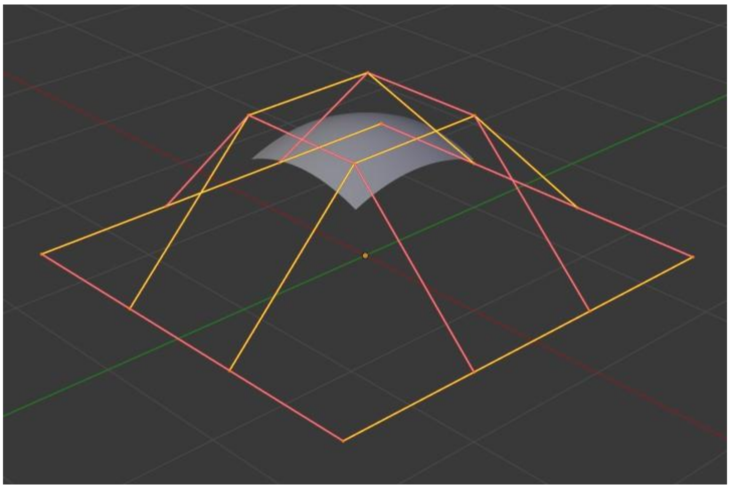
Source-Blender.org

Link-https://docs.blender.org/manual/en/dev/modeling/curves/properties/geometry.html

Surfaces

Surface Editing

Curves are 2D objects, and **Surfaces are their 3D** extension. Note however, that in Blender, you only have **NURBS Surfaces, no Bezier** (you have the Bezier knot type, though; see below), nor polygonal (but for these, you have Meshes!). Even though curves and Surfaces share the same object type (with texts also...), they are not the same thing; for example, you cannot have in the same object both curves and Surfaces.



Title-Img 3. 13Nurbs Surface in edit mode

Source-Blender.org

Link-https://docs.blender.org/manual/en/dev/modeling/surfaces/introduction.html

Nurbs Surface in Edit Mode

You may ask yourself "The Surface appears to be 3D, why is it only 2D?" In order to be 3D, the object needs to have "**Volume**", and a Surface, even when it is closed, does not have volume; it is infinitely **thin**. If it had a volume the Surface would have a **thickness** (its third dimension). Hence, it is only a 2D object, and has only two interpolation dimensions or axes or coordinates (if you know a bit of math, think of non-euclidean geometry – well, Surfaces are just non-euclidean 2D planes...).

Primitives

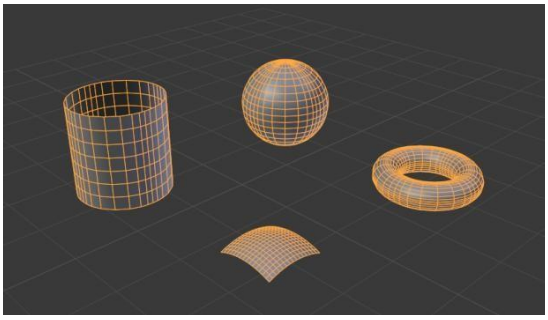
To get started in creating Surfaces, there are **four preset NURBS Surfaces**, found in the Add ‣ Surface as

1. NURBS Surface

2. NURBS Tube

3. NURBS Sphere

4. NURBS Torus

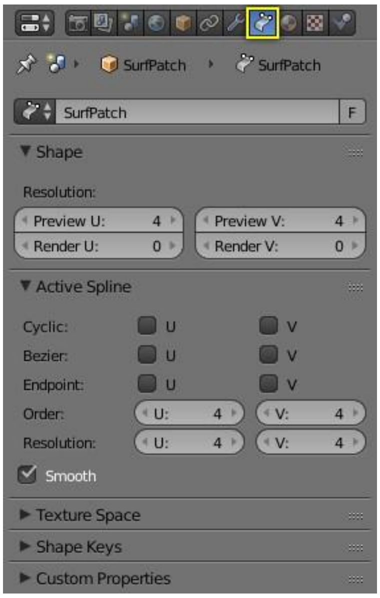


Title-Img 3. 14 *NURBSSurface primitives*.

Source-Blender.org

Link- *https://docs.blender.org/manual/en/dev/modeling/surfaces/primitives.html#comm on-options*

Properties



Title-Img 3. 15 *Surface Properties.*

Source-Blender.org

Link-*https://docs.blender.org/manual/en/dev/modeling/surfaces/properties.html*

Shape

Title-Img 3. 16 *Shape panel.*

Source-Blender.org

Link-*https://docs.blender.org/manual/en/dev/modeling/surfaces/properties.html*

You can adjust the resolution separately for both preview and render, to not slow things down in the viewport, but still get **good render results**.

Preview

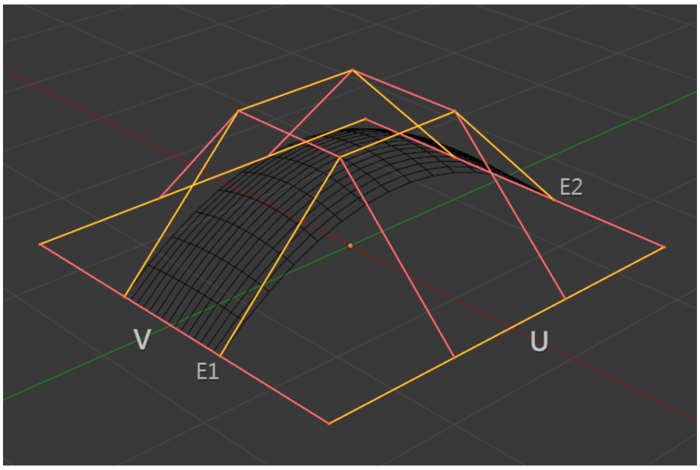
U, V

Render

U, V

Bezier Endpoint

Just like with NURBS curves, **NURBS Surfaces have two knot vectors**, one for each **U and V axis**. Here again, they can be one of Cyclic, Endpoint, or Bezier, with the same properties as for curves. And as with curves, only Open Surfaces (in the relevant direction) are affected by this setting.



Title-Img 3. 17*Endpoint U.*

Source-Blender.org

Link-*https://docs.blender.org/manual/en/dev/modeling/surfaces/properties.html*

In Img 3.22 Endpoint U, the **U interpolation** axis is labeled as "U" and the **V interpolation** axis is labeled as "V". The U's interpolation axis has been set to **Endpoint** and as such the Surface now extends to the outer edges from **E1 to E2** along the U interpolation axis.

Adding or Extruding

- **Mode**: Edit Mode
- **Menu**: Surface ‣ Extrude
- **Hotkey**: E, Ctrl-LMB

Unlike Meshes or curves, you cannot generally directly add new control points to a Surface (with **Ctrl-LMB** clicks), as you can only extend a Surface by adding a **whole U- or V-row** at once. The only exception is when working on a NURBS Surface curve, i.e. a Surface with only one control point on each U- or V-row. In this special case, all works exactly as with curves.

Most of the time, **only Extrusion** is available. As usual, once the tool is activated the Extrusion happens immediately and you are placed into Grab mode, ready to drag the new extruded Surface to its destination.

There are two things very important to understand:

Surfaces are 2D objects. So, you cannot extrude anything inside a Surface (e.g. "inner" row); it would not make any sense!

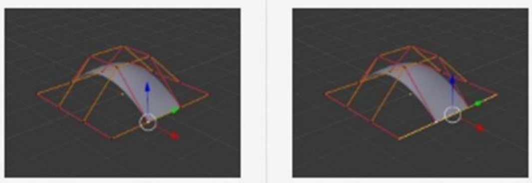
The control "grid" must remain "squarish", which means that you can only extrude a whole row, not parts of rows here and there.

To summarize, the Extrude tool will only work, when **only one whole border row** is selected, otherwise nothing happens.

Examples

Selecting control-point to show a typical Extrusion along the side of a Surface.

In Img 3.23, Selecting **control-point** and **Shift-R**, a border row of control points was highlighted by selecting a single control point, and then using the handy row select tool **Shift-R** to select the rest of the control points.



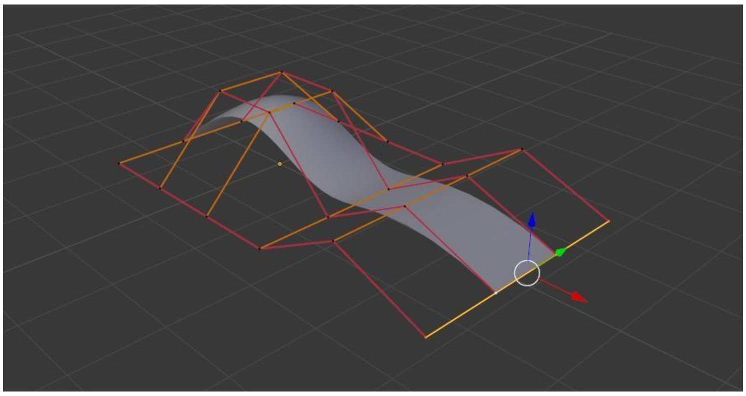
Selecting control-point. Shift-R

Title-Img 3. 18 *Selecting control point*

Source-Blender.org

Link-*https://docs.blender.org/manual/en/dev/modeling/surfaces/editing.html*

The edge is then extruded using E as shown in *Img 3.24* Extruding. Notice how the Mesh has bunched up next to the highlighted edge. That is because the new extruded Surface section is bunched up there as well.



Title-Img 3. 19 *Extruding*

Source-Blender.org

Link-*https://docs.blender.org/manual/en/dev/modeling/surfaces/editing.html*

By moving the new section away from the area, the Surface begins to "**un-bunch**".

You can continue this process of extruding or adding new Surface sections until you have reached the final shape for your model.

Deleting Elements

- **Mode**: Edit Mode
- **Menu**: Curve ‣ Delete...
- **Hotkey**: X, Delete

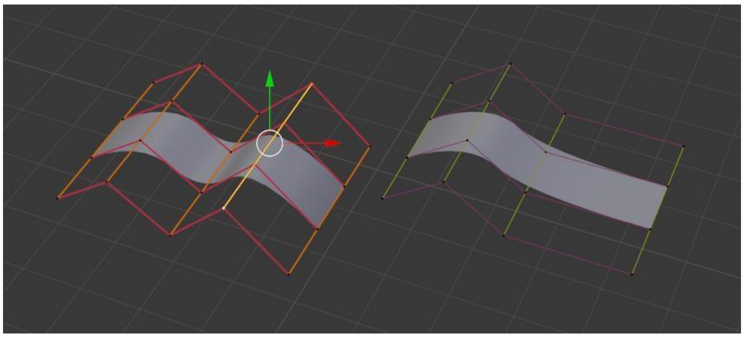
The Erase pop-up menu of Surfaces offers an option:

- **Selected**

This will delete the selected rows, without breaking the Surface (i.e. the adjacent rows will be directly linked, joined, once the intermediary ones are deleted). The selection must abide by the following rules:

Whole rows, and only whole rows must be selected. Only rows along the same axis must be selected (i.e. you cannot delete **both U- and V-rows** at the same time).

Example



Title-Img 3. 20 *Before and After*

Source- Blender.org

Link-*https://docs.blender.org/manual/en/dev/modeling/surfaces/editing.html*

In Img 3. 21 Before and after (left) a row of control points has been selected by initially selecting the one control point and using **Shift-R** to select the remaining control points. Then, using the **Delete Menu X,** the selected row of control points is erased, resulting in Img 3. 22 Before and after (right).

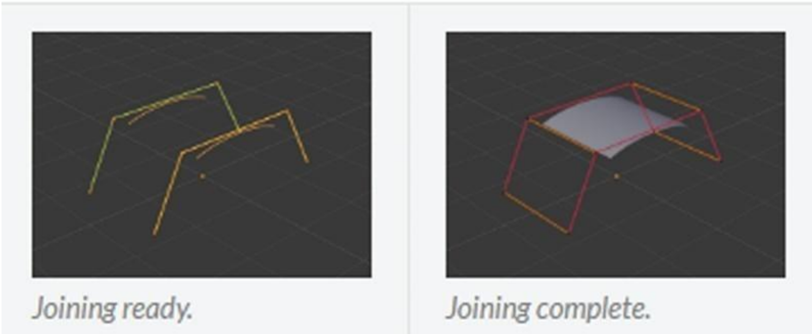
Joining or Merging Surfaces

- **Mode**: Edit Mode
- **Menu**: Surface ‣ Make Segment
- **Hotkey**: F

This command is equivalent to creating edges or Faces for Meshes (hence its shortcut), and so it only works in **Edit Mode**. The selection must contain only border rows of the same resolution (with the same number of control points), else Blender will try to do its best to guess what to merge with, or the merge will fail (either silently, or stating that Resolution does not match if rows with different number of points are selected, or that there are too few selections to merge if you only selected points in one Surface).

Examples

Title-Img 3. 23 *Before and After*



Source-Blender.org

Link-*https://docs.blender.org/manual/en/dev/modeling/surfaces/editing.html*

Unit summary

In this Unit, you have learnt what is 3D Interface and how to

- Create Objects and work with Curves and Surfaces in Blender
- Edit the Curves and Surfaces using different Modes in Blender
- Work with Surface modelling
- Work with Nurbs modelling
- Work effectively with 2D shapes
- Prepare Curve Deformation and Curve Extrusion

After learning this Unit, you can download the Open Source Software available on the internet for free of cost to practice the possibilities of creating 3D Interface.

Assignment

- Create a **Flower Vase**, a **Wine Glass** and a **Cup** using Nurbs curves

Assessment

- Explain Nurbs Modelling.
- Write a brief note on the Editing methods in Curve.
- Explain Bezier handle types.
- Describe the properties of 2D and 3D shapes. Write a brief note on Extending curves Explain the types of Curve Extrusion

Fill in the Blanks

1. _______are the most commonly used curves for designing letters or logos.
2. __________turns a one-dimensional curve into a two-dimensional curve by giving it height.
3. __________moves the Extrusion parallel to the curve normal.
4. __________allows you to directly control the width of the Extrusion along the "spinal" curve.
5. __________handle has a completely automatic length and direction which is set by Blender to ensure the smoothest result.

Resources

While studying this Unit, you can browse the internet links for online tutorials and several books and training DVDs available in the Blender Store and on the Blender Cloud.

- wiki.blender.org
- archive.org
- www.blender.org
- docs.blender.org

Unit 4 Organic Modeling

Introduction

In this Unit, you will learn the **creation of a 3D scene** and the usage of three key components to create the **real-time geometry Modelling** in Blender.

You will also learn to use the specific features of your chosen 3D software, each one of these **Primitives** can be manipulated to produce an Object. You will create **a model in 3D**, and explore the various modelling methods used in the production.

There are **three basic methods** that will be used to create a 3D model, and you will understand **how to create a model** using each technique.

Outcomes

Upon completion of this unit you will be able to:

- Create Object with 3D Primitives
- Edit the Object with different Modes
- Mesh Modelling
- Create Polygon Objects
- Analyse the Mesh

Terminology

Structure:	With Meshes, everything is built from three basic structures: Vertices, Edges and Faces.
Vertices:	A vertex is primarily a single point or position in 3D space.
Edges:	An edge always connects two vertices by a straight line.
Faces:	Faces are used to build the actual surface of the Object.
Loops:	Edge and Face Loops are sets of faces or edges that form continuous "loops".
Edge Lops:	Loops (1 and 2) in Img 4. 1 Edge and Face Loops are edge Loops.
Face Lops:	These are a logical extension of Edge Loops in that they consist of the faces between two Edge Loops.

Edge Ring: In Edge select mode, holding Ctrl-Alt while selecting an edge selects a sequence of edges that are not connected.

Subdividing: Technique for adding more geometry to a Mesh. It creates new vertices on subdivided edges, new edges between subdivisions and new faces based on new edges.

Tessellation: The tiling of a plane using one or more geometric shapes usually resulting in Micro polygons.

Coplanar: Refers to any set of elements that are all aligned to the same 2D plane in 3D space.

Modeling Modes

3D View has **three principal modes** that allow for the creation, editing and manipulation of the Mesh models. Each of the three modes has a **variety of tools**. Some tools may be found in one or more of the modes.

Modes used forModeling

Creation of a **Mesh Primitive** typically starts by adding a **Mesh Object** in Object Mode. Limited types of editing such as size, location, and orientation can be accomplished in Object Mode. Object Mode also provides the means to **Join and Group Multiple Mesh** Primitives.

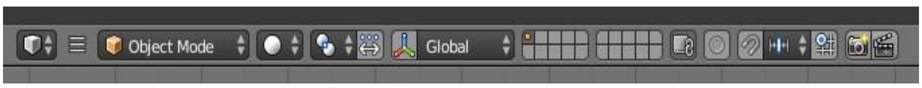
- Object Mode
- Edit Mode
- Sculpt Mode

More detailed editing of the Mesh model shape is done in **Edit Mode, and Sculpt Mode**. The nature of these three modes determines the tools that are available within the various panels of 3D View. Switching between modes while Modelling is common. Some tools may be available in more than one mode while others may be unique to a particular mode.

You can work with **Geometric Objects** in two modes.

Object Mode

Object Mode Operations in Object Mode affect the **whole Object**. Object Mode has the following header in 3D View:



Title-Img 4. 1 Object Mode Header.

Source-Blender.org

Link-https://docs.blender.org/manual/en/dev/modeling/meshes/introduction.html

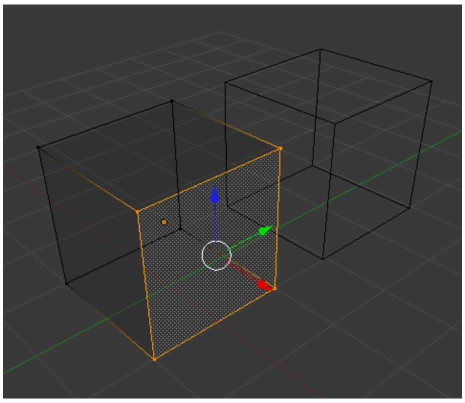
Edit Mode

Operations in Edit Mode affect only the **geometry of an Object**, but not global properties such as location or rotation. Edit Mode has the following header in 3D View:

Title-Img 4. 2 Edit Mode Header.

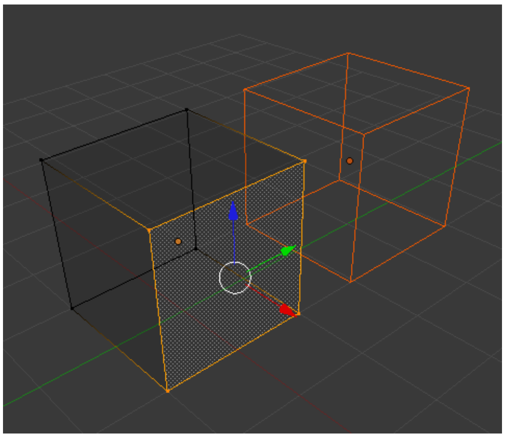
Source-Blender.org
Link-https://docs.blender.org/manual/en/dev/modeling/meshes/introduction.html

Visualization



Title-Img 4. 3 One cube selected

Source-Blender.org
Link-https://docs.blender.org/manual/en/dev/modeling/meshes/introduction.html



Title-Img 4. 4 Two cube selected before entering edit mode

Source-Blender.org

Link-https://docs.blender.org/manual/en/dev/modeling/meshes/introduction.html

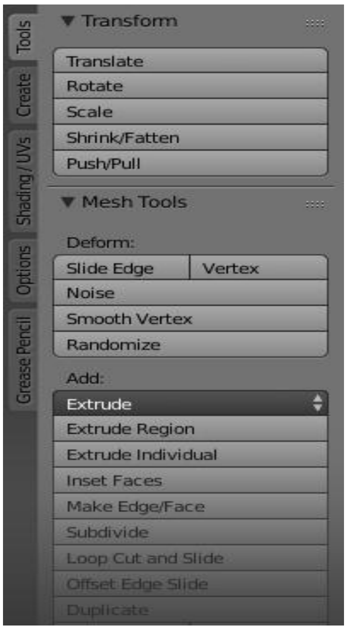
By default, **Blender** highlights selected geometry in **orange in both Object Mode and Edit Mode.**

- In **Object Mode** with Wireframe shading enabled **Z**, Objects are displayed in black when unselected and in orange when selected. If more than one Object is selected, all selected Objects except the active Object, typically the Object last selected, are displayed in a **darker orange color**. Similarly, in Edit Mode, unselected geometry is drawn in black while selected faces, edges, or vertices are drawn in orange. The active face is highlighted in **white**.

- In **Edit Mode**, only **one Mesh** can be edited at the time. However, several Objects can be joined into a single Mesh (**Ctrl-J** in Object Mode) and then separated again (**P** in Edit Mode). If multiple Objects are selected before entering Edit Mode, all the selected Objects remain highlighted in **orange** indicating that they are part of the active selection set.

If two vertices joined by an edge are selected in **Vertex selection mode**, the edge between them is highlighted too. Similarly, if enough vertices or edges are selected to define a face, that face is also highlighted.

Tool Shelf



Title-Img 4. 5 The Tool Shelf panel in edit mode.

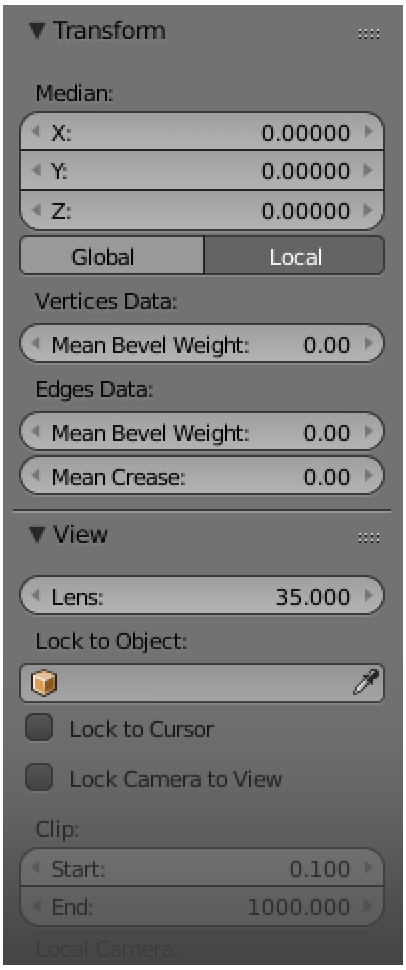
Attribution- Source-Blender.org

Link-https://docs.blender.org/manual/en/dev/modeling/meshes/introduction.html

Open/Close the Mesh Tools panel using **T**. When entering Edit Mode, several Mesh tools become available.

Most of these tools are also available as shortcuts (displayed in the **Tooltips** for each tool) and/or in the Specials Menu **W**, the Edge menu **Ctrl-E**, and Face menu **Ctrl-F**. The properties of each tool are displayed in the operator panel at the bottom of the **ToolShelf**.

Properties Region



Title-Img 4. 6 The Properties Region in edit mode.

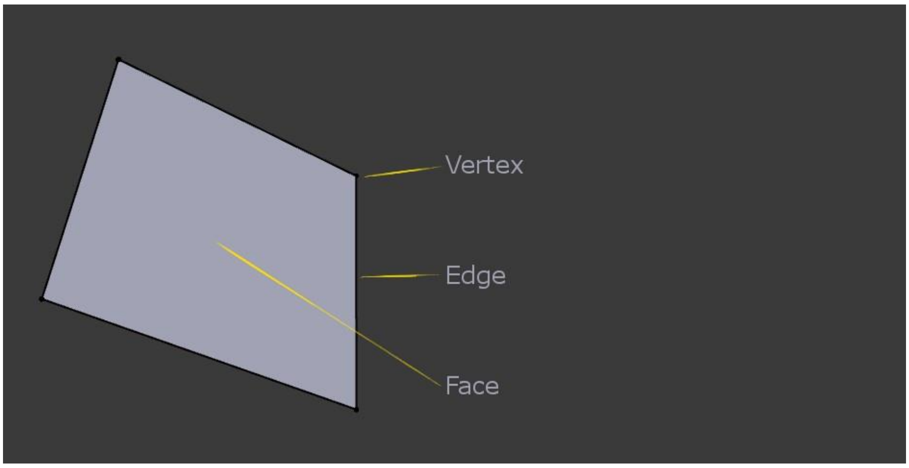
Source-Blender.org

Link-https://docs.blender.org/manual/en/dev/modeling/meshes/introduction.html

Open/close the Properties Region using N.

In the Properties Region, panels directly related to Mesh editing are the Transform panel, where numeric values can be entered, and the Mesh Display panel, where for example normals and numeric values for distances, angles, and areas can be turned on.

With Meshes, everything is built from **three basic** structures: **Vertices, Edges and Faces.**



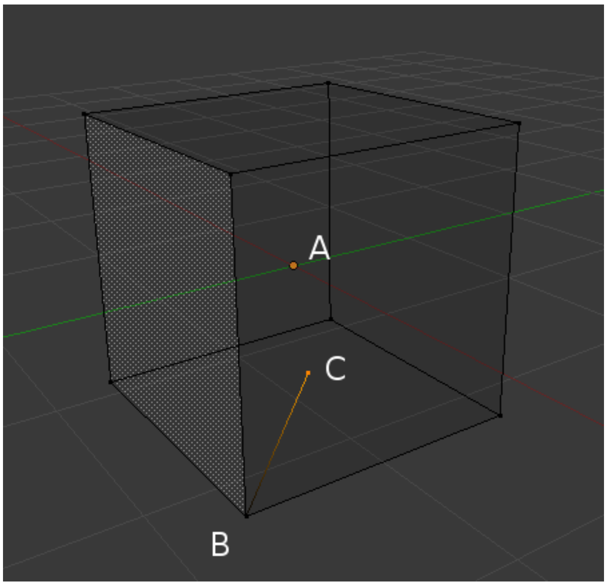
Title-Img 4. 7 Example of Mesh structure.

Source-Blender.org

Link-https://docs.blender.org/manual/en/dev/modeling/meshes/structure.html

Vertices

A vertex is primarily a **single point or position** in 3D space. It is usually invisible in rendering and in Object Mode. Do not mistake the center point of an Object for a vertex. It looks similar, but it is **bigger** and you cannot select it. Refer Vertex example (Img 4.8). Shows the center point labelled as "A"; "B" and "C" are vertices.



Title-Img 4. 8 Vertex example

Source-Blender.org

Link-https://docs.blender.org/manual/en/dev/modeling/meshes/structure.html

A simple way to create a new vertex is to click **Ctrl-LMB** in Edit Mode. Of course, as a computer screen is two-dimensional, Blender cannot determine **all three vertex** coordinates from a single mouse click, so the new vertex is placed at the depth of 3D cursor. Using the method described above (Img 4.8), any vertices selected previously are automatically connected to the new ones by an edge. In the image above, the vertex labelled "C" is a new vertex added to the cube with a new edge added between "B" and "C".

Edges

An Edge always **connects two vertices** by a straight line. The edges are the "**wires**" you see when you look at a Mesh in wireframe view. They are usually invisible on the rendered image. They are used to construct faces. Create an edge by selecting two vertices and pressing **F**.

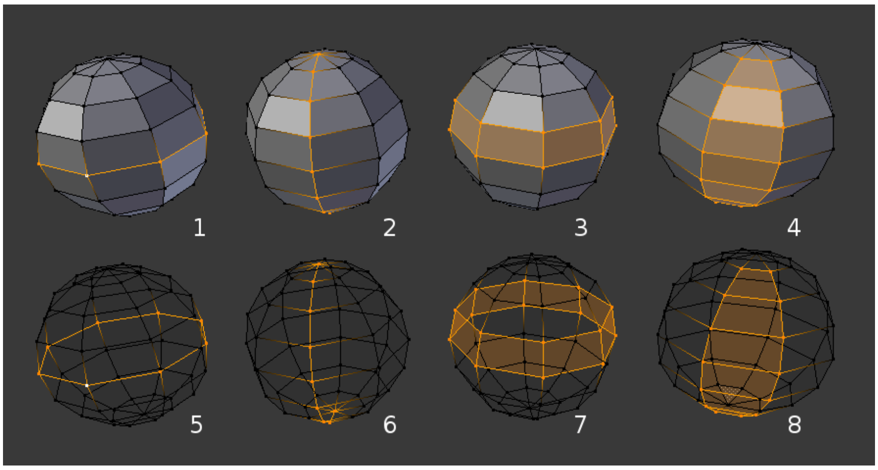
Face

A Face is defined as the area between either **three (triangles)**, **four (quadrangles**) or more (ngons) vertices, with an edge on every side. These are often abbreviated to **tris, quads & ngons.**

Triangles are always **flat** and therefore **easy to calculate**. On the other hand, quadrangles "**deform well**" and are therefore preferred for **subdivision Modelling**.

While you could build a cube with triangular faces, it would just look more confusing in Edit Mode.

Loops



Title-Img 4. 9 Edge and Face Loops

Source-Blender.org

Link- https://docs.blender.org/manual/en/dev/modeling/meshes/structure.html#fig- mesh-topo-loop

Edge and Face Loops are sets of faces or edges that form continuous "loops" as shown in Img 4. 9.

Edge and Face Loops:

- Top row (1 - 4) shows a **solid view**,
- Bottom row (5 - 8) a **wireframe view** of the same loops.

In the image above (Img 4. 9), loops that do not end in poles are **cyclic (1 and 3)**. They start and end at the **same vertex** and divide the model into two partitions. Loops can be a quick and powerful tool to work with specific, continuous regions of a Mesh and are a prerequisite for **Organic Character Animation**.

Edge Loops

Loops (1 and 2) in Img 4. 9**Edge** and **Face Loops** are edge Loops. They connect vertices so that each one on the loop has exactly two neighbours that are not on the loop and placed on both sides of the loop (except the start and end vertex in case of poles).

Edge Loops are an important concept especially in **organic (subsurface) Modelling** and **character animation**. When used correctly, they allow you to build models with relatively few vertices that look very natural when used as subdivision surfaces and deform very well in animation.

Face Loops

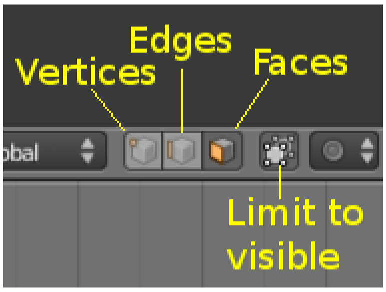
These are a **logical extension of Edge Loops** in that they consist of the faces between two Edge Loops, as shown in loops (3 and 4) in Img 4. 9 Edge and Face Loops. Note that for non-circular loops (4) the faces containing the poles are not included in a Face Loop. (Refer Img 4. 9)

Selection Mode

Select Mode Header Widgets

- **Mode**: Edit Mode
- **Menu**: 3D View Header ‣ Select Mode
- **Hotkey**: Ctrl-Tab

In Edit Mode, there are **three different selection modes**. You can enter the different modes by selecting one of the three buttons in the header.



Title-Img 4. 6 Edit Mode selection buttons

Source-Blender.org

Link- https://docs.blender.org/manual/en/dev/modeling/meshes/selecting/introduction.html

Vertices

In this mode, vertices **are drawn** as points.

- Selected **vertices** are drawn in **orange**,
- Unselected **vertices** in **black**
- **Active** or last selected vertex in **white**

Edges

In this mode, the vertices **are not drawn**. Instead,

- Selected **edges** are drawn in orange,
- Unselected **edges** black,
- **Active** or last selected edge in white.

Faces

In this mode, the faces **are drawn** with a selection point **in the middle** which is used for selecting a face.

- Selected **faces** and their selection point are drawn in orange,
- Unselected **faces** are drawn in black,
- **Active** or last selected face is highlighted in white.

Almost all tools are available in all three Mesh selection modes. So, you can **Rotate, Scale, Extrude, etc**. in all modes. Of course, rotating and scaling a single vertex will not do anything useful (without setting the pivot point to another location), so some tools are applicable in some modes.

Selection Loops

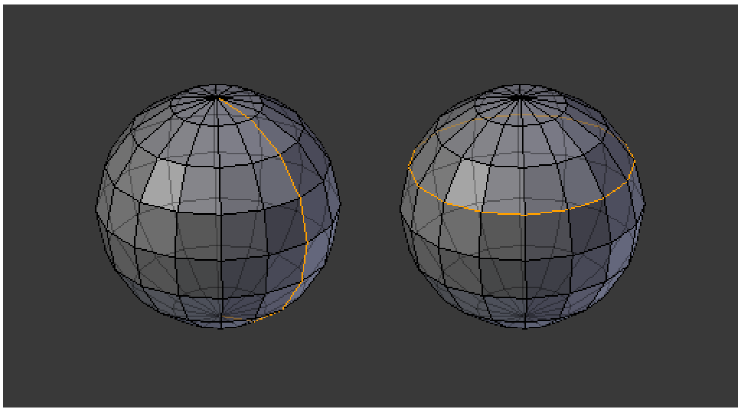
You can easily select loops of components:

Edge Loops and Vertex Loops

- **Mode**: Edit Mode –> Vertex or Edge select mode
- **Menu**: Select ‣ Edge Loop or Mesh ‣ Edges ‣ Edge Loop
- **Hotkey**: **Alt-RMB** or **Ctrl-E** ‣ Edge Loop

Holding **Alt** while selecting an edge selects a loop of edges that are connected in a line end to end, passing through the edge under the mouse pointer. Holding **Alt-Shift** while clicking adds to the current selection.

Edge loops can also be selected based on an existing edge selection, using either **Select ‣ Edge Loop,** or the Edge Loop Select option of the Edge Specials Menu **Ctrl-E.**



Title-Img 4. 7 Longitudinal and latitudinal edge loops

Source-Blender.org

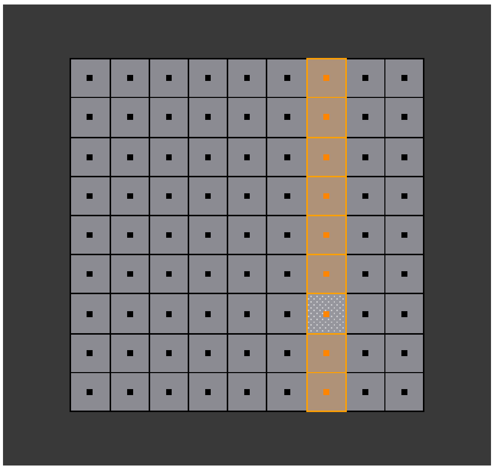
Link- https://docs.blender.org/manual/en/dev/modeling/meshes/selecting/advanced.html

Face Loops

- **Mode:** Edit Mode –> Face or Vertex select modes
- **Hotkey: Alt-RMB**

In **face select mode**, holding **Alt** while selecting an edge selects a loop of faces that are connected in a line end to end, along their opposite edges.

In **vertex select mode**, the same can be accomplished by using **Ctrl-Alt** to select an edge, which selects the face loop implicitly**.**

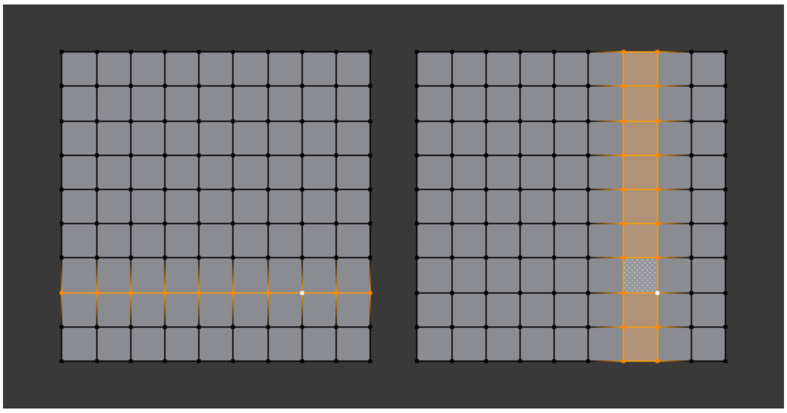


Title-Img 4. 8 Face loop selection

Source-Blender.org

Link- https://docs.blender.org/manual/en/dev/modeling/meshes/selecting/advanced.html

This face loop was selected by clicking with **Alt-RMB** on an edge, in face select mode. The loop extends perpendicular from the edge that was selected.



Title-Img 4. 9Alt versus Ctrl-Alt in vertex select mode

Source-Blender.org

Link- https://docs.blender.org/manual/en/dev/modeling/meshes/selecting/advanced.html

A face loop can also be selected in Vertex select mode. Technically **Ctrl- Alt-RMB** will select an Edge Ring, however, in Vertex select mode, selecting an Edge Ring implicitly selects a Face Loop since selecting opposite edges of a face implicitly selects the entire face.

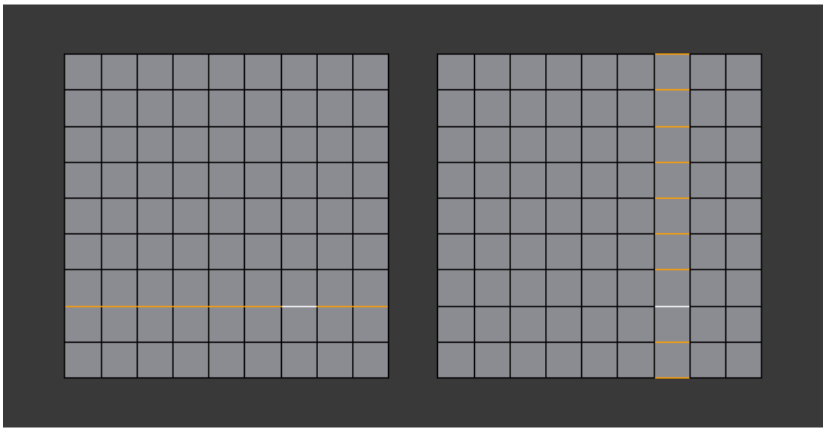
Edge Ring

- **Mode:** Edit Mode –> Edge select mode

- **Menu:** Select ‣ Edge Ring or Mesh ‣ Edges ‣ Edge Ring
- **Hotkey: Ctrl-Alt-RMB** or **Ctrl-E** ‣Select ‣ Edge Ring

In Edge select mode, holding **Ctrl-Alt** while selecting an edge selects a sequence of edges that are not connected, but on opposite sides to each other continuing along a face loop.

As with edge loops, you can also select **edge rings** based on current selection, using either **Select ‣ Edge Ring**, or the Edge Ring Select option of the Edge Specials Menu **Ctrl-E.**



Title-Img 4. 10 A selected edge loop, and a selected edge ring

Source-Blender.org

Link- https://docs.blender.org/manual/en/dev/modeling/meshes/selecting/advanced.html

In Img 4.14, A selected edge loop, and a selected edge ring. The same edge was clicked on, but two different "groups of edges" were selected, based on the different commands. One is **based on edges** during computation and the other is **based on faces**.

Duplicating / Mesh Editing Tools

This section covers **Mesh editing tools** that add additional geometry by duplicating existing geometry in some way.

Duplicate Geometry

Extrusion

Spin

Screw

Duplicate Geometry Tool

- **Mode:** Edit Mode
- **Menu:** Mesh ‣ Duplicate
- **Hotkey: Shift-D**

This tool simply **duplicates the selected** elements, without creating any links with the rest of the Mesh (unlike extrude, for example), and places the duplicate at the location of the original. Once the duplication is done, only the new duplicated elements are selected, and you are automatically placed in **grab/move mode**, so you can translate your copy elsewhere.

Extrude Tool

Extrude Region

- **Mode**: Edit Mode
- **Panel**: Mesh Tools ‣ Extrude
- **Menu: Mesh**‣ Extrude Region
- **Hotkey**: **E** or **Alt-E**

One tool of paramount importance for working with Meshes is the **Extrude tool**. It allows you to create parallelepipeds from rectangles and cylinders from circles, as well as easily create such things as **tree limbs**. **Extrude is one of the most frequently used Modelling tools in Blender**

The selection is extruded along the common normal of selected faces. In every other case the extrusion can be **limited to a single axis** by specifying an axis (e.g. X to limit to the X axis or Shift-X to the YZ plane. When extruding along the face normal, limiting movement to the **global Z axis** requires pressing **Z twice,** once to disable the face **normal Z axis** limit, and once to enable the global Z axis limit.

Selected face **During extrude** **Set to Z axis**

Title-Img 4. 15 Extrude face

Source-Blender.org

Link- https://docs.blender.org/manual/en/dev/modeling/meshes/editing/duplicating/extrude.html

Ext Mode: Edit Mode

- **Panel:** Mesh Tools ‣ Extrude Individual
- **Menu:** Mesh ‣ Extrude Individual
- **Hotkey:** Alt-E

Extrude Individual allows you to **extrude a selection** of multiple faces as individuals, instead of as a region. The faces are extruded along their own normals, rather than their average. This has several consequences: first, "**internal**" edges (i.e. edges between two selected faces) are **no longer deleted** (the original faces are).

Title-Img 4. 11 Selection of multiple faces, extruded using extrude region and Extruded using Extrude Individual

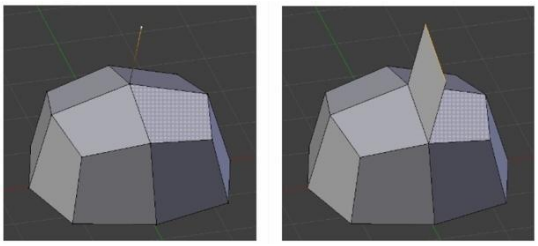
Source-Blender.org

Link- https://docs.blender.org/manual/en/dev/modeling/meshes/editing/duplicating/extrude.html

Extrude Edges and Vertices Only

- **Mode**: Edit Mode, Vertex and Edge
- **Hotkey: Alt-E**

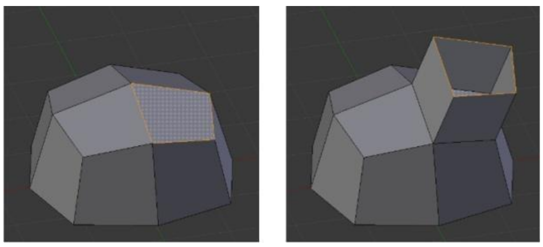
If vertices are selected while doing an extrude, but they do not form an edge or face, they will extrude as expected, forming a non-manifold edge. Similarly, if edges are selected that do not form a face, they will extrude to form a face.



Title-Img 4. 12 Single vertex extruded. Single edge extruded

Source-Blender.org

Link- https://docs.blender.org/manual/en/dev/modeling/meshes/editing/duplicating/extrude.html



Title-Img 4. 13Single edge extruded. Edge only extrude

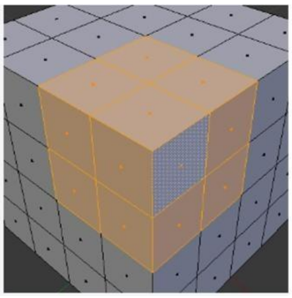
Source-Blender.org

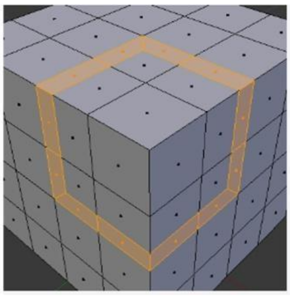
Link- https://docs.blender.org/manual/en/dev/modeling/meshes/editing/duplicating/extrude.html

Inset Tool

- **Mode**: Edit Mode
- **Menu**: Mesh ‣ Faces ‣ Inset
- **Hotkey: I**

This tool takes the **currently selected** faces and creates an inset of them, with adjustable thickness and depth. The tool is modal, such that when you activate it, you may adjust the thickness with your mouse position. You may also adjust the depth of the inset during the modal operation by **holding Ctrl.**





Selection to inset **Selection with inset**

Title-Img 4. 14Single vertex extruded. Single edge extruded

Source-Blender.org

Link- https://docs.blender.org/manual/en/dev/modeling/meshes/editing/duplicating/inset.html

Spin Tool

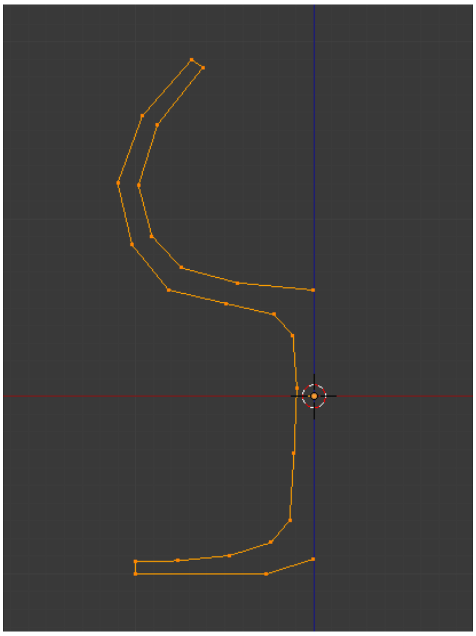
- **Mode:** Edit Mode
- **Panel:** Mesh Tools

Use the Spin tool to create the sort of Objects that you would produce on a lathe (this tool is often called a "**lathe**"-tool or a "**sweep**"-tool in the literature, for this reason). In fact, it does a sort of circular extrusion of your selected elements, center on 3D cursor, and around the axis perpendicular to the working view...

The point of view will determine around which axis the extrusion spins.

The position of 3D cursor will be the center of the rotation. (Refer Img. 4.20)

Example



Title-Img 4. 15Glass profile

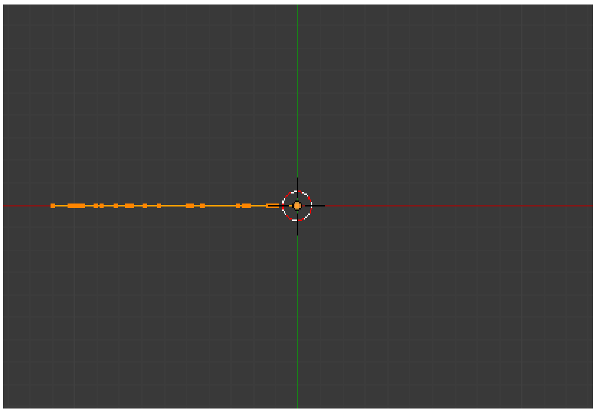
Source-Blender.org

Link-https://docs.blender.org/manual/en/dev/modeling/meshes/editing/duplicating/spin.html?highlight=glass%20profile

First, create a Mesh representing the profile of your Object. If you are Modelling a hollow Object, it is a good idea to thicken the outline. Img.4.20 Glass profile Shows the profile for a **wine glass** we will model as a demonstration.

Go to the **Edit Mode** and select all the vertices of the Profile with A.

We will be rotating the Object around the cursor in the top view, so switch to the top view with **Numpad7.**



Title-Img 4. 16 Glass profile, top view in Edit Mode, just before spinning.

Source-Blender.org

Link-

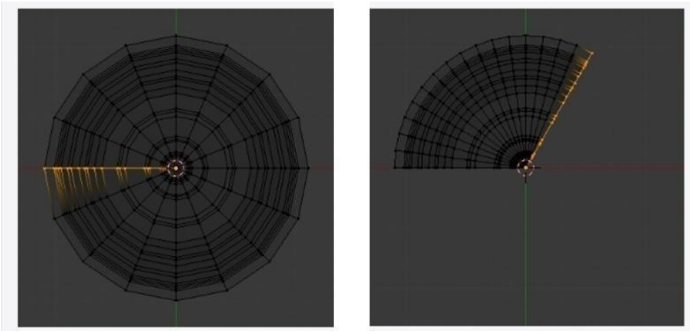
https://docs.blender.org/manual/en/dev/modeling/meshes/editing/duplicating/spin.html?highlight=glass%20profile

Place the cursor along the center of the profile by selecting one of the vertices along the center, and snapping 3D cursor to that location with

Mesh ‣ Cursor ‣ Selection. (Img 4. 171 Glass profile, top view in Edit Mode, just before spinning.) Shows the wine glass profile from **top view**, with the cursor correctly positioned.

Click the **Spin button**. If you have **more than one 3D View** open, the cursor will change to an arrow **with a question mark** and you will have to click in the area containing the top view before continuing. If you have **only one 3D View open**, the spin will happen immediately. Img 4. 18 Spun profile Shows the **result of a successful spin**.

Angle

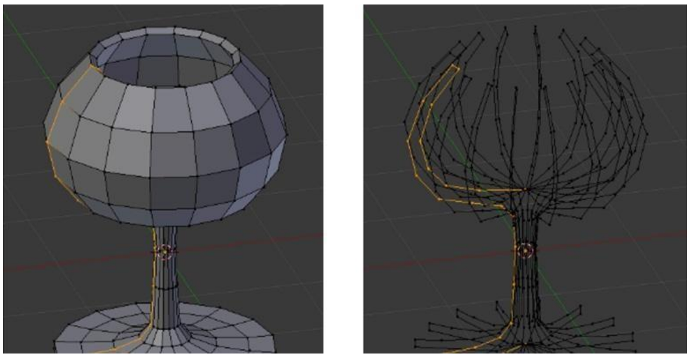


Title-Img 4. 19 Spun Profile with an angle of 360 and 120.

Source-Blender.org

Link-

https://docs.blender.org/manual/en/dev/modeling/meshes/editing/duplicating/spin.html?highlight=glass%20profile



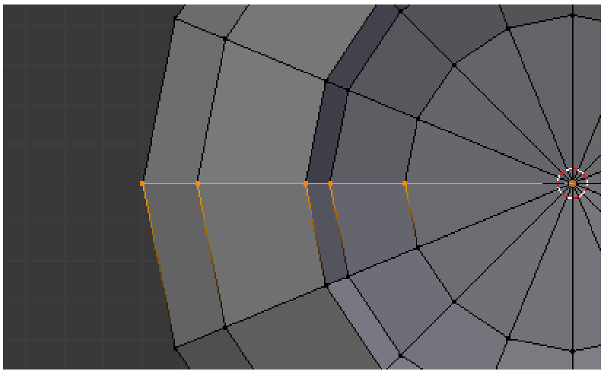
Result of spin operation **Result of Dupli enabled**

Title-Img 4. 20 Result of spin and Dupli

Source-Blender.org

Link-https://docs.blender.org/manual/en/dev/modeling/meshes/editing/duplicating/spin.html?highlight=glass%20profile

Merge Duplicates



Title-Img 4. 21Duplicate Vertices

Source-Blender.org

Link-

https://docs.blender.org/manual/en/dev/modeling/meshes/editing/duplicating/spin.html?highlight=glass%20profile

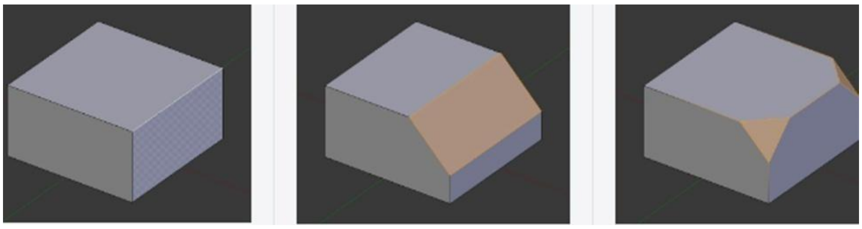
The spin operation leaves duplicate vertices along the profile. You can select all vertices at the seam with **Box select B** shown in Img 4. 24 Duplicate vertices. Seam vertex selection and perform a **Remove Doubles operation**.

Bevel Tool

- **Mode**: Edit Mode
- **Menu**: Mesh ‣Edges ‣Bevel or **Ctrl-E**‣Bevel
- **Usage**

The **Bevel tool** works only on selected edges. It will recognize any edges included in a vertex or face selection as well, and perform the bevel the same as if those edges were explicitly selected. In "**vertex only**" mode, the Bevel tool works on selected vertices instead of edges. The Bevel tool smooths the **edges and/or "corners**" (vertices) by replacing them with faces making smooth profiles with a specified number of segments (see the options below Img 4. 25 for details about the bevel algorithm).

Use **Ctrl-B** or a method listed above to run the tool. Move the mouse to interactively specify the bevel offset, and scroll the Wheel to increase or decrease the number of segments. (See Img 4. 25)



Edge before beveling **Edge Bevel** **Vertex bevel**

Title-Img 4. 22Bevel

Source-Blender.org

Link- https://docs.blender.org/manual/en/dev/modeling/meshes/editing/subdividing/bevel.html

Merge Vertices

This tool allows you to **merge all selected** vertices to a unique one, deleting all others. You can choose the location of the surviving vertex in the menu this tool pops up before executing**.**

Unit summary

- Create Object with 3D Mesh / Primitives
- Edit the Object with different Modes
- Work with Mesh Modelling
- Create Polygon Objects
- Analyse the Mesh

After learning this Unit, you can download the Open Image Source Software available on the internet for free of cost to practice the possibilities of creating 3D Objects.

Assignment

Create a **flower vase**, a **wine glass** and **a cup** using **Nurbs** curves.

Assessment

1. Explain the Modelling Modes in Blender
2. Write a brief note on the Structure of a Mesh
3. Explain the Loops used in Polygon Modelling

4. Describe the types of selection modes in Mesh modelling
5. Write a brief note on Edge/Face tool
6. How is Mirror Editing tool used?

Fill in the Blanks

1. ___is available in either Edit Mode or Object Mode.

2. Selected vertices are drawn in___color, unselected vertices in__color.

3. Pressing____________________Key when selecting a higher selection mode, all elements touching the current selection will be added.

4. A___is primarily a single point or position in 3D space.

5. Operations in__________effect only the geometry of an Object.

Resources

While studying this Unit, you can browse the internet links for online tutorials and several books and training DVDs available in the Blender Store and on the Blender Cloud.

- wiki.blender.org
- archive.org
- www.blender.org
- docs.blender.org

DMA-201

3D Animation

Block – 2: 3D Shading

Unit-1 Introduction to Materials & Shader

Introduction

A Material is defined as the **Artistic Qualities** of the substance that an object is made of. To define this in the simplest form, you can use the materials to show the substance of how an object is made of, or to “paint” the object with different colors. Usually, the substance is represented by its surface qualities (color, shininess, reflectance, etc.) but it can also exhibit more complicated effects such as transparency, diffraction and sub-surface scattering. Typical materials might be brass, skin, glass, or linen. The basic (un-textured) Blender material is uniform across each face of an object (although the various pixels of each face of the object may appear differently because of lighting effects). However, different faces of the object may use different materials. In Blender, Materials can describe the substance: e.g. polished brass, dirty glass or embroidered linen. In this Unit, you will learn about **Materials and Shader in Blender**.

Outcomes

Upon completion of this unit you will be able to:

- Apply Materials and Shaders to your 3D Scenes
- Demonstrate the utility of Material Panel and its Slots
- Use Multiple Materials
- Practice Material Operations like Naming and Linking
- Use Material Type and Assigning a Material
- Reuse Existing Materials

Terminology

BSDF:	Bidirectional Scattering Distribution Function is defined as how light is reflected and refracted at a surface.
Reflection:	BSDF Reflects an incoming ray on the same side of the surface.
Transmission:	BSDF Transmits an incoming ray through the surface, leaving on the other side.
Refraction:	BSDF refraction is a type of Transmission, transmitting an incoming ray and changing its direction as it exists on the other side of the surface.

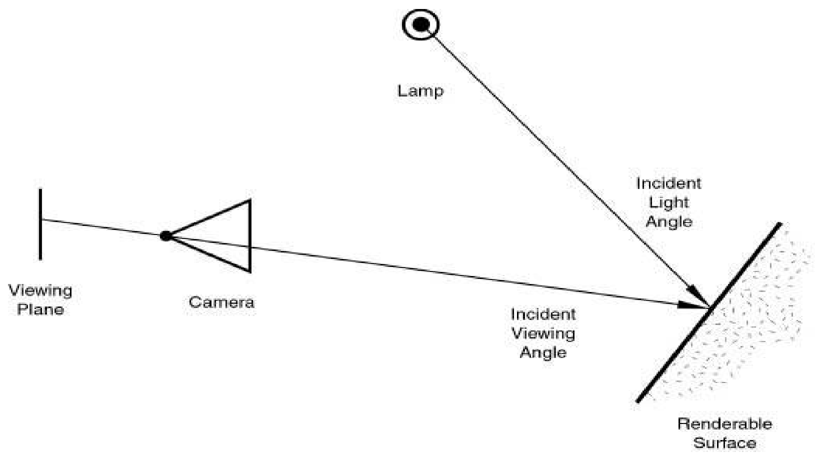
Functions of Materials

Before you can describe how to design effectively with materials, you must understand how **simulated light and surfaces interact** in Blender’s rendering engine and how material settings control those interactions. A deep understanding of the engine will help you to get the most from it.

The **Rendered Image** you create with Blender is a projection of the scene onto an imaginary surface called the **Viewing Plane**. The viewing plane is analogous to the film in a traditional camera, or the rods and cones in the human eye, except that it receives ***simulated light, not real light.***

To render an image of a scene, you must first determine what light from the scene is arriving at each point on the viewing plane? The best way to answer this question is to **follow a straight line** (the simulated light ray) backwards through that point on the viewing plane and the focal point (the location of the camera) until it hits a renderable surface in the scene, at which point you can determine what light would strike that point. (Refer image 1.1)

The surface properties and **Incident Light Angle** tell us how much of that light would be reflected along the **IncidentViewing Angle** (Rendering Engine Basic Principle).



Title- Img 1. 1 Rendering Engine Basic Principle

Source-

Link- http://blender-manual- i18n.readthedocs.io/ja/latest/render/blender_render/materials/introduction.ht ml

Two basic types of phenomena would take place at any point on a surface when a light ray strikes it:

1. Diffusion

2. Specular Reflection

Diffusion and Specular reflection are distinguished from each other mainly by the relationship between the **Incident Light Angle** and the **Reflected Light Angle**.

The **shading (or coloring)** of the object during render will then consider the base color (as modified by the diffusion and specular reflection phenomenon) and the light intensity.

Using the **Internal Ray Tracer,** other (more advanced) phenomena could occur.

In **Ray-Traced Reflections,** the point of a surface struck by a light ray will return the color of its ***surrounding environment***, according to the rate of reflection of the material (mixing the base color and the surrounding environment) and the viewing angle.

On the other hand, in **Ray-Traced Refractions**, the point of a surface struck by a light ray will return the color of its ***background environment,*** according to the rate of transparency (mixing the base color and the background environment along with its optional filtering value) of the material and the optional index of refraction of the material, which will distort the viewing angle.

Of course, shading of the object hit by a light ray will be about mixing all these phenomena at the same time during the rendering.

Material Settings

While rendering, the appearance of the object depends upon many inter-related settings:

- World (Ambient color, Radiosity, Ambient Occlusion)
- Lights
- Material settings (including ambient, emission, and every other setting on every panel in that tab)
- Texture(s) and how they are mixed
- Material Nodes
- Camera
- Viewing Angle
- Obstructions and transparent occlusions
- Shadows from other opaque/transparent objects
- Render settings
- Object dimensions (SS settings are relevant to dimensions)
- Object shape (refractions, Fresnel effects)

As stated above, the material settings usually determine the **surface properties of the object.** There are several ways in which materials can be set up in Blender. Generally, these are not compatible.

You must choose which method you are going to use for each particular object in your scene:

Step 1: you can set the Properties in the various Material Panels.

Step 2: you can use Nodes; a Graphical Nodes Editor is available.

Step 3: you can directly set the colour of object surfaces using various special effects.

Strictly, these are not the materials at all, however they are included here because they will affect the appearance of your objects. These include

- Vertex Painting,
- Wire Rendering,
- Volume Rendering, and
- Halo Rendering

The exact effect of Material settings can be affected by the number of system settings.

1. First and foremost is the **Render Engine** used: **Cycles and the Blender Render Engine (aka Blender Internal or BI)** require quite different illumination levels to achieve similar results, and even then, the appearance of objects would be quite different.

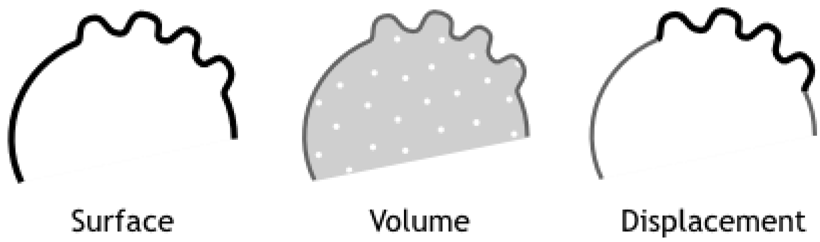
2. Also, the material properties settings can be affected by the **Texture Method** used **(Single Texture, Multitexture or GLSL)**.

So, it is always recommended to select the appropriate system settings before starting the design of materials.

Shaders

Materials define the appearance of meshes, curves and other objects. They consist of **Three Shaders,** which define the appearance of the

1. Surface of the mesh,
2. Volume inside the mesh, and
3. Displacement of the surface of the mesh.



Title- Img 1. 2 Materials with shaders

Source- Blender.org

Link- https://docs.blender.org/manual/en/dev/render/cycles/materials/introduction. html

Surface Shader

The Surface Shader defines the light interaction at the surface of the mesh. One or more BSDFs specify if incoming light is reflected back, refracted into the mesh, or absorbed.

Emission defines how light is emitted from the surface, allowing any surface to become a light source.

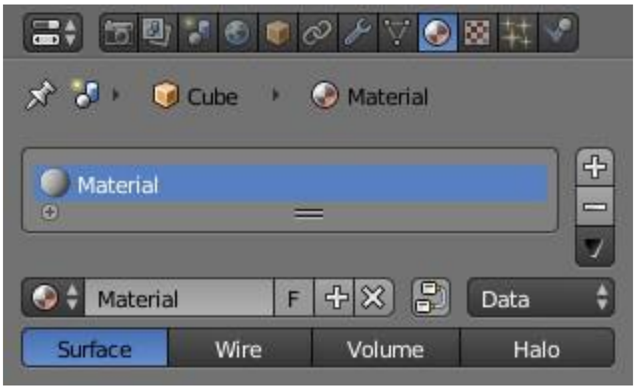
Material Panel

Materials can be linked to Objects and Object's data in the

Materials Tab ▸ Materials Panel

Here, you can manage how materials are linked to objects, meshes, etc. and activate a material for editing in the rest of the panels. (Refer 1.3)

Title-Img 1.3 Material panel



Source- Blender.org

Link- https://docs.blender.org/manual/en/dev/render/blender_render/materials/ma terial_panel.html

- **Material slots - Active Material**

  The object's material slots are displayed in a List View. (Refer 1.4)

- **Specials**
- Copy and paste the selected material slot.
- **Multiple materials**
- Meshes can handle having more than one material. Materials can be mapped on a per-face basis, as detailed on the Multiple Materials. In edit mode, the following tools appear:
- **Assign**

- Assign the material in the selected material slot to selected vertices.

- **Select**

- Select vertices assigned to the selected material slot.

- **Deselect**

  Deselect vertices assigned to the selected material slot.

Materials Slots

The object's material slots are displayed in a List View.

List View

Title-Img 1. 4 List view

Source- Blender.org

Link- https://docs.blender.org/manual/en/dev/interface/controls/templates/list_pre sets.html#ui-list-view

This control is useful to manage lists of items. They can be found in example in the object data properties.

Select

To select an item, **LMB** on it.

- **Rename**

  By double clicking on an item, you can edit its name via a text field. This can also be achieved by pressing **Ctrl-LMB** over it.

- **Resize**

  The list view can be resized to show more or fewer items. Hover the mouse over the handle **(==)** then click and drag the handle to expand or shrink the list.

- **Filter**

  Click the *Show filtering options* button **(+)** to toggle filter option buttons.

  Search Type part of a list item's name in the *filter text field* to filter items by their name.

Filter Include When the magnifying glass icon has a + sign then only items that match the text will be displayed.

Filter Exclude When the magnifying glass icon has a - sign then only items that do not match text will be displayed.

- **Sort**

Sort list items.

Alphabetical This button switches between alphabetical and non-alphabetical ordering.

Inverse Sort objects in ascending or descending order. This also applies to alphabetical sorting, if selected.

On the right of the list view are additional buttons:

- **Add +**

Adds a new item.

- **Remove -**

To remove the selected item.

- **Specials**

The down arrow on dark background opens a pop-up menu with operators' context-sensitive to the item type. i.e. copy paste, or operations on all items.

- **Move Up**

The button showing an up arrow moves the selected item up one position.

- **Move Down**

The down arrow moves the item down.

Presets

Title-Img 1. 5 Presets without and with specials

Attribution- Source- Blender.org

Link- https://docs.blender.org/manual/en/dev/interface/controls/templates/list_presets.html#ui-list-view

- **Selector**

A list of available presets. A selection will override the included properties.

- **Add +**

New presets can be added based on the preset included properties, which will be saved for later re-use. A pop-up opens, where you can set a name after which you can select it from the list and in some cases additional settings.

- **Remove -**

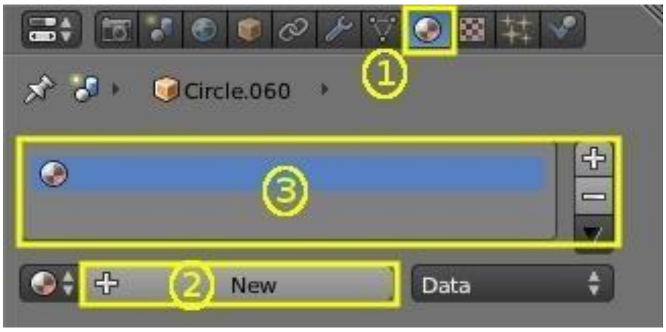
Deletes the selected preset.

- **Specials**

The down arrow on dark background opens a pop-up menu with operators' context-sensitive to the preset type. i.e. copy paste.

Multiple Materials

Normally, different colors or patterns on an object are achieved by adding textures to your materials. However, in some applications you can obtain multiple colors on an object by assigning different materials to the individual faces of the object.

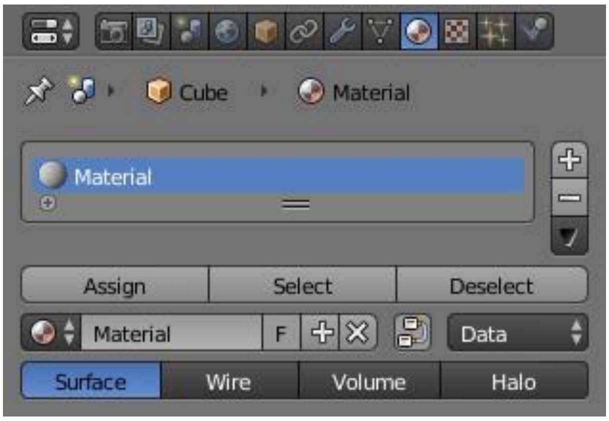


Title-Img 1. 4Add new material

Attribution- Source- Blender.org

Link- https://docs.blender.org/manual/en/dev/render/blender_render/materials/assigning_a_material.html

To apply several materials to different faces of the same object, you use the Material Slots **options (3)** in the Materials Header Panel. (Refer 1.6)



Title-Img 1. 5 Material menu in edit mode

Attribution- Source- Blender.org

Link- https://docs.blender.org/manual/en/dev/render/blender_render/materials/assigning_a_material.html

The workflow for applying a Second Material to some faces of an object covered by a Base Material is as follows:

Step 1:

In Object Mode, apply the Base Material to the whole object (as shown in Assigning a material)

Step 2:

Create/select the Second Material (the whole object will change to this new material).

Step 3:

In the Active Material box (2), re-select the base material.

Step 4:

Go to Edit Mode and Face Select (a new box appears above the Active Material box with Assign/Select/Deselect).

Step 5:

Select the face/faces to be coloured with the second material.

Step 6:

In the Object Material Slots box (3), click the Plus to create a new slot, and while this is still active, click on the second material in the Available Materials list.

Step 7:

Click the Assign button, and the second material will appear on the selected object faces.

You can also make this new material a copy of an existing material by adding the data-block:

- Select the object,
- get the material,
- (R Click) and Copy data to clipboard.

When you have renamed the material,

- click**"Link: Data"** to link to the existing material.
- Proceed to assign faces as required.

Note: If you change the material on the original object, the new object color changes too.

Meshes can handle having **more than one material.** Materials can be mapped on a per-face basis, as detailed on the Multiple Materials. In **Edit Mode,** the following tools appear:

- **Assign**

Assign the material in the selected material slot to selected vertices.

- **Select**

  Select vertices assigned to the selected material slot.

- **Deselect**

  Deselect vertices assigned to the selected material slot.

Material Naming and Linking

- **Material**

  The **Material Data-Block Menu** for the selected material slot.

- **Nodes**

  Toogle that designates this material to be a material node setup, and not from the Material /Ramps / Shaders settings.

- **Data-block Links**

  It specifies whether the material is to be linked to the Object or to the Object Data. The **Link selector** has two choices: **1. Data** and **2. Object**. These two menu choices determine whether the material is linked to the object or to the data, (i.e. a mesh or curve).

- The **Data Menu Item** determines that this material will be linked to the mesh's data-block which is then linked to the object's data-block.
- The **Object Menu Item** determines that the material will be linked to the object's data-block directly.

This will have consequences, of course. For example, different objects may share the same mesh data-block. Since this data-block defines the shape of the object, any change in "Edit Mode" will be reflected on all those objects. Moreover, anything linked to that mesh data-block will be shared by every object that shares that mesh. So, if the material is linked to the mesh, every object will share it.

On the other hand, if the material is linked directly to the object data-block, the objects can have different materials and still share the same mesh.

Brief explanation: If connected to the object, you can have several instances of the same Object Data using different materials.

Unit 2 Introduction to Shader & Texture Editing

Introduction

Materials can have a **Wide Array of Properties**. It is the combination of things that define the way how the **Material looks,** and how **objects will appear** when rendered. These properties are set using the various panels in the Material tab.

Remember that the appearance of your Materials is affected by the way that they are **rendered** (surface, wire, volume or halo), and by the **rendering engine** (Blender, Cycles, or Game) used. Most properties for images rendered using **Cycles** can only be controlled using the **Node system.**

Outcomes

In this Unit, you will learn about **how to design Materials and Shaders.**

Upon completion of this unit you will be able to:

- Design suitable Materials and Shaders to your 3D Scenes
- Utilize Materials effectively to shade the 3D Objects
- Create Color Ramps, Specular, Transparency, Reflection and Refraction
- Use Material properties and
- Practice Material Operations on 3D Scenes.

Terminology

Preview:	A Preview of the current Material mapped on to one of the basic objects.
Diffuse Shaders:	The basic color of the Material, together with different models for dispersion.
Specular Shaders:	The reflected highlights: color, strength and different models for dispersion.
Color ramps:	How to vary the base color over a surface in both Diffuse and Specular Shaders.
Shading:	Properties of various characteristics of the shading model for the Material.

Transparency:	Sets options for objects in which light can pass through.
Mirror:	(Only Blender Render): Reflective properties of the Material.
Subsurface scattering:	(Only Blender Render): Simulates semi- translucent objects in which light enters, bounces around, then exits in a different place.
Strand:	(Only Blender Render): For use when surfaces are covered with hair, fur, etc.
Options:	Various options for shading and colouring the object.
Shadow:	Controls how objects using this Material cast and receive shadows.
Game settings:	(Only Blender Render): Controls settings for real-time rendering of Game Engine objects.

Diffuse Shaders

A **Diffuse Shader** is determined by the **General Color of a Material** when light shines on it. Most Shaders that are designed to mimic reality give a smooth falloff from bright to dark from the point of the strongest illumination to the shadowed areas, however **Blender** also has **other Shaders** for various special effects.

Common Options

All Diffuse Shaders have the following options:

Color

Select the base *Diffusecolor* of the Material.

Intensity

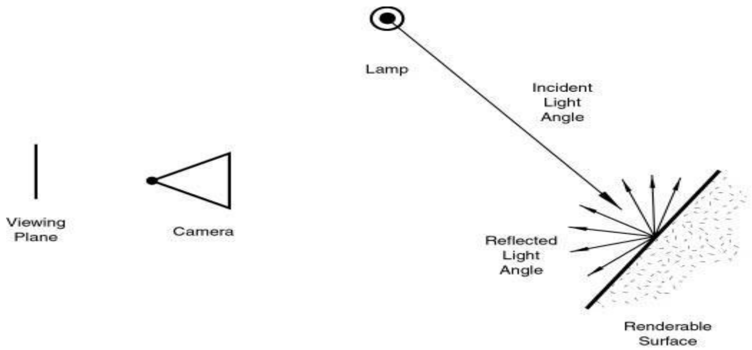
The Shader's brightness, or more accurately, the amount of incident light energy that is Diffusely reflected towards the camera.

Ramp

Allows you to set the range of colors for the *Material*, and define how the range will vary over a surface.

Technical Details

Light striking a surface and then re-irradiated via a Diffusion phenomenon will be scattered, i.e., re-irradiated in all directions isotopically. This means that the camera will see the **same amount of light** from that surface point no matter what **the *incident viewing angle* is.** This quality makes Diffuse light ***viewpoint independent***. Of course, the amount of light that strikes the surface depends on the incident light angle. If most of the light striking a surface is reflected Diffusely, the surface will have a ***matte appearance*** (Light re-irradiated in the diffusion phenomenon).

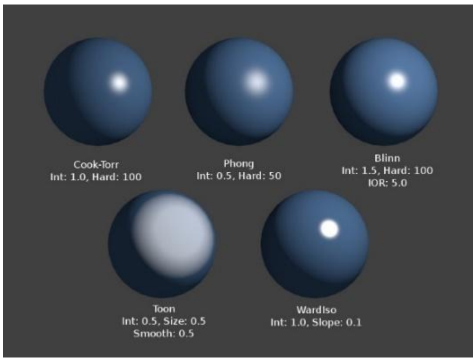


Title- Img 2. 1 Light re-irradiated in the diffusion phenomenon.

Source- blender.org

Link *https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/diffuse_shaders.html*

Types of Diffuse Shaders



Lambert Shader

Title- Img 2.2 Lambert Shader.

Source- blender.org

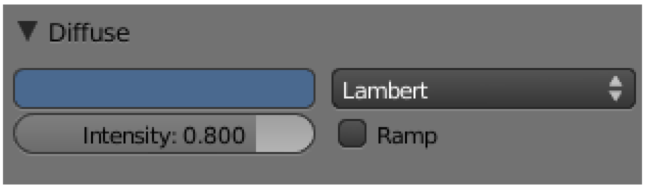
Link-*https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/diffuse_shaders.html*

This is **Blender's default Diffuse Shader**, and is a good general all- around workhorse for

Materials showing low levels of Specular reflection.

Johann Heinrich Lambert (1728-1777) was a Swiss mathematician, physicist and astronomer who published the works on the reflection of light, most notably the **Beer-Lambert Law,** which formulates the law of light absorption.

This Shader has only the default option, determining **how much of available light is reflected**. **Default is 0.8** to allow other objects to be brighter.



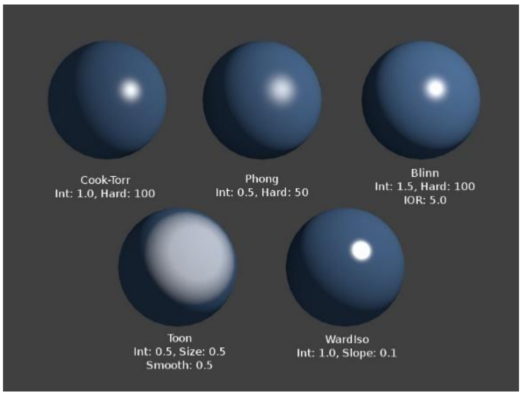
Title- Img 2.3 The Lambert Diffuse Shader settings.

Source-blender.org

Link-**https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/diffuse_shaders.html**

Oren-Nayar Shader

Title- Img 2.4 Oren-Nayar Shader.



Source-blender.org *Link*-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/diffuse_shaders.html

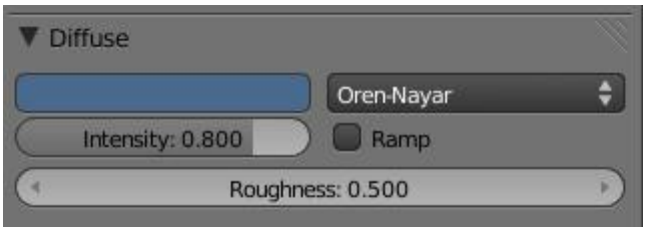
Oren-Nayar has taken a somewhat more **'physical'** approach to the diffusion phenomena as it considers the **amount of microscopic roughness of the surface**.

Michael Oren and **Shree K. NayarTheir** reflectance model developed in the **early 1990s**, is a generalization of Lambert's law now widely used in Computer Graphics.

Options

Roughness

The roughness of the surface, and hence, the amount of Diffuse scattering.

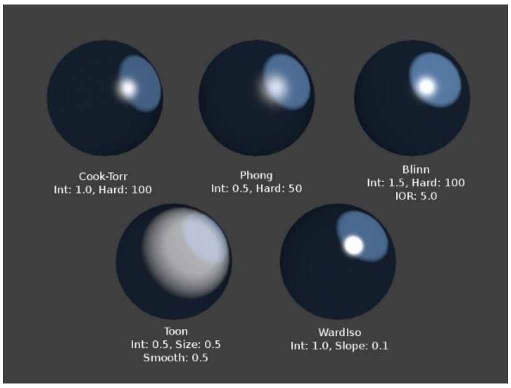


Title-Img 2.5 The Oren-Nayar Diffuse Shader settings.

Source-blender.org

Link-**https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/diffuse_shaders.html**

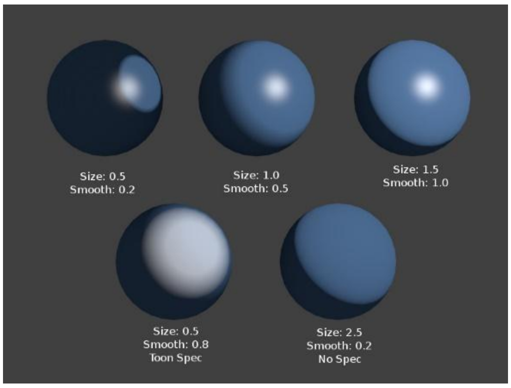
Toon Shader



Title- Img2.6 Toon Shader, Different Spec.

Source-blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/diffuse_shaders.html



Title-Img 2.7 Toon Shader Variations.

Source-blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/diffuse_shaders.html

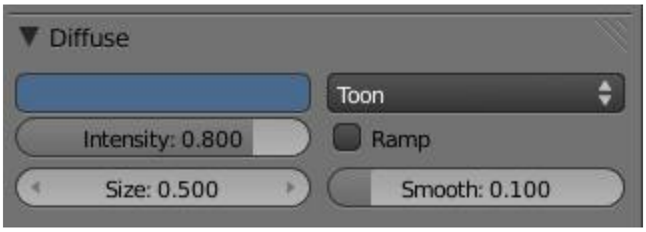
Toon Shader is a very **'un-physical'** Shader that is not meant to fake reality, however to produce cartoon cell styled rendering, with clear boundaries between light and shadow and uniformly lit/shadowed regions.

Options Size

The size of the lit area.

Smooth

The softness of the boundary is between lit and shadowed areas.

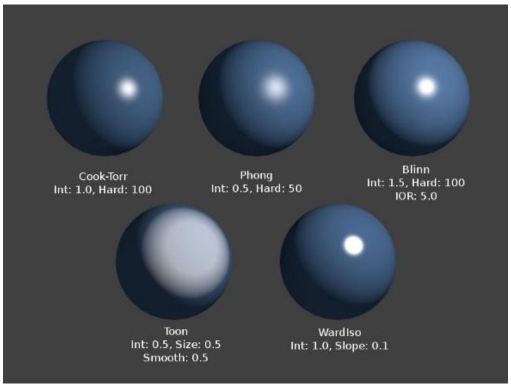


Title-Img 2.8 Toon Diffuse Shader settings.

Source-blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/diffuse_shaders.html

MinnaertShader



Title- Img 2.9 Minnaert Shader.

Source-blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/diffuse_shaders.html

Minnaert Shader works by **darkening** parts of the standard Lambert Shader.

So, if ***Dark* is 1**, you get **exactly the Lambertian** result.

Higher darkness values will darken the center of an object (where it points towards the viewer).

Lower darkness values will lighten the edges of the object, making it look somewhat velvet.

Marcel Minnaert (1893-1970) was a Belgian astronomer interested in the effects of the atmosphere on light and images who in **1954** published a book entitled "***The Nature of Light and Color in the Open Air***".

Options

Dark

The darkness of the 'lit' areas (higher) or the darkness of the edges pointing away from the light source (lower).

Title-Img2.10 Minnaert Diffuse Shader settings.

Fresnel Shader

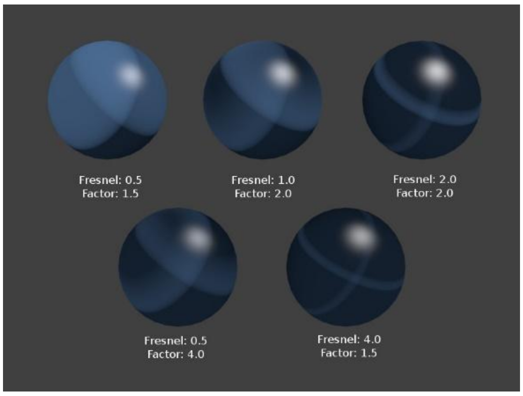
Source-blender.org

Link-[https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/diffuse_shaders.html](https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/diffuse_shaders.html)

Reference

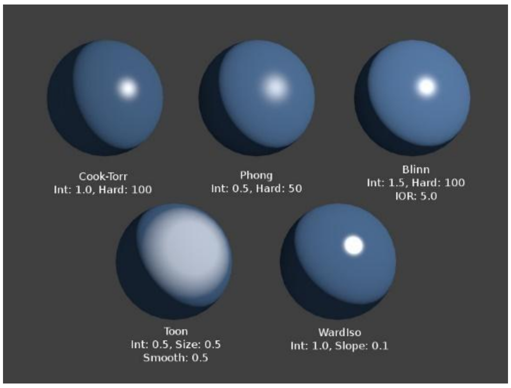
Mode: All Modes

Panel: Shading/Material Shaders



Title- Img 2. 11 Various settings for the Fresnel Shader, Cook-Torr Specular Shader kept at Intensity 0.5, Hardness: 50.

Source-blender.org
Link-*https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/diffuse_shaders.html*



Title-Img2.12 Fresnel Shader, Different Spec.

Source-blender.org *Link*-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/diffuse_shaders.html

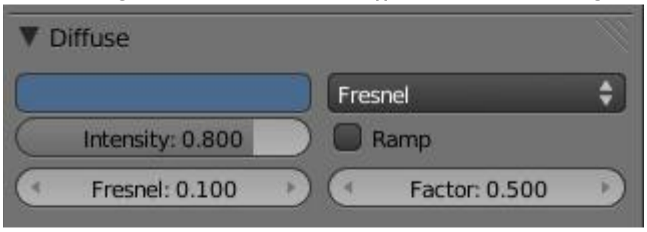
With a **Fresnel Shader,** the amount of Diffuse reflected light depends on the incidence angle, i.e. from the direction of the light source.

Areas pointing directly towards the light source appear darker; Areas perpendicular to the incoming light become brighter.

Augustin-Jean Fresnel (1788-1827) was a French physicist who contributed significantly to the establishment of the theory of **wave optics.**

Options

Title- Img 2.13 The Fresnel Diffuse Shader settings.



Source-blender.org *Link*-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/diffuse_shaders.html

Fresnel

Power of the Fresnel effect, 5.0 is max.

Factor: Blending factor of the Fresnel factor to blend in, 5.0

Emit:

Amount of light to emit

Ambient

Amount of global ambient color the Material receives

Translucency

Amount of Diffuse shading on the back side

Shadeless

Make this Material insensitive to light or shadow

Specular Shaders

Tangent Shading

Use the Material's tangent vector instead of the normal for shading – for anisotropic shading effects (e.g. soft hair and brushed metal).

Specular Shaders create the bright highlights that one would see on a **glossy surface**, mimicking the **reflection of light sources**. Unlike Diffuse shading, Specular reflection is *viewpoint dependent*. According to **Snell's Law**, light striking a Specular surface will be reflected at an angle which mirrors the incident light angle (with regard to the surface's normal), which makes the viewing angle very important.

Common Options

Each Specular Shader shares the following common options:

Specular Color

The color of the Specular highlight

Intensity

The intensity, or brightness of the Specular highlight. This has a range of [0-1].

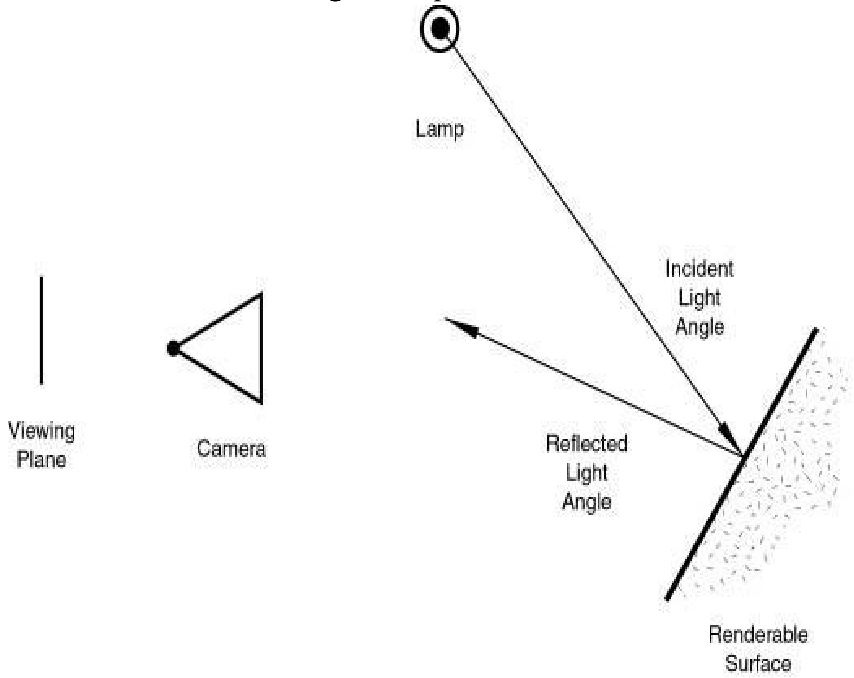
Ramp

Allows you to set a range of Specularcolors for *Material*, and define how the range will vary over a surface.

As a result, a Material has at least **two different colors**, a Diffuse, and a Specular one. The Specular color is normally set to **pure white** (the same "pure white" as the reflected light source), however, it can be set to **different values for various effects** (e.g. metals tend to have colored highlights).

Technical Details

Title- Img 2.14 Specular Reflection.



Source-blender.org

Link-

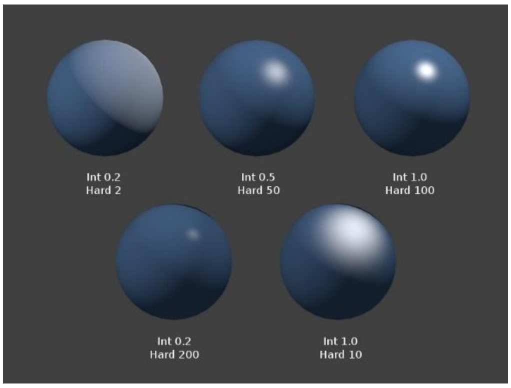
https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/specular_shaders.html?highlight=specular%20reflection

In reality, the quality of Diffuse and Specular reflection is generated during the **same process of light scattering**, however are not the same. Diffusion is actually subsurface scattering at a very small scale.
Imagine that a surface is made up of extremely microscopic semi- transparent, reflective facets. The **sharpness of Specular** reflection is determined by the **distribution of the angle** of these microfacets on the surface of an object. The deeper and jagged these facets are, the

more the light spreads when it hits the surface. When these facets are flatter against the "**macro surface**", the surface will have a tighter reflection, closer to a mirror. This is a condensed explanation of the generally accepted microfacet theory of reflectance, which is the basis of all modern **BRDFs** (Bi-directional Reflectance Distribution Functions), or shading models.

Because these microfacets are **transparent**, some light that hits them travels into the surface and Diffuses. The light that makes it back out is roughly Lambertian most of the time, meaning that it **spreads evenly** in all directions. It is also attenuated by the pigmentation in the surface, hence creating what you perceive as Diffuse, and **the color of an object**.

Note that at glancing angles, the reflectivity of a surface will always go to 1. *(Refer*Img 2.14*)*
Cook-Torrance Shader



Title-Img 2.15 Cook-Torrance Shader(Lambert 0.8).

Source-blender.org
Link-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/specular_shaders.html?highlight=specular%20reflection

Cook-Torrance is a **basic Specular**Shader that is **most useful for creating shiny plastic surfaces**. It is a slightly optimized version of **Phong.**

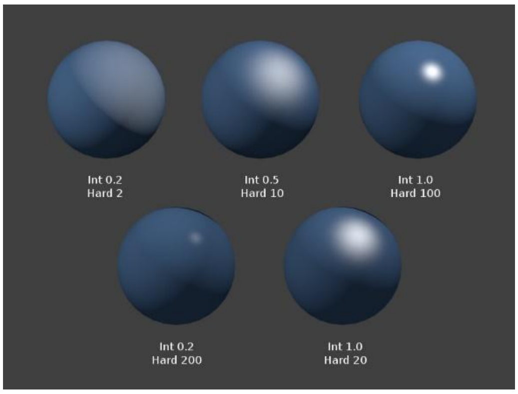
Robert L. Cook (LucasFilm) and **Kenneth E. Torrance (Cornell University)** In their **1982** paper A Reflectance Model for Computer Graphics (PDF), they described "**a new reflectance model for rendering computer synthesized images**" and applied it to the simulation of metal and plastic.

Option

Hardness

Size of the Specular highlight

PhongShader



.

Title-Img 2.16 Phong Shader (Lambert 0.8).

Source-blender.org

Link

https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/specular_shaders.html?highlight=specular%20reflection

Phong is a basic Shader that is very **similar to CookTorr**, however, it is better for **skin and organic surfaces.**

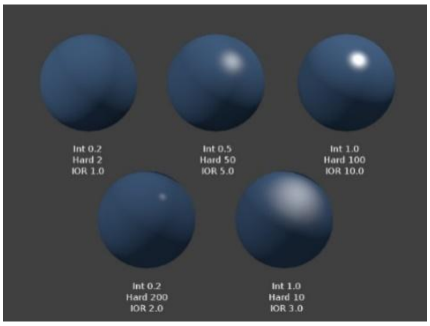
Bui TuongPhong (1942-1975) was a Vietnamese-born Computer Graphics pioneer that developed the first algorithm for simulating Specular phenomenon. His model included components not only for Specular lighting, but **also Diffuse and ambient lighting.**

Option

Hardness

Size of the Specular highlight.

BlinnShader



Title-Img 2. 17 Blinn Shader (Oren-Nayar Int 0.8, Rough 0.5).

Source-blender.org

Link

https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/specular_shaders.html?highlight=specular%20reflection

Blinn is a more **'physical' Specular Shader**, often used with the **Oren-Nayar Diffuse Shader**. It can be **more controllable** because it adds a fourth option, **an index of refraction**, to the above mentioned three.

James F. Blinn worked at NASA's Jet Propulsion Laboratory and became widely known for his work on **Carl Sagan's TV** documentary ***Cosmos***. The model he described in his **1977** paper Models of Light Reflection for **Computer Synthesized Pictures** (PDF) included changes in Specular intensity with light direction and more accurately positioned highlights on a surface.

Options

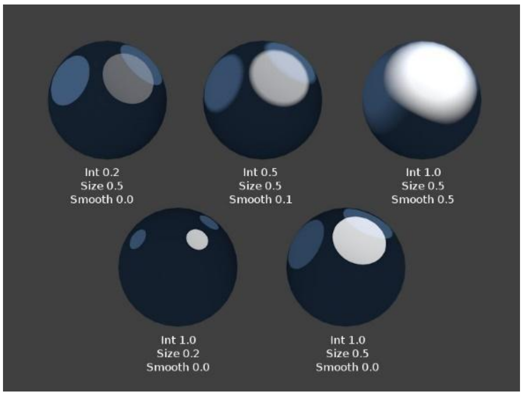
Hardness

Size of the Specular highlight. The BlinnShader is capable of much tighter Specular highlights than **Phong**or**CookTorr.**

IOR

'Index of Refraction'. This parameter is not actually used to compute refraction of light rays through the Material (a ray tracer is needed for that), however to correctly compute Specular reflection intensity and extension via Snell's Law.

Toon Shader



Title-Img 2. 18 Toon Specular Shader (Toon Diffuse, Int 0.8, Size & Smooth match).

Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/specular_shaders.html?highlight=specular%20reflection

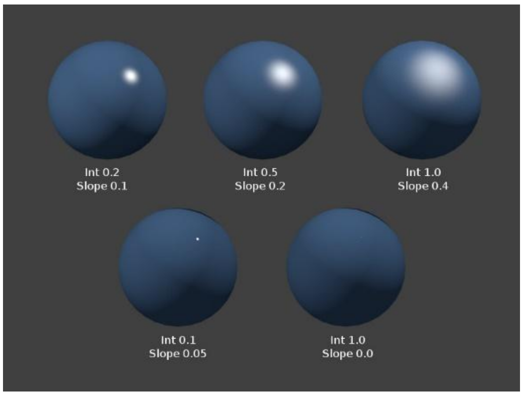
Toon Specular Shader matches the Toon Diffuse Shader. It is designed to produce the ***sharp, uniform highlights of cartoon cells.***

Options

Size: Size of the Specular highlight.

Smooth: Softness of the highlight's edge.

Ward Isotropic Shader



Title- Img2.19 Ward isotropic Shader.

Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/specular_shaders.html?highlight=specular%20reflection

Ward Isotropic is a **flexible Specular Shader** that can be useful for metal or plastic**.**

Gregory J. Ward developed a relatively simple model that obeyed the most basic laws of physics. In his 1992 paper, "Measuring and modeling anisotropic reaction", Ward introduced a **Bidirectional Reflectance Distribution Function (BRDF)** since then widely used in Computer Graphics because the few parameters it uses are simple to control. His model could represent **both isotropicsurfaces** (independent of light direction) and **anisotropic surfaces** (direction dependent). In Blender, the Ward Specular Shader is still called "**Ward Isotropic**" however is actually anisotropic.

Option

Slope

Standard deviation for surface slope. Previously known as the **root-mean-square or rms value**, this parameter in effect controls the size of the Specular highlight, though using a different method to that of the other Specular Shaders. It is capable of extremely sharp highlights.

Color Ramps Shading

In many real-life situations, like skin or metals, the **color of Diffuse and Specular** reflections can differ slightly, based on the amount of energy a surface receives or on the light angle of incidence. The ***Ramp Shader*** options in Blender allow you to

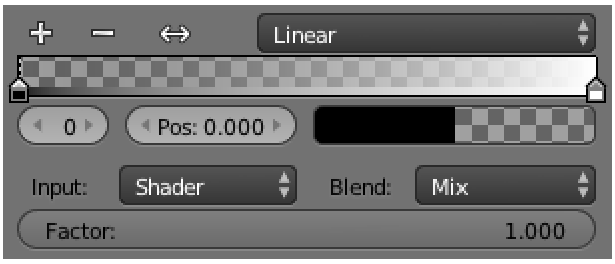
- set a **range of colors for a *Material*,**
- define how the **range will vary** over a surface,
- how it **blends** with the 'actual color' (typically from a Material or as output of a texture).

Ramps allow you to precisely control the **color gradient across a Material**, rather than just a simple blend from a brightened color to a darkened color, from the most strongly lit area to the darkest lit area. As well as several options for controlling the gradient from lit to shadowed, ramps also provide 'normal' input, to define a gradient from surfaces facing the camera to surfaces facing away from the camera. This is often used for Materials of **metallic car paint that change color based on viewing angle.**

Since texture calculations in Blender happen before shading, the *Ramp Shader* can completely replace texture or Material color. However, using the mixing **options and Alpha values**, it is possible to create an **additional layer of shading** in Blender Materials.

Options

Title- Img 2.20 Ramps Panel.



Source-blender.org *Link*-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/ramps.html

For the first part of the color ramp option, see Color Ramp Widget.*(Refer* Img 2.20*)*

Input

The input menu contains the following options for defining the gradient:

Shader

The value as delivered by the Material's Shader (*Lambert, Cook Torrance*) defines the color. Here the **amount of light** does not matter for color, only the **direction** of the light.

Energy

As *Shader,* now also lamp **energy, color, and distance** are considered. This makes the Material change color when more light shines on it.

Normal

The surface normal, relative to the camera, is used for the Ramp Shader. This is possible with a texture as well, however added for convenience.

Result

While all three previous options work per lamp, this option only works **after shading calculations**. This allows full control over the entire shading, including 'Toon' style results. Using alpha values here is most useful for tweaking a finishing touch to a Material.

Blend

A list of the various Color Blend Modes are available for blending the ramp Shader with the color from Input.

Factor

This slider denotes the overall factor of the ramp Shader with the color from Input.

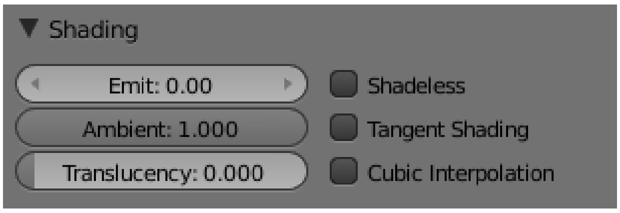
Shading Panel

While all three previous options work per lamp, this option only works **after shading calculations**. This allows full control over the entire shading, including 'Toon' style results.

Using alpha values here is most useful for tweaking a finishing touch to a Material.

A list of the various Color Blend Modes are available for blending the ramp Shader with the color from Input.

This slider denotes the overall factor of the ramp Shader with the color from Input. In the separate *Shading* panel **SIX MORE OPTIONS** are available:



Title- Img 2.21 Shading menu, default settings.

Source-blender.org

Link-*https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/ramps.html*

Emit

Amount of light to emit.

Ambient

Amount of global ambient color the Material receives. Each Material has an Ambient slider that lets you choose **how much ambient light** that object receives. Set to **1.0 by default**.

Ambient Color

You should set this slider depending on the amount of ambient light you think the object will receive. Something ***deep in the cave*** *will not get any ambient light, whereas something* ***close to the entrance will get more****. Note that you can animate this effect, to change it as the object comes out of the shadows and into the light.*

Translucency

Amount of light from the back side that shows through.

Shadeless

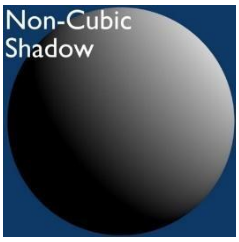
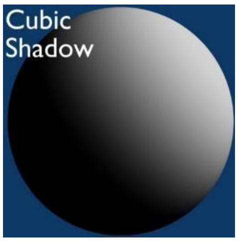
Disables the calculation of any shading. This makes the Material insensitive to light or shadow, resulting in a solid, uniform color for the whole object.

Tangent Shading

Use the Material's **tangent vector** instead of the normal for shading, i.e. for anisotropic shading effects (like soft hair and brushed metal).

Cubic Interpolation

Use cubic interpolation for Diffuse values, for smoother transitions between light areas and shadowed areas. Enhances the perceived contrast.

 Without Cubic enabled.	 With Cubic enabled Cubic enabled.

Title- Img 2. 22 Shading menu, default settings.

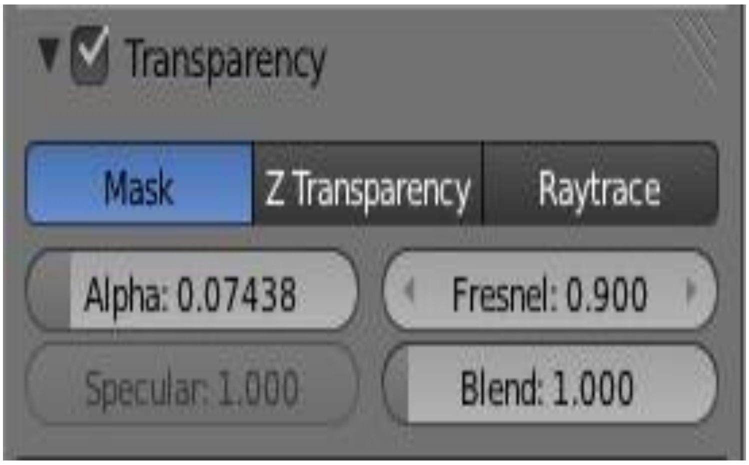
Source-blender.org

Link-http://blender-manual.readthedocs.io/en/master/render/blender_render/materials/properti es/shading.html

Transparency Panel

Materials in Blender can be set **to be transparent**, so that light can pass through any objects using the Material. Transparency is controlled using **an "alpha" channel**, where each pixel has an additional value, **range 0-1**, in addition to its RGB color values.

- If **alpha=0**, then the pixel is **transparent**, and the RGB values for the surface contribute nothing to the pixel's appearance;
- If **alpha=1**, the surface is **fully opaque**, and the color of the surface determines the final color of the pixel.



Title-Img 2.23 Transparency Panel.

Source-blender.org *Link*-

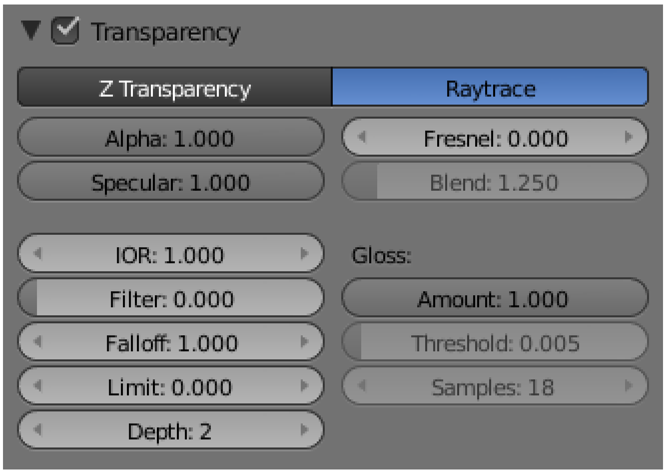
https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/transparency.html

In Blender, there are **three ways** in which the transparency of a Material can be set:

1. **Mask,**
2. **Z-Buffer**
3. **Ray-trace**

Each of these is explained in more detail below. The Material Preview option with a sphere object gives a good demonstration of the capabilities of these three options.

Options



Title- Img 2. 24 The Transparency Panel.

Source-blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/transparency.html

IOR

In addition to the common options given above, the following property controls are available: Index of Refraction. Sets how much a ray traveling through the Material will be refracted, hence producing a distorted image of its background.

Filter

Amount of filtering for transparent ray trace. The higher this value, the more the base color of the Material will show. The Material will still be transparent; however, it will start to take on the color of the Material. **Disabled (0.0) by default**.

Falloff

How fast light is absorbed as it passes through the Material. Gives '**depth**' and '**thicknesses to glass**.

Limit

Materials **thicker than** this are not transparent. This is used to control the threshold after which the filter color starts to come into play.

Depth

Sets the **maximum number** of transparent surfaces a single ray can travel through. There is no typical value. Transparent objects outside the Depth range will be rendered **pitch black** if viewed through the transparent object that the Depth is set for. In other words, if you notice black areas on the surface of a transparent object, the solution is probably to **increase its Depth value** (this is a common issue with ray tracing transparent objects). You may also need to turn on transparent shadows on the background object.

Gloss

Settings for the glossiness of the Material.

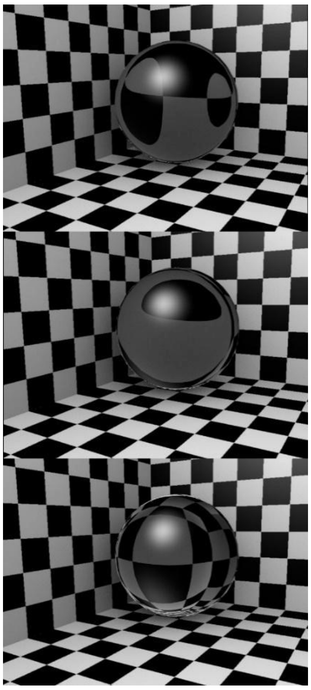
Amount

The **clarity** of the refraction. Set this to something **lower than zero** to get **a blurry** refraction.

Threshold

Threshold for **adaptive sampling**. If a sample contributes less than this amount (as a percentage), sampling is stopped.

Index of Refraction (IOR)



Title- Img 2. 25 Influence of IOR of an Object on the distortion of the background: spheres of Water, Glass and Diamond (top to bottom).

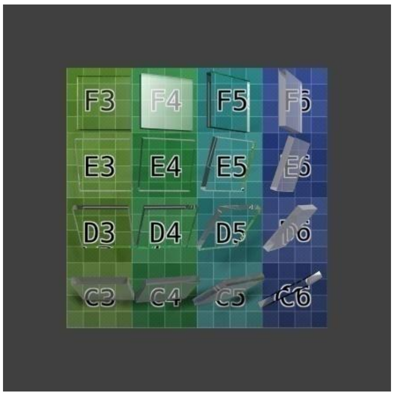
Source-blender.org

Link-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/transparency.html

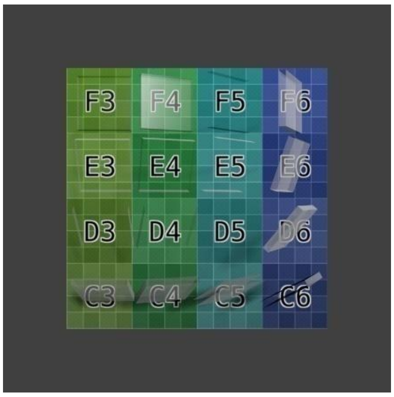
There are different values for typical Materials:

- **Air:** 1.000 (no refraction),
- **Alcohol:** 1.329,
- **Glass:** 1.517,
- **Plastic:** 1.460,
- **Water:** 1.333 and
- **Diamond:** 2.417

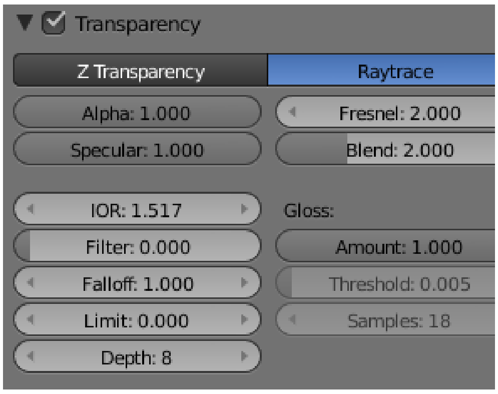
Fresnel



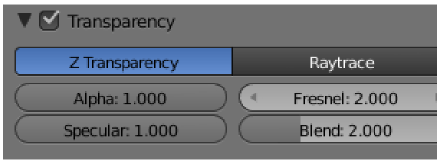
With ray-traced transparency.



With alpha buffered transparency.



Settings for Fresnel using ray- traced.



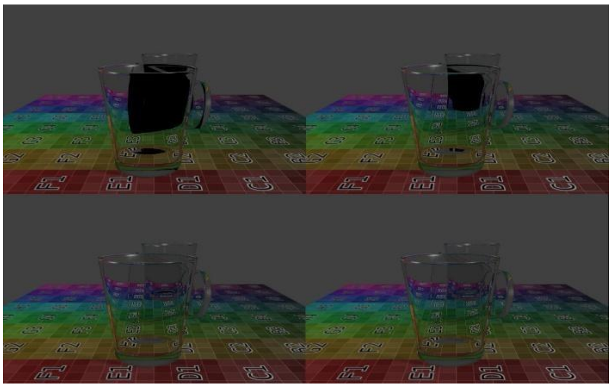
Settings for Fresnel using Z transparency.

Title- Img 2. 26 Fresnel Effect

Source-blender.org

Link-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/transparency.html

Depth



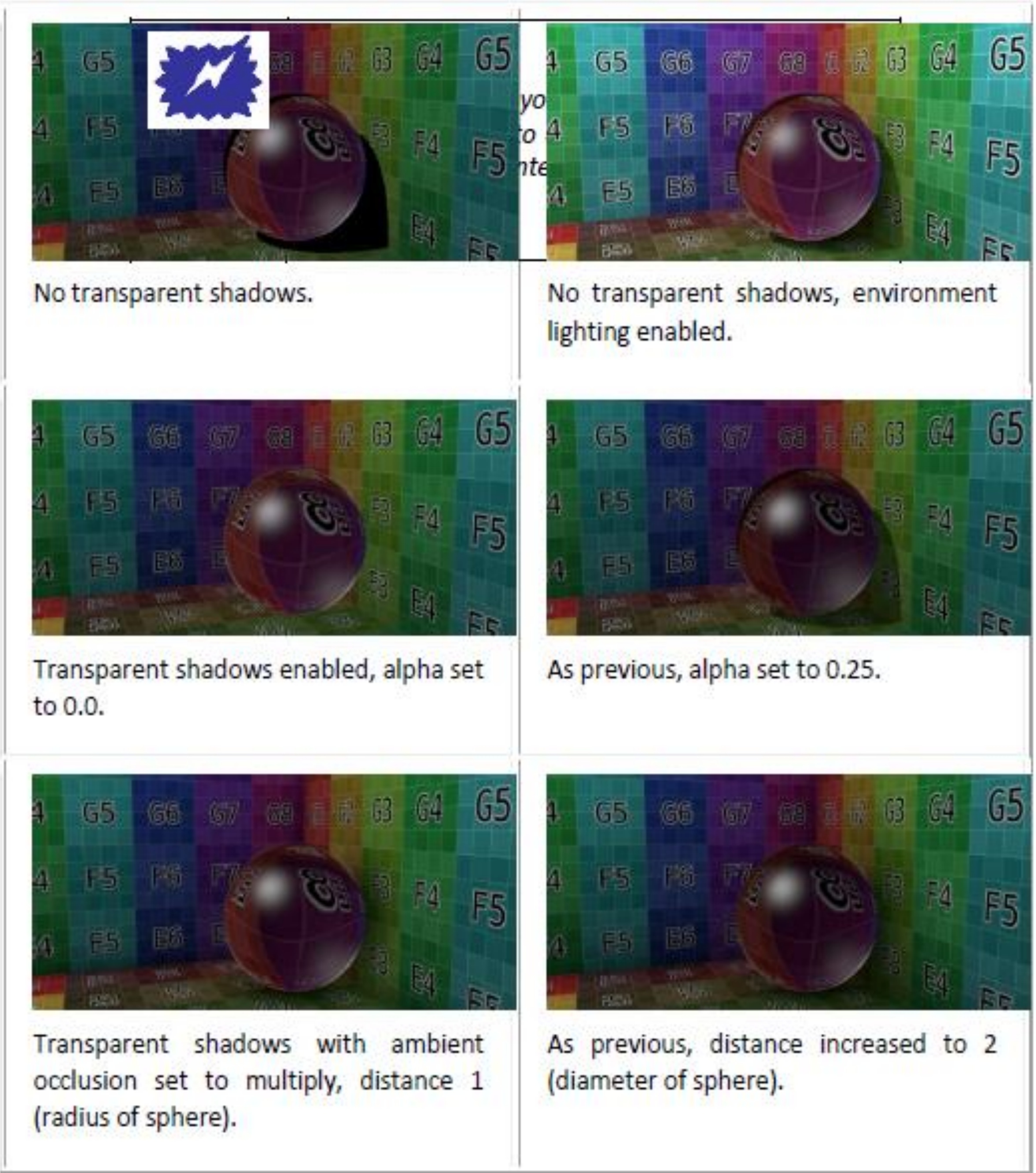
Title- Img 2. 27 Depth

Source-blender.org *Link*-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/transparency.html

Increasing *Depth* also considerably **increases render time**. Each time a light ray passes through a surface, the **ray-tracing algorithm** is called recursively. In the example above, each side of each glass has an **exterior and an interior surface**. Light rays thus have to pass through four surfaces for each glass.

However not only that, at every point on a surface, some of the light can **be reflected**, or **mirrored off** the surface in various directions. This results in multiple rays needing to be calculated for each point (often referred to as a tree of rays). In each of the rendered images above there are **640×400=256 000 pixels**. By increasing *Depth*, at least one tree of rays is added to each pixel.



No transparent shadows.

No transparent shadows, environment lighting enabled.

Transparent shadows enabled, alpha set to 0.0.

As previous, alpha set to 0.25.

Transparent shadows with ambient occlusion set to multiply, distance 1 (radius of sphere).

As previous, distance increased to 2 (diameter of sphere).

Title- Img 2. 28 Transparent Shadows

Source-blender.org

Link-*https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/transparency.html*

Transparent shadows

By default, the shadows of transparent objects are rendered **solid black**, as if the object was not transparent at all. However, in reality, the **more transparent** an object is, the **lighter its shadow** will be.

In Blender, transparent shadows are set on the Materials that receive the shadows from the transparent object. This is enabled and disabled with the ***Receive Transparent* button**, in the

Material

- Shadow panel. The shadow's brightness is dependent on the ***Alpha* value** of the shadow casting Material.

Alternatives to transparent ray-traced shadows can be found in the ***World* tab**, namely the ***Ambient Occlusion*, *Environment Lighting*, and *Gather* panels**. Alternatively, a texture can be used to control the *Intensity* value of the shadow-receiving Material.

Mirror Reflection

Mirror reflections are computed in the Blender Render and Cycles render engines using **ray tracing**. (NB: Reflections are not available in the **Game Engine**.) Ray tracing can be used to make a Material reflect its **surroundings, like a mirror**.

The principle of ray-traced reflections is very simple: a ray is fired from the camera and travels through the scene until it encounters an object.

- If the first object hit by the ray **is not reflective**, then the ray takes **the color** of the object.
- If the object is **reflective**, then the ray bounces from its current location and travels up to another object, and so on, until a non-reflective object is finally met and gives the whole chain of rays its color.

Eventually, the first reflective object **inherits the colors** of its environment, proportional to its ***Reflectivity* value**. Obviously, if there are only reflective objects in the scene, then the render could last forever. Hence a mechanism for limiting the travel of a single ray is set through the ***Depth* value**: this parameter sets the maximum number of bounces allowed for a single ray.

Options

Title- Img 2. 28 The Mirror Panel.

Source-blender.org *Link-*

https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/mirror.html?highlight=mirror%20panel

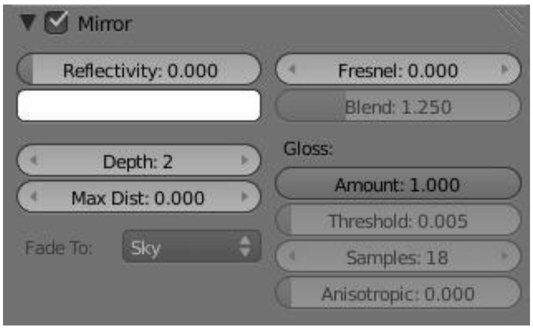
Enable ray-traced reflections

Enable or disable ray-traced reflections

Reflectivity

Sets the amount of reflectiveness of the object. Use a value of 1.0 if you need a perfect mirror, or set it to 0.0 if you do not want any reflection.

Mirror Color



Title- Img 2. 29 Picking a mirror color.

Source-blender.org *Link-*

https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/mirror.html?highlight=mirror%20panel

Color of mirrored reflection by default, an almost perfectly reflective Material like chrome, or a mirror object, will **reflect the exact colors** of its surrounding. However, some other equally reflective Materials tint the reflections with their own color. This is the case for **well-polished copper and gold,** for example. In order to replicate this within Blender, you have to set the Mirror Color accordingly. To set a mirror color, simply click the color button in the mirror panel and select a color.

Options Fresnel

Sets the power of the Fresnel effect. The Fresnel effect controls how reflective the Material is, depending on the angle between the surface normal and the viewing direction. Typically, the **larger the angle**, the **more reflective** a Material becomes (this generally occurs on the outline of objects).

Blend

A controlling factor **to adjust** how the blending happens between the reflective and non-reflective areas.

Depth

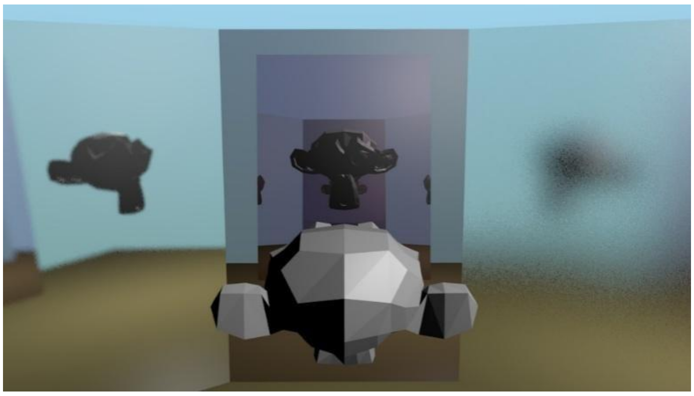
Maximum allowed number of light inter-reflections. If your scene contains many reflective objects and/or if the camera zooms in on such a reflective object, you will need to increase this value if you want to see surrounding reflections in the reflection of the reflected object. In this case, a **Depth of 4 or 5** is typically a good value.

Max Distance

Maximum distance of reflected rays away from camera **(Z-Depth)** in Blender Units. Reflections further than this range fade out to reduce compute time.

Fade to

The color that rays with no intersection within the ***Max Distance*** **take**. *Material* color can be best for indoor scenes, *Sky* color (World settings) for outdoor scenes.



Title- Img 2.30 Suzanne in the Fun House

Source-blender.org *Link*-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/mirror.html?highlight=mirror%20panel

Gloss

In paint, a **high-gloss finish** is very smooth and shiny. A flat, or low gloss, finish disperses the light and gives a very blurry reflection. Also, uneven or waxed-however-grainy surfaces (such as car paint) are not perfect and therefore slightly need a Gloss **greater than 1.0**

In the example to the right, the left mirror has a **Gloss of 0.98**, the middle is **Gloss = 1.0**, and the right one has **Gloss of 0.90**. Use this setting to make a realistic reflection, all the way up to a completely foggy mirror. You can also use this value to mimic depth of field in mirrors.

Amount

The shininess of the reflection. **Values < 1.0** give Diffuse, blurry reflections and activate the settings below.

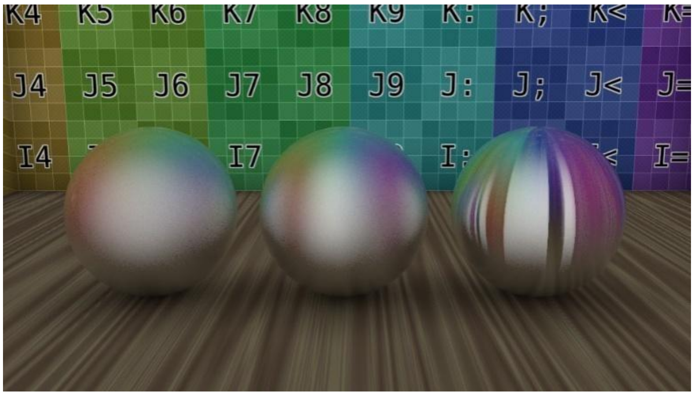
Threshold

Threshold for **adaptive sampling**. If a sampling contributes less than this amount (as percentage), sampling is stopped. Raising the threshold will make the adaptive sampler skip more often, however, the reflections could become noisier.

Samples

Number of cone samples averaged for blurry reflection. More samples will give a **smoother result**, however will also **increase render time**.

Anisotropic



Title- Img 2. 31 Anisotropic tangent reflecting spheres with anisotropic set to 0.0, 0.75, 1.0. (.blend)

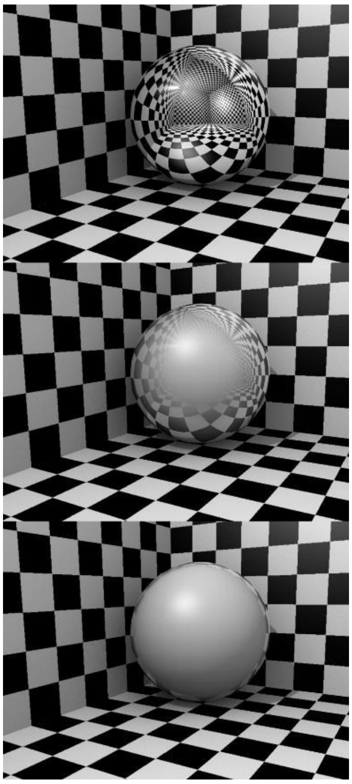
Source-blender.org

Link-**https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/mirror.html**

The shape of the reflection, from 0.0 (circular) to 1.0 (fully stretched along the tangent). If the ***Tangent Shading*** **is on**, Blender automatically renders **blurry reflections** as anisotropic reflections. When Tangent is switched on, the *Anisotropic* slider controls the strength of this anisotropic reflection, with a range of 1.0 (default) being fully anisotropic and 0.0 being fully circular, as is when tangent shading on the Material is switched off.

Anisotropic ray-traced reflection uses the same tangent vectors as for tangent shading, so you can modify the angle and layout the same way, with the auto-generated tangents, or based on the mesh's UV co-ordinates.

Examples Fresnel



Title- Img 2. 32 Demonstration of Fresnel effect with values equal to (from top to bottom) 0.0, 2.5 and 5.0.

Source-blender.org *Link*-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/mirror.html

Let us undertake a small experiment in order to understand what **Fresnel is really about**. After a rainy day, go out and stand over a puddle of water. You can see the ground through the puddle. If you kneel just in front of the puddle, your face close to the ground, and look again at a distant point on the puddle of water, the liquid surface part which is closer to you lets you see the ground, however if you move your gaze towards the other end of the puddle, then the ground is gradually masked until all you see is the reflection of the sky. This is the **Fresnel effect:** having a surface sharing reflective and non-reflective properties according to the viewing angle and the surface normal.

In *Demonstration of Fresnel effect with values equal to (from top to bottom)* ***0.0, 2.5 and 5.0***, this behavior is demonstrated for a perfectly reflective Material (Mirror Reflectivity 1.0).

- Fresnel 0.0 stands for a perfect mirror Material,
- Fresnel 5. 0 could stand for a glossy Material.

It is barely noticeable however in the lower picture, the Material is perfectly reflective around the edges.

The **smoothness** of the Fresnel limit can be further controlled using the ***Blend*** **slider**.

Subsurface Scattering (SSS)

Many organic and inorganic Materials are **not totally opaque** right at the surface, so light does not just bounce off the top surface. Instead, some light also penetrates the skin surface deeply, and scatters around inside, taking on the color of the insides and emerging back out at a different location. **Human/animal skin, the skin of grapes, tomatoes, fruits, wax, gels (like honey, or Jello)** and so on all have Subsurface Scattering (SSS), and photo-realism really cannot be achieved without it.

It is important to understand that **Subsurface Scattering and Diffuse are one and the same.** The difference is in how far light can Diffuse beneath the surface before it is absorbed or transmitted back out.

How it works

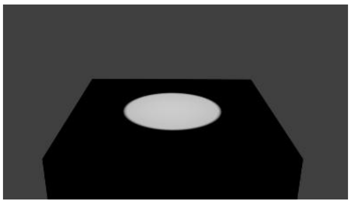
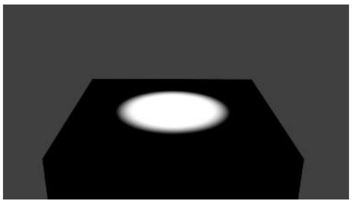
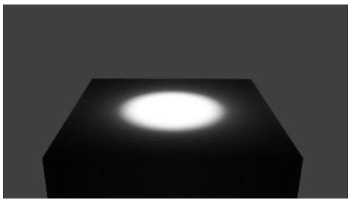
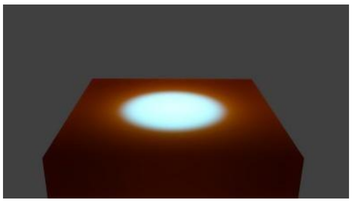
Actually, calculating the light path **beneath the surface** of an object is not practical. However, it has been shown that it is not necessary to do this, and that one can use a different approach.

Blender calculates SSS in two steps:

Step 1: At first, the **irradiance, or brightness** of the surface is calculated, from the front side of the object as well as from its back side. This is pretty much the same as in a **normal render**. Ambient Occlusion, Radiosity, the type of Diffuse Shader, the light color, etc. are considered.

Step 2: In the second step, the final image is rendered, however now the **SSS Shader replaces the Diffuse Shader**. Instead of the lamps, the calculated lightmap is used. The brightness of a surface point is the calculated "**Average**" of the brightness of its surrounding points. Depending on your settings the whole surface may be considered, and it is a bit more complicated than simply calculating the average, however do not bother too much with the math behind it.

Instead, let us see what **SSS** does to a **distinct light point**.

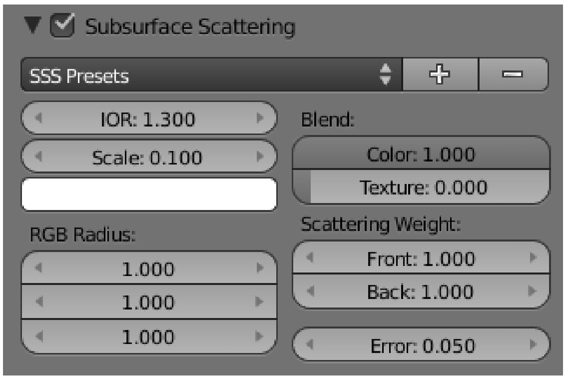
 No SSS.	 Small SSS radius.
 SSS radius enlarged.	 SSS with very large red radius value.

Title- Img 2.33 SSS.

Source-blender.org *Link*-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/subsurface_scattering.html

If you **turn on SSS**, the light is distributed over a **larger area**. The size of this area depends on the **radius values**. Instead of distributing all colors with the same amount, you may choose different radius values for each of the RGB colors. If you use a very large radius value for a color, its light is evenly distributed over the whole object.

Enabling Subsurface Scattering



Title- Img 2. 34 The SSS Panel. SSS is already enabled.

Source-blender.org *Link*-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/subsurface_scattering.html

Step 1: Enable SSS by clicking on the *Subsurface Scattering* button.

Step 2: Accessible at the top are various presets. When you select a preset, the *Radius* values, the *RGB Radius* and the IOR are set for you. The remaining options are not set (because they are mostly dependent on the size of your object).

Subsurface Scattering does **not need ray tracing**. However, since it is dependent on the incident light and shadows, you need proper shadow calculation (which may need ray tracing).

Developing your own SSS Material

The Traditional Approach

A more common however less intuitive approach is to use "layering". This is a simplified version of the layering approach. See the external links for more information:

Step 1:

Set the SSS color on a value of your choice, normally the predominant color of the object. If you want to use different radii for the colors, do not make it too dark.

Step 2:

Set the scale factor. If you want to see much translucency you need small objects or large scale values.

Step 3:

Set the radius values.

Step 4:

Adjust the brightness with the *Front* and *Back* values.

A more intuitive approach

Step 1

Set the Scattering color to 0.5

Step 2

Set the Front weight to 2.0

Step 3

Set the scale factor based on the size of your object relative to the scene. If you want to see much translucency you need small objects or large scale values.

Step 4

Set the radius values appropriately.

Examples

Skin

				
Scale: 1.	Scale: 2.	Scale: 3.	Scale: 4.	Scale: 5.

Title-Img 2.35 Increasing SSS scale (blend-file)

Source-blender.org *Link*-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/subsurface_scattering.html

Strands

The **Strand** section of the Material tab is specific to the **rendering of Hair particles**. There are two different strand methods available:

Polygon strands

This is the **default (old) method**. The strands are rendered as **flat polygons**. The number of polygons depend on the ***Steps*** settings in the ***Particles system*** tab.

Strand Primitive

You activate Strand Primitive with the button ***Strand render* in the *Render* panel** of the particle system. The hair curves are not stored as polygons; only the key points are stored, which are then converted to polygons on the fly. A second difference is the **way transparency works**. Rather than rendering using the existing system, all strand segments in a part are sorted front to back and rendered in that order.

Polygon strands

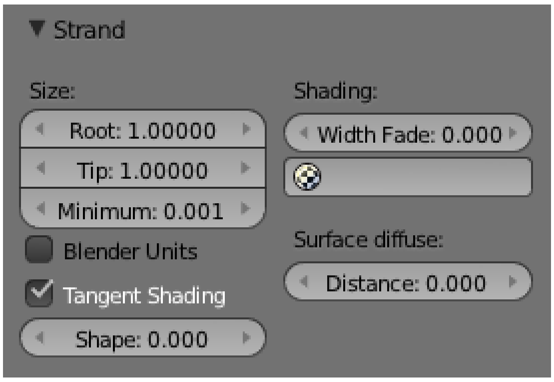
- Work well with greater width, so you can use them as an **alternative to billboards** because the strands may have an **animated shape**.
- Can be textured with a **UV-Texture** along the strands.
- Are seen by **ray tracing**.

Strand Primitives

Are more memory efficient and faster, to make rendering of large amounts of **fur and grass** possible. For good performance, the **render steps button should be lowered** (e.g.2 should be good enough fur), since the result will be a smoothed curve anyway. You need 1 to 2 render steps less than steps in the 3D View. Also, using more render parts helps to **reduce memory usage.**

- Have a distance of **vision reduction** (in the *Render* panel under *Child Simplification*) for children from faces.
- May be faded out towards the tip without an additional texture.
- Are not ray traced. So, they are not visible through ray- transparent Materials or in a ray mirror (you can use ***Environment Mapping*** for that).
- Have **shape problems** if they are rendered with a **greater width**.
- Cannot carry a **UV-Texture** along the strand.

Strands Shading



Title- Img 2.36 Strands Panel.

Root Tip

Source-blender.org *Link*-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/subsurface_scattering.html

Strands are rendered with the Material of the **underlying face/vertex**, including shading with a UV-Texture. Since you can assign more than one Material to each face, each particle system may have its own Material and the Material of the underlying face can be different from the Material of the strands.

Additionally, strands can be shaded along the strand (**from root to tip**) with a **mono-dimensional texture**; only **polygon strands can carry a two-dimensional UV-Texture**.

Options:

The options for strand shading are in the *Strands* section of the *Material* tab. *(Refer* Img 2.37*)*

Width of the hair at the root. Width of 42the hair at the tip.

Minimum

This is the minimum thickness (in pixels) of the strands. Strands below that size are not rendered smaller, however are faded to alpha (well, the fading works only for strand primitives). This gives a **much better rendering** result for **thin hair**.

Blender Units

Normally strands are **quite thin**; the thickness is given in screen pixels. If you use **Blender Units (BU)** you may set the **root value up to 2 BU**, and the **tip value up to 1 BU.** You have to consider the overall object size, because the smallest possible size is 0.001 BU. So if you use 1 BU for 1 meter the smallest possible size would be **1 mm (too thick for thin hair).**

Use Tangent Shading

Calculates the light as if the strands were **very thin and round**. This makes the hair appear **brighter and shinier**. Disabling the "**Tangent Shading**" option will still render nicely, however resembles more solid strands, as though made of metal or wood.

Shape Slider

This slider allows you **to control the interpolation**. Default (**0.0**) is a linear interpolation between ***Root* and *Tip***. A negative value will make the strand narrower (spiky), a positive value will make it fatter.

Title- Img 2. 37 Various Shape settings. From left to right, 0 (root and tip are equal in the first), 0, -0.4, -0.9, 0.4, 0.9.

Source-blender.org *Link*-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/strands.html

Width Fade

To fade out along the width of the strand. This works only for **Strand Primitives**. 0.0 is no fading at all, 1.0 linear fading out.

UV Layer

You can texture **polygon strands with a UV-Texture**. Fill in the name of the UV-Set (not the texture) here. You also must load the texture in the **Texture tab** and **Material tab** (Mapping: UV) you may use every Influence setting you like – especially the alpha value;

Refer Img 2.38 **->**From left to right, 0 (root and tip are equal in the first), 0, -0.4, -0.9, 0.4, 0.9.).

Surface Diffuse

Computes the strand normal, taking the normal at the surface into account. This eases the **coloring and lighting of hair** a lot, especially for **Strand Primitives**. Essentially hair reacts similar to ordinary surfaces and do not show exaggerated strong and large Specular highlights.

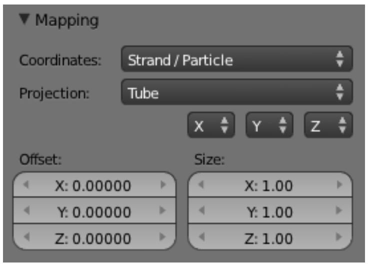
Distance

The distance in Blender Units over which to blend in the normal at the surface (if you want to use *Surface Diffuse* only for **Grass/Fur** at greater distances).

Texturing along the Strand

Strands can be textured along the strand, i.e. from root to tip. To do that you must select ***Strand/Particle*** in the ***Coordinates* select menu** in the *Mapping* panel of the *Material* tab.

Pretty much the most important setting is shown in **Image 2.39 ->**Fading a strand to alpha. How to fade the tip of a strand to alpha to make nice, fuzzy-looking hair. Normally you would use a **linear blend** texture for this.



Fading a strand to alpha.

The render result.

Title- Img 2. 38Texturing along the strand

Source-blender.org Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/strands.html

You may of course set any attribute you like, **especially color**. Be careful with Specularity; hairs tend to get too shiny.

Strand Render Simplification

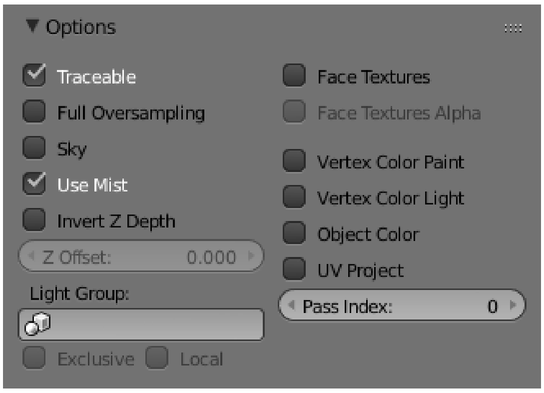
If you use **Strand Primitives** (*Strand render* button) and haveactivated ***Interpolated Children***, the *Child Simplification* option appears. The strand render has options to remove child strands as the object's faces become smaller.

Title- Img 2. 39 Strand render child simplification.

Source-blender.org Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/strands.html

Material Options Panel



Title- Img 2. 40 Material Options panel

Source-blender.org Link-

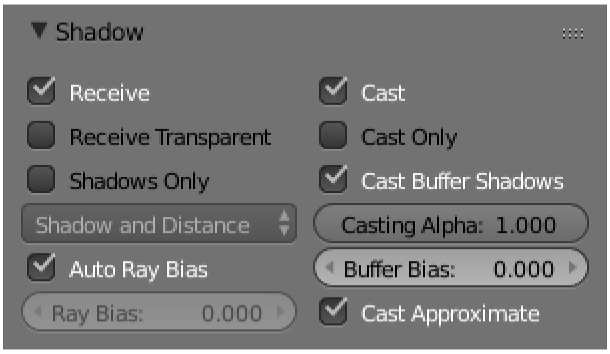
https://docs.blender.org/manual/en/dev/render/blender_render/materials/p roperties/options.html

Shadows Panel

This panel provides a series of control options concerning how **objects using this Material** will appear in the rendered image. All controls are set default to **"Off"** unless otherwise stated.

The Shadows that appear in a scene are affected by a combination of the **layout** of objects, **the shape** of the objects, the **Materials** of the objects, and the **lighting**. In Blender, the **Display Mode** (Single Texture, Multitexture, or GLSL) also affects the appearance of shadows.

Title- Img 2. 41 Shadow Panel.

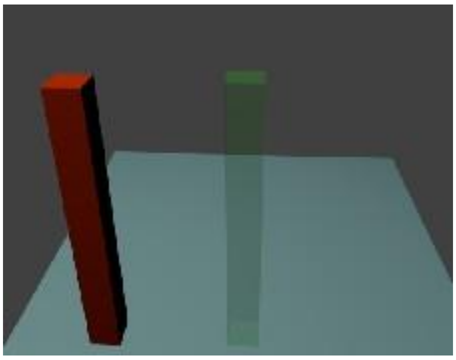


Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/shadows.html?highlight=shadows%20panel

The Shadow panel in the *Materials Properties editor**(Refer** Img 2.42***)*** controls the effects that the Material can have on the shadows that appear in the scene. The various properties are described in the sections below.



Title- Img 2. 42 Scene with all shadow properties off.

Source-blender.org Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/shadows.html?highlight=shadows%20panel

Options

The following properties can be set for each individual Material with which objects in the **scene are shaded**. The effects are illustrated with rendered images for a simple scene (**Refer** Img 2.43) consisting of two “posts”, one with red (totally non-transparent) Material one with green (partially transparent) Material **set up on a light blue plane to receive the shadows.** The illustrations were all taken in **Blender Render engine**, with Multitexture mode.

Shadow Receiving Object Material

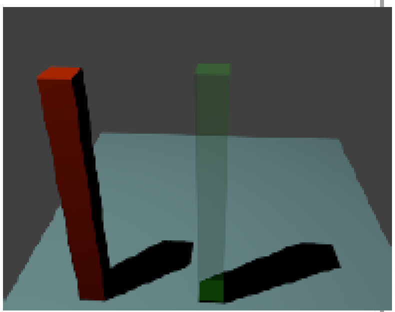
The following options affect the Material that receives shadows:

Receive

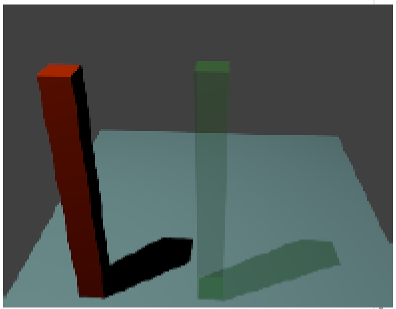
Allows this Material to receive **full-intensity shadows** (Refer Img 2.44 Plane with Receive.).

Receive Transparent

Allows this Material to receive shadows whose intensity is modified by the transparency and color of the shadow-casting object (Refer Img 2.44 Plane with Receive and Receive Transparency.).



Plane with Receive.



Plane with Receive and Receive Transparency.

Title- Img 2. 43Shadow receiving object material

Source-blender.org Link- *https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/shadows.html?highlight=shadows%20panel*

Shadow Casting Object Material

The following options affect the Material that casts shadows:

Cast Only

Causes objects with the Material to only cast a shadow, and not appear in renders. *(Refer* Img 2.45 - *Posts with Cast Only.).*

Casting Alpha

Sets the Alpha of shadow casting. Used for **irregular and deep** shadow buffering.

Shadows Only

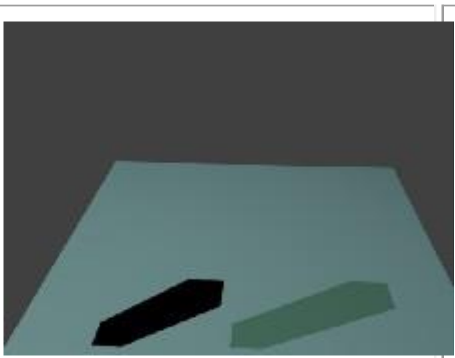
Renders shadows as Materials alpha value, making Materials transparent, except for areas where it receives shadows from other objects, and it retains its own transparency *(Refer* Img

2.45 - *Posts with Shadows Only)*. Note the faint image of the partly- transparent post.

Shadow Only Type

Set the type of shadows used when Shadows only is enabled.

- Shadow and Distance
- Shadow Only
- Shadows and Shading



Posts with Cast Only.

Posts with Shadows Only.

Title- Img 2. 44 Shadow & cast

Source-blender.org Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/properties/shadows.html?highlight=shadows%20pane

Buffered Shadow Options

In addition to the shadow options described above, there are further Material properties which control buffered shadow features. See Section On-Spot Buffered Shadows for further discussion of these techniques.

Unit summary

In this Unit, we have learnt what is the Material and how to

- Use Shaders, Colors
- Preview those Shaders with Specular and Ramps in your Material editor
- Edit the Properties of the Shaders
- Work on Transparency settings to create Reflection and Refractions using Index tables to create Mirrors and Glasses
- Work on Subsurface Scattering which helps the objects to create scattering of lights and shadows within the objects.

After learning of this Unit, you can download the Open Source Software available on the internet for free of cost to practice the possibilities of creating Materials.

Assignment

Create a Simple Living Room with few objects like Chairs, Tables, Flower Vases, Metal Objects, Papers/Files/Books, Glasses etc., and assign Shaders to the scene. Use Index of Refraction table https://en.wikipedia.org/wiki/List_of_refractive_indices

Use these key words ***"living room"***, ***"3d Shaders"*** *on* https://www.google.com *to collect the reference images to build your shading scenes.*

Assessment

- Define Diffuse Shader
- Differentiate between Lambert Shader and Toon Shader
- Write notes about Specular Shaders with Illustrations
- Explain the Process of making a Glass Shader
- List the IOR values of any 5 common Materials based on Liquids, Transparent Materials, Opaque Materials, Gemstones and Metals
- Write notes about Subsurface Scattering and its usage in the real-time situations
- Describe the use of Strands Shader
- Define Shadows in 3D Mode

Resources

While studying this course, you can browse the internet links for video tutorials and to download the relevant texture maps to assign on the objects that you have created and use the same for your assignments.

- wiki.blender.org
- archive.org
- www.blender.org
- docs.blender.org

Unit 3 Shading Organic Models

Introduction

Our eyes have been trained to believe that **an image is real** if it shows **Artifacts** that result from the **Mechanical Process** of photography.

Three examples of these **Artifacts** are

1. **Motion Blur**
2. **Depth of Field**
3. **Lens Flares**

We will learn about Motion Blur and Depth of Field in the next Unit 04**.**

We will learn about **Lens Flares** in this Unit, which can be produced with special **Materials and Shader**. A simulated lens flare tells the viewer that **the image was created with a camera**, which makes the viewer think that it is **authentic**.

Many things can happen to the light as it passes through the volume, which will influence the final color that arrives at the camera. This represents physical interactions that happen in the real world. Most of these are dependent on the **density of the volume**, which can either be a **constant density** throughout, or **varied, controlled** by a texture.

It is by controlling the density that one can get the **typical 'Volumetric' Effects** such as **clouds or thick smoke or fire** using **Volume Rendering**.

Outcomes

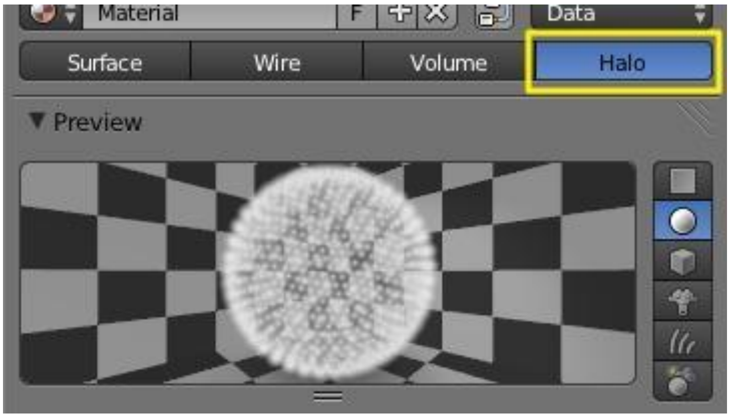
Upon completion of this unit you will be able to:

- Create **Special Effects** for your 3D Scenes using the Materials and Shaders;
- Identify the different type of Material effects available in Blender to create **Authentic Photo Effects**;
- Create **Volume Renders** for light that passes through Materials;
- Create **Fire and Fog Effects**
- Design various styles of rendering using Special Materials and Shaders

Terminology

Alpha:	This is the Transparency information of the Shader.
Diffuse Color:	The color of the Halo itself.
Size:	Sets the dimension of the Halo.
Seed:	If non-zero, it will randomize the ring dimension and line location. To use, give any (integer) number to start the random-number generator.
Hardness:	Sets the hardness of the Halo. Like specular hardness
Vertex Normal:	Use the vertex normal to specify the dimension of the Halo.

Halo Rendering



Title- Img3.1 Activating Halo rendering.

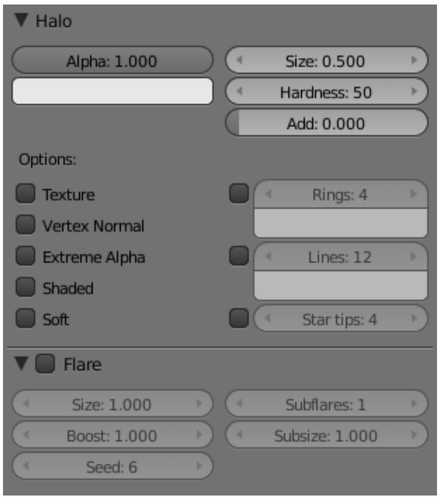
Source-blender.org Link-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/halo.html?highlight=activating%20halo%20rendering

Halo Material renders each object's points as glowing dots or some little clouds of light. Although they are not really lights, because they do not cast light into the scene like a lamp. These are called Halos because you can see them, however, they do not have any substance.

Halos are rendered with **Vertex Shaders** and not with **Face Shaders**.

This Material is useful for simulating special effects, like **Particle effects** or **Lens Flares.**

Options



Title- Img 3. 2 Halo panels.

Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/halo.html?highlight=activating%20halo%20rendering

To enable *Halos*, **Step 1:** Press the ***Halo* button** in the ***Material* menu**'s top panel. As you would see in the 3D View, the **Mesh faces** are no longer rendered. Instead just the **Vertex** is rendered, since that is where each Halo will originate. Halos can be **hard to find** in a crowded scene, so name it well for easy location in the outliner. In the roperties Editors, we normally find the ***Diffuse, Specular,*** and ***Shading* panels**. Now, we see Panels relative to the *Halo* characteristics:

Halo Panel

Alpha	The transparency.
Diffuse Color	The color of the Halo itself.
Seed	If non-zero, it randomizes the ring dimension and line location. To use, give any (integer) number to start the random-number generator.
Size	Sets the dimension of the Halo
Hardness	Sets the hardness of the Halo. Like specular hardness
Add	Determine how much the Halo colors are 'added to', rather than mixed with, the colors of the objects behind and together with other Halos. **By increasing Add**, the Halo will appear to **light up objects** that move behind it or through the Halo field. (Refer Img 3.3)

Title- Img 3. 3 Effect of Add. Source-blender.org

Link-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/halo.html?highlight=activating%20halo%20rendering

Texture	Gives Halo a texture. By default, textures are applied to objects with Object coordinates and reflects on the Halos by affecting their color based on the color of the vertex originating the Halo. Enable this feature to have the texture **take effect *within* the Halo**, and hence to have it with varying colors or transparencies; this will map the whole texture to ***every* Halo**. This technique proves very useful when you want to create a **realistic rain effect** using particle systems, or similar.
Vertex Normal	Use the vertex normal to specify the dimension of the Halo.
Extreme Alpha	Boosts alpha.
Shaded	Let Halo receive light and shadows from external objects. **When shaded** is enabled, the Halo will be affected **by local light**; a lamp will make it brighter and affect its diffuse color and intensity.
Soft	Softens the edges of the Halos at intersections with other geometry. In addition, several other special effects are available. To enable some of these effects, set the number of points/rings, or set the color of each effect individually:

You **cannot use color ramps**. Lines, Rings and an assortment of special effects are available with the relevant toggle buttons, which include Flare, Rings, Lines, Star, Texture, Extreme Alpha, and Shaded. *Halo Variations* shows the result of applying a Halo Material to a single vertex mesh.

Title- Img 3. 4 Halo Variations

Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/halo.html?highlight=activating%20halo%20rendering

Flare Panel	Enabling Flare Renders the Halo as a lens flare.
Size	Sets the factor by which the flare is larger than the Halo.
Boost	Give the flare extra strength.
Seed	Specifies an offset in the flare seed table.
Subflares	Sets the number of subflares.
Subsize	Sets the dimensions of the subflares, dots, and circles.

Lens Flares

Our eyes have been trained to believe that **an image is real** if it shows **Artifacts** that result from the **Mechanical Process** of photography.

Three examples of these **Artifacts** are

1. **Motion Blur**
2. **Depth of Field**
3. **Lens Flares**

We will learn about Motion Blur and Depth of Field in the next Unit 04.

Now, we learn about **Lens Flares** in this Unit, which can be produced with special **Materials and Shader**. A simulated lens flare tells the viewer that **the image was created with a camera**, which makes the viewer think that it is **authentic**.

We create **Lens Flares** in Blender from a mesh object using first **the *Halo* button** and then the ***Flare* options** in the ***Shaders* Panel** of the Material settings. Try turning on ***Rings* and *Lines***, however, keep the colors for these settings fairly subtle. Play with the *Flares:* number and *Fl. seed:* settings until you arrive at something that is pleasing to the eye. You might need to play with *Boost:* for a stronger effect.

Note that this tool does not simulate the physics of photons traveling through a glass lens; it's just **an eye candy**.

Blender's Lens Flare looks nice in motion, and disappears when another object occludes the **flare mesh**.

Title- Img 3. 4Lens Flare. Source-blender.org

Link-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/halo.html?highlight=activating%20halo%20rendering

Halo Texturing

By default, textures are applied to objects with **Object coordinates** and reflects on the Halos by affecting their color, as a whole, on the basis of the color of the vertex originating the Halo. To have the texture take effect *within* the Halo, and hence to have it with varying colors or transparencies press **the *Texture* button**; this will map the whole texture to ***every* Halo**. This technique proves very useful when you want to create a **realistic rain** effect using particle systems, or similar.

Another Option is **Shaded**. When shaded is enabled, the Halo will be affect by local light; a lamp will make it brighter and affect its diffuse color and intensity.

Examples

Dot-Matrix Display

Let us use a Halo Material to create a dot-matrix display:

Step 1: To begin, add a grid with the dimensions **32×16**. Then add a camera and adjust your scene so that you have a nice view of the billboard.

Step 2: Use a 2D image program to create some red text on a black background, using a simple and bold font, you can just save the picture on your hard drive as Dot-matrix image texture and show an image 512 pixels wide by 64 pixels high, with some black space at both sides.

Title- Img 3. 5Dot matrix image texture. Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/halo.html?highlight=activating%20halo%20rendering

Step 3: Add a Material for the billboard, and set it to the type *Halo*. Set the ***Halo Size*** **to 0.06** and when you render the scene you should see a grid of white spots.

Step 4: Add a Texture, then change to the Texture Buttons and make it an image texture. When you load your picture, and render again you should see some **red tinted dots** in the grid. *(Refer* Img 3.6*)*

Step 5: Return to the Material Buttons and adjust the ***size X***

parameter to about 0.5 then render again; the text should now be centered on the Billboard.

Step 6: To remove the white dots, adjust the Material color to a **dark red** and render. You should now have **only red dots**; however, the billboard is still too dark. To fix this enter ***Edit Mode*** for the board and copy all vertices using the **Shift-D** shortcut (take care not to move them!). Then adjust the brightness with the *Add* value in the Halo panel. *(Refer* Img 3.7*)*

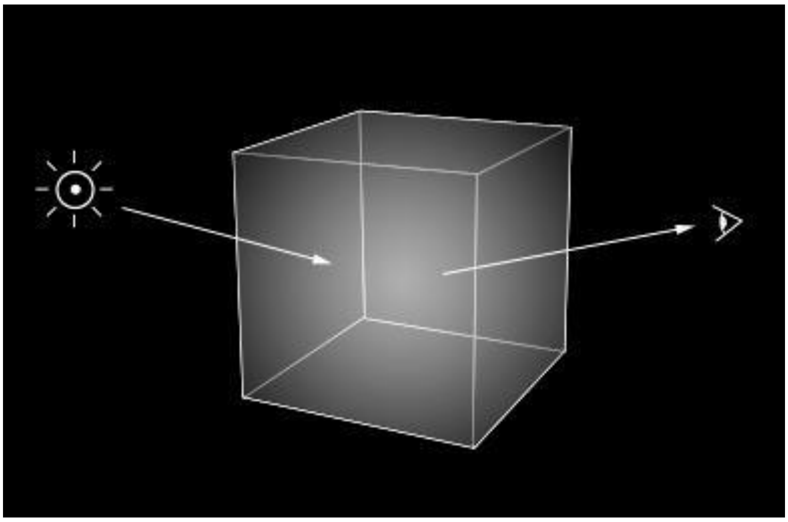
Title- Img 3. 6Dot Matrix display

Source-blender.org Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/halo.html?highlight=activating%20halo%20rendering

You can now animate the texture to move over the billboard, using the ***Offset X* value** in the *Texture* tab of the Mapping panel. (You could use a higher resolution for the grid, however, if you do you must adjust the size of the Halos by shrinking them, or they will overlap. *(Refer* Img 3.7 *Dot Matrix display).*

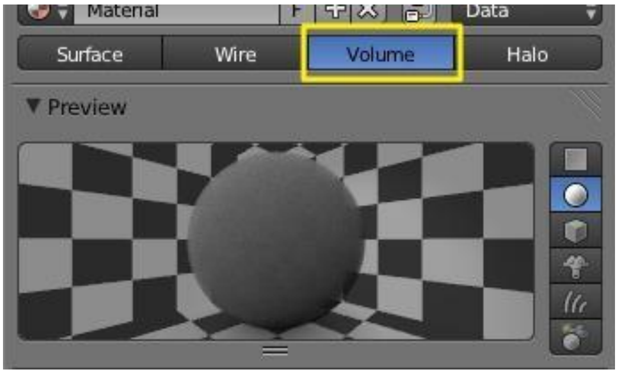
Volume Rendering



Title- Img 3. 7Activation volume rendering.

Source-blender.org Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering



Title- Img 3. 8Volume rendering.

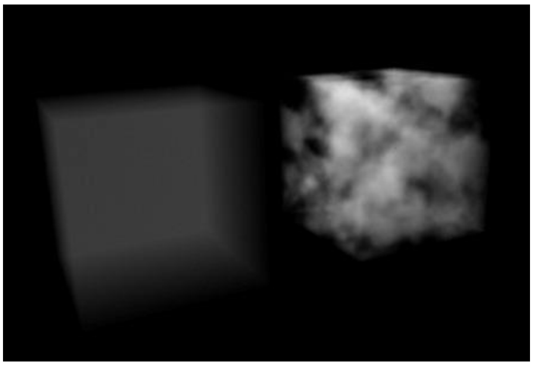
Source-blender.org Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering

Volume Rendering is a method for rendering light as it passes through participating media, within a 3D region. The implementation in Blender a **physically based model**, which represents the various interactions of light in a volume relatively realistically.

Rendering a volume is different than **Solid Render**. For volume light enters a 3D region of space (defined as the volume) that may be filled with small particles, such as **smoke, mist or clouds.** The light bounces around off the various molecules, being scattered or absorbed, until some light passes through the volume and reaches the camera. For that volume to be visible, the renderer must figure out how much Material the light has passed through and how it has acted and reacted within that volume, the volume object needs to contain a 3D region of space, **for example** a manifold closed mesh, such as a cube, not just a flat surface like a plane. To get an image, the renderer must step through that region, and see how much 'stuff' is there (density) to see how light is absorbed or scattered or whatever. This can be a **time-consuming process** since it must check a lot of points in space and evaluate the density at each.

Options



Title- Img 3. 9 Constant density vs textured density. Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activati on%20volume%20rendering

Many things can happen to the light as it passes through the volume, which will influence the **final color** that arrives at the camera. These represent physical interactions that happen in the real world, and most of these are **dependent on the density** of the volume, which can either be a constant density throughout, or varied, controlled by a texture. It is by controlling the density that one can get the typical **'volumetric' effects** such as **clouds or thick smoke.**

Density

The base density of the Material. Other densities from textures are added on top.

Density Scale

A global multiplier to increase or decrease the apparent density. This can be useful for getting consistent results across different scene scales.

Shading

Title- Img 3. 10 Spot lamp scattering in a constant volume.

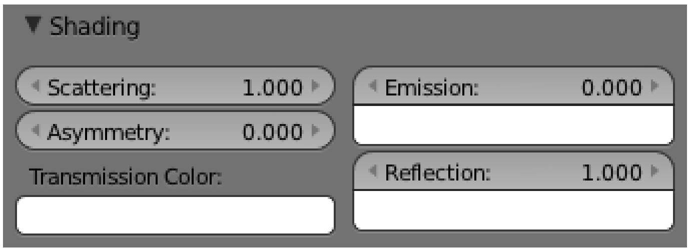
Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activati on%20volume%20rendering

When light enters a volume from an external source, it does not just **pass straight** through. Light gets scattered off tiny particles in the volume, and some proportion of that light reaches the camera. This property makes it possible to **see light beams** as they travel though a volume and are scattered towards the eye.

Options



Title- Img 3. 11 Shading options.

Source-blender.org

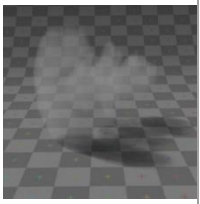
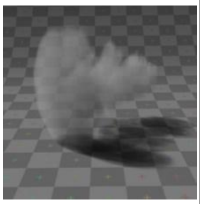
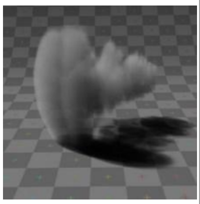
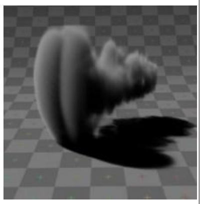
Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering

Scattering

The amount of light that is scattered out of the volume. The **more light** that is scattered out of the volume, the **less it will penetrate** through the rest of the volume. Raising this parameter can have the effect of making the volume seem denser, as the light is scattered out quickly at the '**surface' of the volume**, leaving the areas internal to the volume darker, as the light does not reach it.

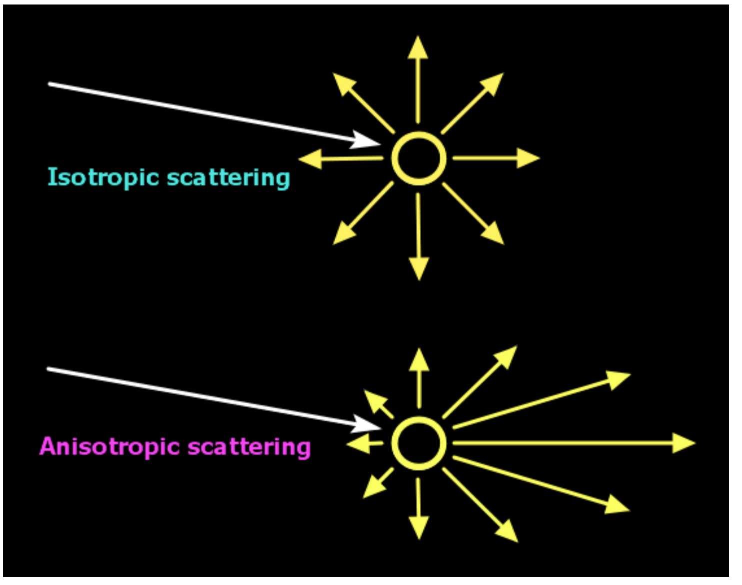
Note in the examples below, the **less light** that is scattered out of the volume, **the more easily it penetrates** throughout the volume and to the shadow.

 Scattering: 0.5.	 Scattering: 1.0.	 Scattering: 2.0.	 Scattering: 5.0.

Title- Img 3. 12 Scattering Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering



Title- Img 3. 13 Isotropic and Anisotropic scattering.

Source-blender.org Link-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering

Types of Scattering

- The default method for scattering light in a volume is for the light to be deflected **evenly in all directions**, also known as **Isotropic scattering**.
- In real life, different types of media can scatter light in **different angular directions**, known as **Anisotropic scattering.**
- **Back-scattering** means that light is scattered more towards the incoming light direction.
- **Forward-scattering** means it is scattered along the same direction as the light is traveling.

Asymmetry

Asymmetry controls the range **between** back-scattering **(-1.0)** and forward-scattering **(1.0).** The default **value of 0.0** gives Isotropic scattering (even in all directions).

Transmission

Transmission is a general term for light that is transmitted throughout a volume.

This transmitted light can be the result of various interactions, for example:

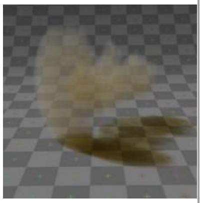
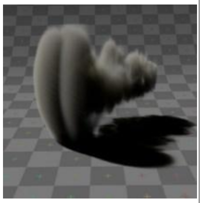
- the left-over result of incoming light after it has reflected/scattered out of the volume
- the left-over result of light after being absorbed by the volume (and converted to heat)

Here, the transmission color is used to set the result color that light becomes after it is transmitted through the volume.

Transmission Color

The resultant color of light that is transmitted through the volume.

Note in the examples below, as **more light** is scattered out of the volume, there is **less available to be transmitted** through.

			
Transmission color: Yellow, Scattering: 0.5.	*Transmission color: Yellow, Scattering: 1.0.*	*Transmission color: Yellow, Scattering: 2.0.*	*Transmission color: Yellow, Scattering: 5.0.*

Title- Img 3. 14 Transmission of color. Source-blender.org

Link-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering

- ***Emission***

  Some volumes can emit light where there was none before, via chemical or thermal processes, such as fire. This light is generated from the volume itself and is independent of light coming from external sources.

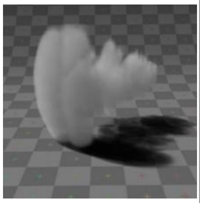
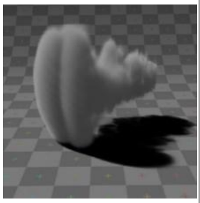
  Currently, this emitted light does not affect other volumes or surfaces (like surface Material type, ‘Emit’ option).

- ***Emission Color***

The color of light that is emitted by the volume.

Emission

An intensity multiplier for the emitted color, for scaling up and down.

			
Emission 0.25, Scattering: 0.5.	*Emission 0.25, Scattering: 1.0.*	*Emission 0.25, Scattering: 2.0.*	*Emission 0.25, Scattering: 5.0.*

Title- Img 3. 15 Emission

Source-blender.org Link-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering

Reflection

The ***Reflection*** parameters can be used **to tint or scale the light** that is scattered out of the volume. This **affects only the light** that has come from lamps and been scattered out, it does **not affect the color** of transmitted or emitted light and is.

These settings are not physically correct, because they **do not conserve energy**. This means the light scattering out does not affect the remaining light, that is transmitted throughout the rest of the volume.

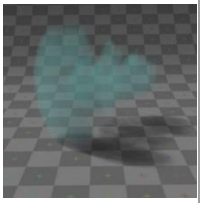
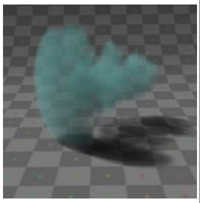
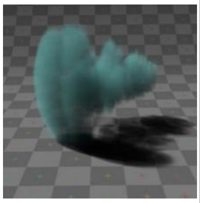
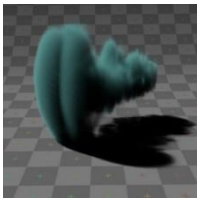
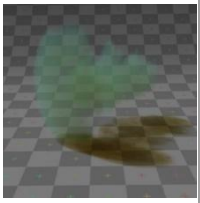
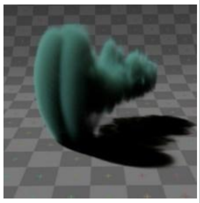
For example, if the orange components of the light are scattered out of the volume towards the camera, only the inverse of that (blue) will remain to continue penetrating through the volume,causing the volume to take on a multi-colored appearance, which can be difficult to use. To make it a bit easier to **plainly set the color of the volume**, you can use the **reflection parameters** to quickly set an overall tint.

- **Reflection Color**

The color of light that is scattered out of the volume.

- **Reflection**

  An intensity multiplier for the reflection, for scaling up and down.

 *Reflection: Green, Scattering: 0.5.*	 *Reflection: Green, Scattering: 1.0.*	 *Reflection: Green, Scattering: 2.0.*	 *Reflection: Green, Scattering: 5.0.*
 *Reflection: Green, Transmission: Yellow,*	 *Reflection: Green, Transmission: Yellow,*	 *Reflection: Green, Transmission: Yellow,*	 *Reflection: Green, Transmission: Yellow,*
Scattering: 0.5.	*Scattering: 1.0.*	*Scattering: 2.0.*	*Scattering: 5.0.*

Title- Img 3. 16 Reflection

Source-blender.org Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering

Lighting

Title- Img 3.17 Lighting options. Source-blender.org

Lighting Mode

Shadeless	Shadeless is the simplest, useful for thin, wispy mist or steam.
Shadowed	Shadowed is similar, however, with shadows of external objects.
Shaded	Shaded uses a volumetric single-scattering method, for self-shading the volume as light penetrates through.
Multiple Scattering	Allows multiple scatter calculations.
Shaded + Multiple Scattering	Combines Shaded and Multiple Scattering functionality.

Shaded Options

External Shadows	Receive shadows from sources outside the volume (temporary).
Light Cache	Pre-calculate the shading information into a voxel grid, speeds up shading at slightly less accuracy.
Resolution	Resolution of the voxel grid, low resolutions are faster, high resolutions use more memory.

Multiple Scattering Options

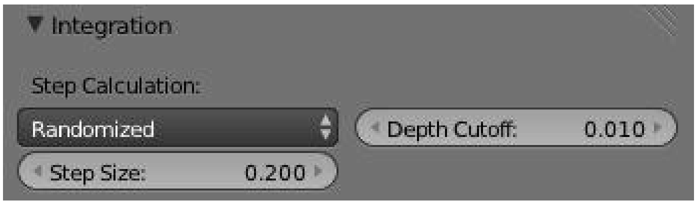
Diffusion	Diffusion factor, the strength of the blurring effect.
Spread	Proportional distance over which the light is diffused.
Intensity	Multiplier for multiple scattered light energy.
Transparency	The transparency settings are the same as Solid Render except you have less settings. For volume rendering you only have:

- Mask
- Z Transparency
- Raytrace

Link-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering

Several **shading modes** are available, providing a range of options between fast to render and physically accurate.

Integration



Title- Img 3. 18 Integration options. Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering

Step Calculation Method	Method of calculating the step through the volume.
Randomized	Randomized method of calculating the step.
Constant	Constant method of calculating the step.
Step Size	Distance between subsequent volume depth samples. Step Sizes determine how noisy the volume is. Higher values result in lower render times and higher noise.
Depth Cutoff	Stop ray marching early if transmission drops below this luminance threshold. Higher values will give a speedup in dense volumes at the expense of accuracy.

Options

Title- Img 3. 19Material volume options.

Source-blender.org Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering

- **Traceable**

Allow this Material to **calculate ray tracing**.

- **Full Oversample**

  Force this Material to render **full shading/textures** for all anti-aliasing samples.

- **Use Mist**

  Use mist with this Material (in world settings).

- **Light Group**

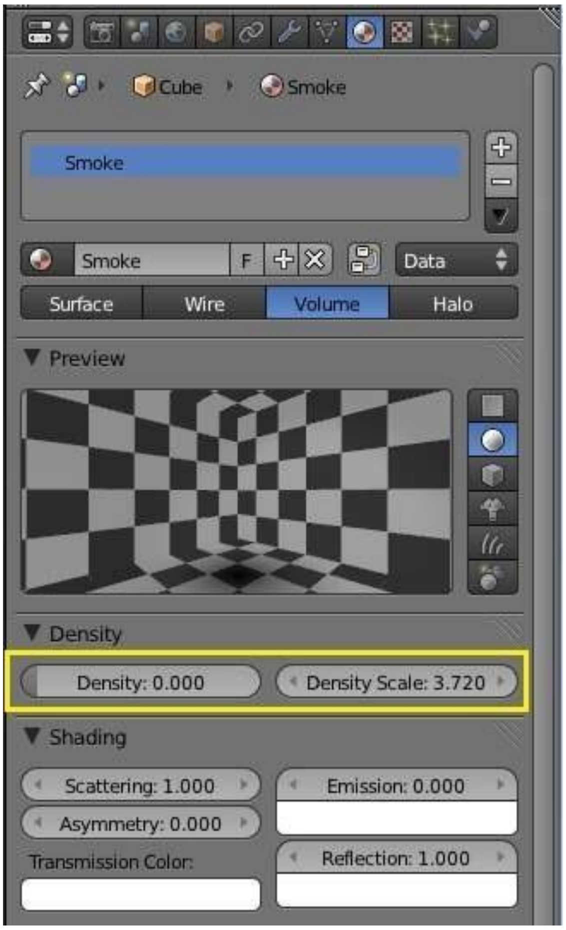
  Limit lighting of this Material to lamps in this group.

- **Exclusive**

  Material uses this group exclusively. Lamps are excluded from other scene lighting.

Smoke and Fire

Create the Material The Material must be a **Volumetric Material** with a **Density of 0**, and a **high-Density** Scale.



Title- Img 3. 20The Material Settings.

Source-blender.org Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering

Smoke requires a **complex Material** to render correctly.

Step 1: Select the big cube

Step 2: Go to the Material tab.

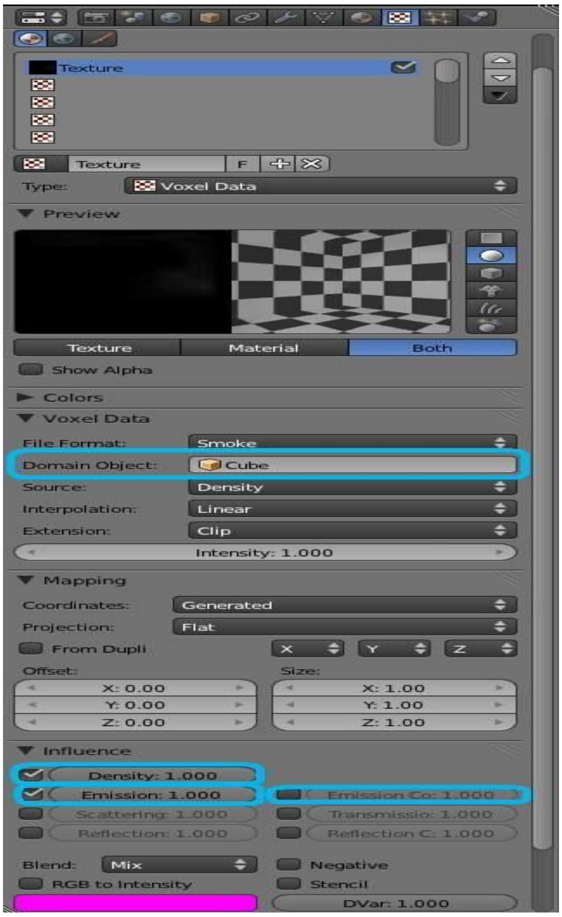
Step 3: Change the Material to ‘Volume’ S

Step 4: Set the density to 0. If you set the density to values bigger than 0 the domain cube will be filled with the volume Material.

The other settings will affect the smoke, though. We’ll cover those later.

Add the Texture

In addition, Smoke requires its **own texture**, you can use a **Volumetric Texture** known as **Voxel Data**. You must remember to set the domain object and change the influence.



Title- Img 3. 21The texture settings.Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering

Step 1: Go to the *Texture tab*

Step 2: Change the *Type* to *VoxelData*.

Step 3: Under the *Voxel Data-Settings*, set the *Domain Object* to our *domain cube* (it should be listed just as ‘Cube’ since we are using Blender’s default cube.

Step 4: Under *Influence* check ‘*Density*’ and leave it *at1.000* (Emission should be automatically checked, too).

Now you should be able to render single frame. You can choose to color your smoke as well, by turning ***Emission Color* back on**.

Title- Img 3. 22Finished Result.

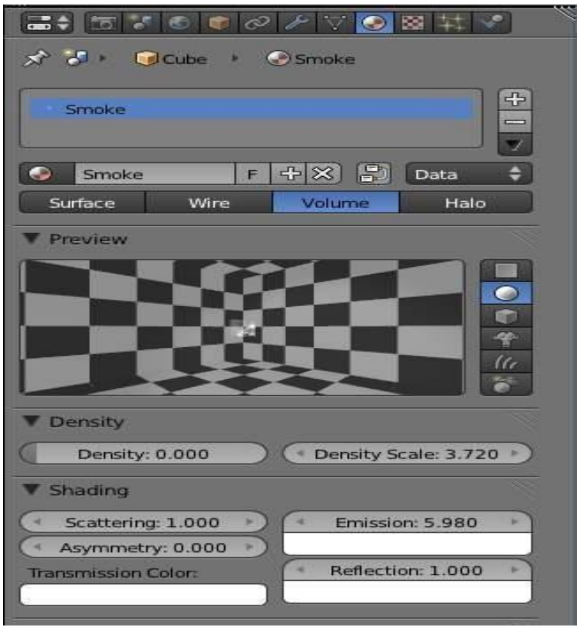
Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering

Smoke Simulator with fire texture

You can also **turn your smoke into fire** with another texture!



Title- Img 3. 23 The Fire Material.

Source-blender.org Link-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering

To make fire,

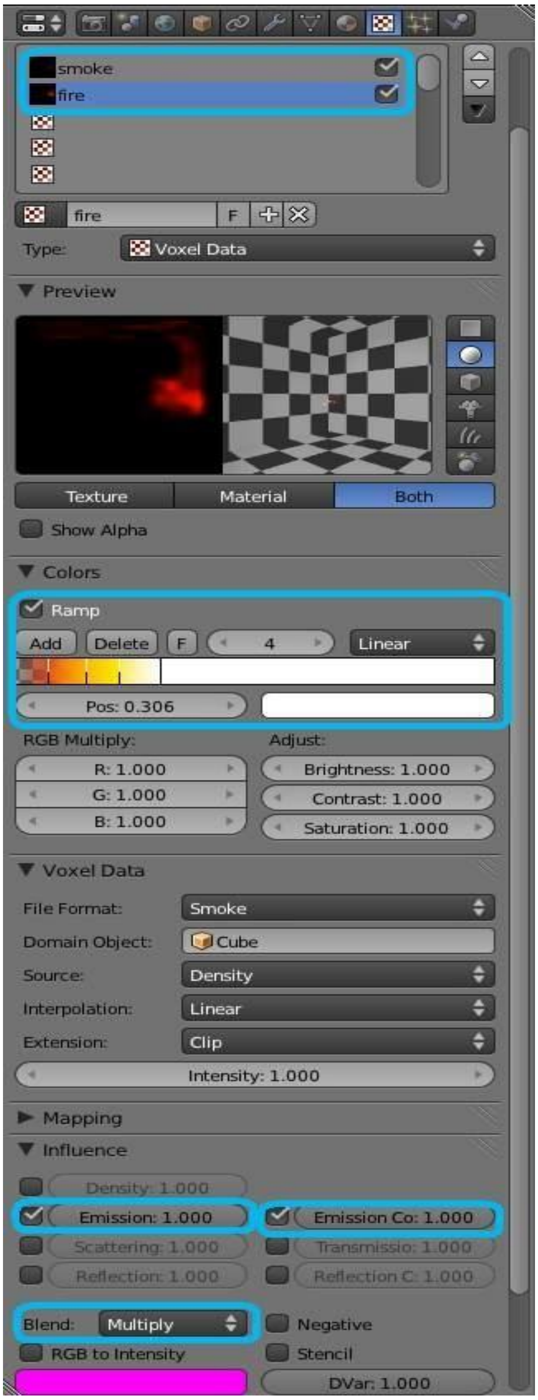
Step 1: Turn up the **Emission Value** in the **Materials panel**

Step 2: Add another texture (Keep the old texture or the smoke will not show)

Step 3: Give it a fiery color ramp, which colors are based on the alpha

Step 4: Change the influence on Emission and Emission color

Step 5: Change the blend to Multiply

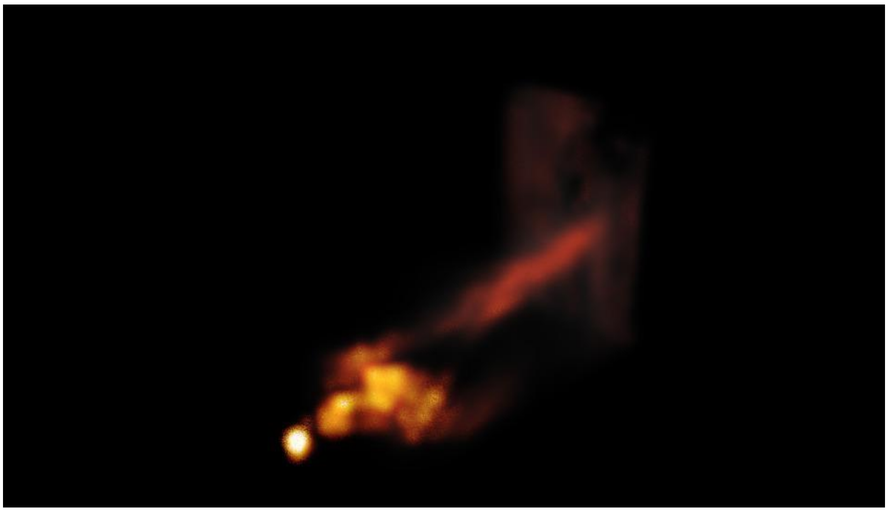


Title- Img 3. 24 The fire texture settings.

Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering



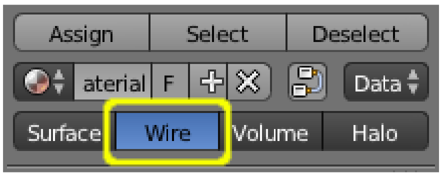
Title- Img 3. 25 The fire render.

Source blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/volume.html?highlight=activation%20volume%20rendering

Wire Render



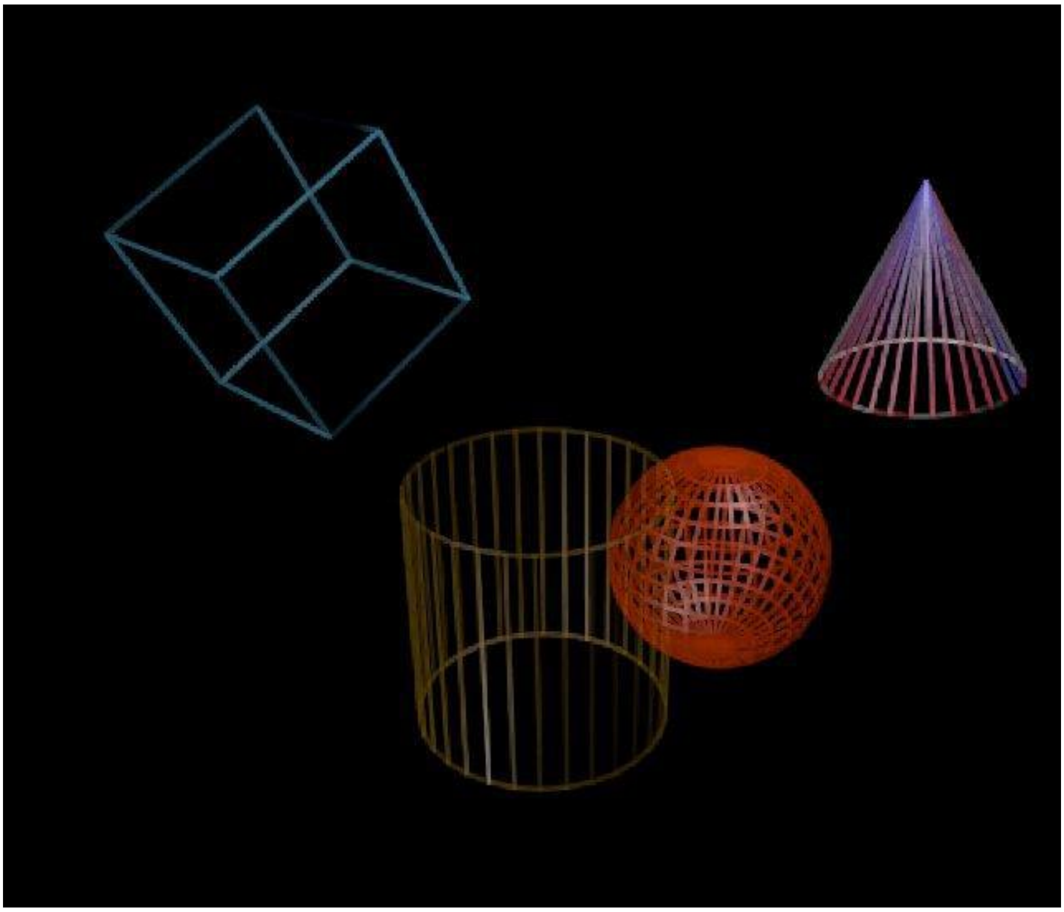
Title-Img 3. 26Wire Render.

Attribution- Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/wire.html?highlight=wire%20render

The Wire Render option in the Materials section provides a way of showing a rendered mage of the edges in an object. Each edge is rendered as a single-pixel image of the edges which make up the mesh. The colors, alpha and other relevant properties of the lines are selected with the same control panels as provided by the Surface rendered image.



Title-Img 3. 27 Wire Render.

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/materials/special_effects/wire.html?highlight=wire%20render

Unit summary

In this Unit, you have learnt how to

- Use **Special Effects Materials**
- Create **Add-on effects** to your 3D Objects like create Glow, Halo, Streaks Lens flare and blurs
- Create **Photorealistic effects** to your 3D Scene, also known as **Post render effects** in many other applications.
- Use **Integrating effects** such as Halo texturing, Volume rendering by using lights
- Create fire, smoke and transparency in your 3D Project
- Create Special render style using Wire Render

After learning of this Unit, you can download the Open Source Software available on the internet for free of cost to practice the possibilities of creating Materials.

Assignment

Create a **Simple Study Room** with few objects like Chair and Study Tables in the corner of the room along with a Table Lamp, few books, pencils, pens beside and assign Normal Shaders and Special Shaders to the scene.

Use these key words **"Study room"**, **"3D Volume light effects"** on https://www.google.com to collect the reference images to build your shading scene.

Assessment

- Write down the steps to create Stars in Halo Effects
- Explain the process of making a Lens Flare
- Describe Halo Textures with examples
- Write the use of Volume Rendering
- Explain Light Scattering in Volume Render
- Explain the process of creating Fire and Smoke using Volume Render
- State how to use Wire Render
- Define Reflection and Refraction in Scattering of Volume Materials.

Resources

While studying this course, you can browse the internet links for video tutorials and to download the relevant texture maps to assign on the objects that you have created and use the same for your assignments.

Links to Download Open Projects

The iconic Blender Institute Open Movies. Featuring all the production files, assets, artwork, and never-seen-before content.

https://cloud.blender.org/open-projects

- wiki.blender.org
- archive.org
- www.blender.org
- docs.blender.org

Unit 4 Textures and Mapping

Introduction

In Computer Graphics Imaginary (CGI), **Texture Mapping** is a method to add detail to surfaces by projecting images and patterns onto those surfaces.

The projected images and patterns can be set to affect **not only color**, however, **also specularity**, **reflection**, **transparency**, and even **fake 3-dimensional depth**. Most often, the images and patterns are projected during render time, however, Texture Mapping is also used to **sculpt, paint** and **deform** objects.

In this Unit, you will learn more about **Textures and Mapping**.

Outcomes

Upon completion of this unit you will be able to:

- Create appropriate Textures for 3D Objects
- List the different type of mapping techniques
- Design various blending modes to mix textures with Shaders
- Create more natural effect using Bump, Normal and Displacement mapping techniques
- Organize the maps for various texture types and Procedural mapping for complex 3D scenes

Terminology

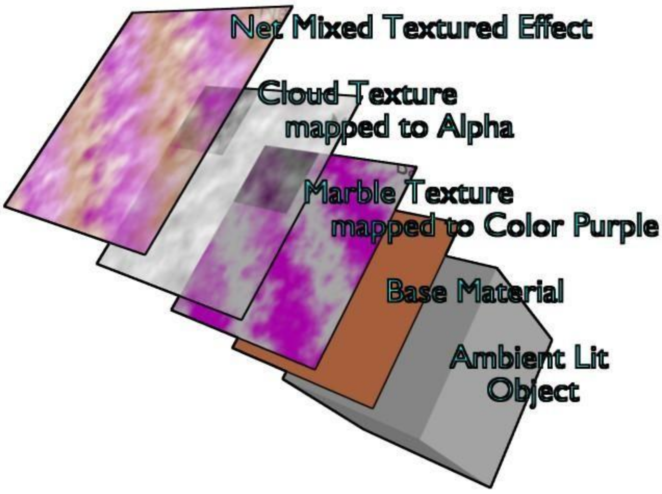
CGI:	Computer Graphics Imaginary
Environment maps:	It take a render of the 3D scene and apply it to a texture, to use for faking reflections.
Hue:	Specifies how the hue rotation of the image. 360° are mapped to (0 to 1). The hue shift of 0 (-180°) and 1 (+180°) have the same result.
Saturation:	A saturation of 0 removes hues from the image, resulting in a grayscale image. A shift greater 1.0 increases saturation.
Value:	Value is the overall brightness of the image. De/Increasing values shift an image darker/lighter.

Factor:	Controls the amount of influence the node exerts on the output image.
Image:	Standard image input.

Properties: The transformations are relative shifts. In the Shader and texture context the following properties are available as input sockets.

Material Textures

The Material settings that you have seen so far produce **smooth, uniform objects**, however, such objects are not particularly true to reality, where uniformity tends to be uncommon and out of place. In order to deal with this unrealistic uniformity, **Blender** allows the user to **apply "textures"** which can modify the reflectivity, specularity, roughness and other surface qualities of a Material.



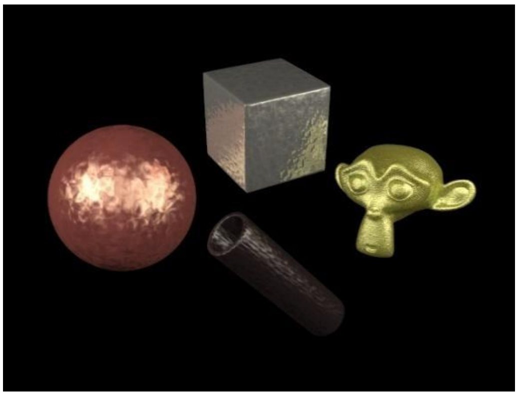
Title-Img 4. 1 Textures Layer on base Material.

Source-blender.org **Link-** https://docs.blender.org/manual/en/dev/render/blender_render/textures/introduction.html?highlight=textures%20layer%20base%20material

Textures are like additional layers on **top of the base Material**. Textures affect one or more aspects of the **Object's Net Coloring**. The net color you see is a sort of layering of effects, as shown in the example image (Refer Img 4. 1). The layers are:

- **Your Object**, lit with ambient light based on your world settings.
- **Your Base Material**, which colors the whole surface in a uniform color that reacts to light, giving different shades of the diffuse, specular, and mirror colors based on the way light passes through and into the surface of the object.

- **A Primary Texture Layer** that overlays a purple marble coloring.
- **A Second Cloud Texture** that makes the surface transparent in a misty/foggy sort of way by affecting the Alpha value.
- These two textures are mixed with the base Material to provide the net effect: a cube of purplish-brown fog. (**Net Mixed Textured Effect**)



Title-Img 4. 2 Some Metal Textures.

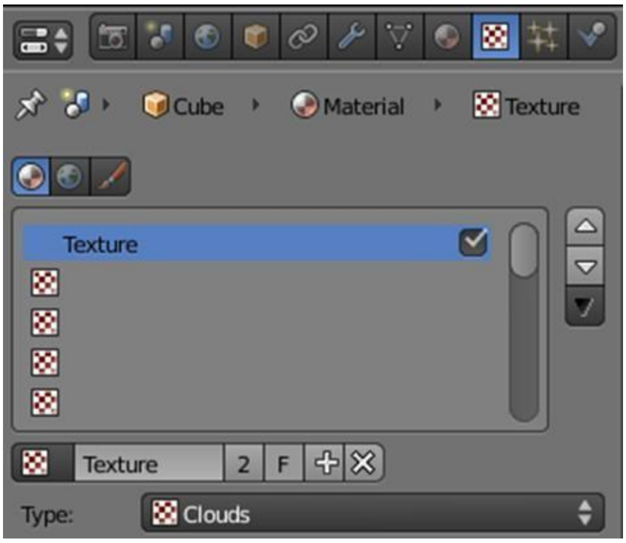
Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/textures/introduction.html?highlight=textures%20layer%20base%20material

This notion of using **more than one texture**, to achieve a combined effect, is one of the **"hidden secrets"** of creating realistic-looking objects. If you carefully "look at the light" while examining any real-life object, you will observe that the final appearance of that object is best described as the combination, in different ways and in different amounts, of several distinct underlying visual characteristics. These characteristics might be more (or less) **strongly apparent** at different angles, under different lighting conditions, and so forth. **Blender allows you to achieve** this in many ways.

You can use "**a stack of texture layers**" as described in this Unit, or you can also use arbitrarily-complex networks of "**texture nodes**" as discussed here.

Texture Panel

In the **Properties Editor**, choose the **Texture Tab**: this will show the **Texture Panel**.



Title-Img 4. 3 Texture Panel.

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/textures/introduction.html?highlight=textures%20layer%20base%20material

Texture Context The radio button selects the texture data type, that is, the kind of texture that is being edited.

World

World Background.

Material/Lamp

Material type is described in the following section. Lamps Textures in the lightning section. **Brush**

Brush textures are applied in Painting & Sculpting.

Textures Stack Active Texture

The Texture slots are displayed in a List Views & Presets. The order in the stack defines how textures are overlayed in the rendered image. The checkbox enables/disables the selected texture.

Texture Data-Block Texture

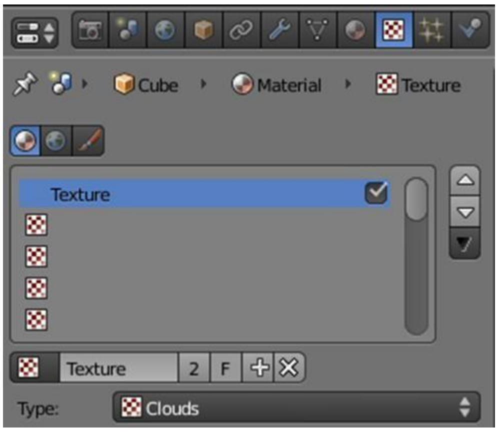
The Texture Data-Block Menu for the selected texture slot.

Texture Type

Choose the type of texture that is used for the current texture data-block.These types are described in detail in this Unit.

Assigning a Texture

This page just shows how to add a texture to a slot. The Texture Panel is explained on the previous page.



Title-Img 4. 4 Texture Panel.

Source-blender.org

Link-http://blender-manual-i18n.readthedocs.io/ja/latest/render/blender_render/textures/assigning_a_tex ture.html

Creating a new Texture Data-Block in a new Texture Slot Step 1:

Select an *empty slot*

Step 2: click on the *New button*. This will do two things:

- It will create a **new texture data-block**.
- Also, it will add **a new slot** in the textures stack.

Creating a new Texture Data-Block in a non-empty slot Step 1:

Select a non-empty slot

Step 2: Click on the *Plus* button. This will do two things:

- It will create a new texture data-block, with a new name, by making a copy of the texture data-block assigned to the selected slot.
- It will assign this new data-block to the selected slot.

Sharing a Texture Data-Block in a non-empty slot

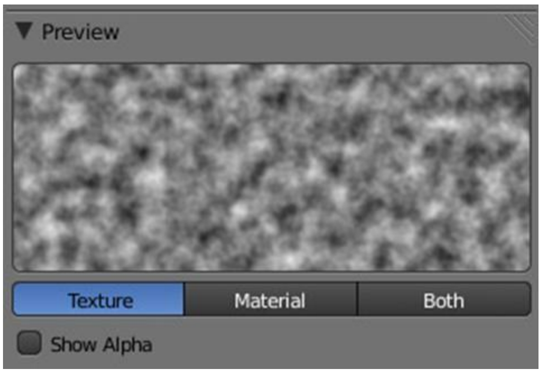
Step 1: Select a non-empty slot

Step 2: Click on the *Browse* button. This will open a menu showing all the available Texture data-blocks in this file.

Step 3: Choose a texture data-block in the menu to assign it to the selected slot.

This will share the chosen texture with more than one object, hence the *Number of users* shown in the texture data-block will **increase by one**.

Texture Properties



Title-Img 4. 5 Texture Preview Panel.

Source-blender.org

Link-http://blender-manual- i18n.readthedocs.io/ja/latest/render/blender_render/textures/options.html?highlight=Texture%20Preview%20Panel

The **Texture Preview Panel** provides a **quick pre-visualization** of how the texture looks on its own, without mapping.

Preview

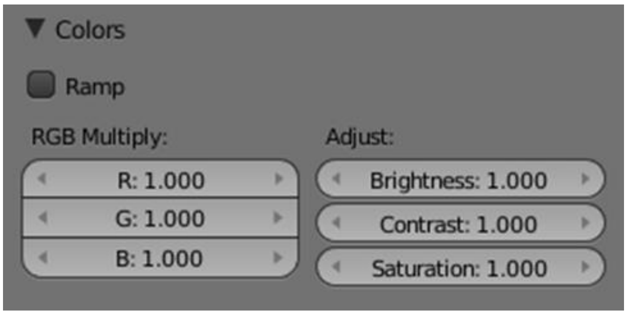
Choose to display only the flat texture, only the Material Preview, or both side-by-side.

Texture, Material/World, Both Show Alpha

Show alpha in preview:

- ❖ If Alpha: Use is **checked** in the **Image Sampling Panel**, the image's alpha channel is displayed.
- ❖ If Alpha: Use is **unchecked,** an alpha channel based on averaged RGB values is displayed like it would be used by the Alpha slider in the Influence Panel.

Colors



Title-Img 4. 6 Colors Panel.

Source-blender.org

Link-http://blender-manual- i18n.readthedocs.io/ja/latest/render/blender_render/textures/options.html?highlight=Texture%20Preview%20Panel

The ***Ramp*** **button** activates a color ramp which allows you to remap the colors of a texture to new ones.

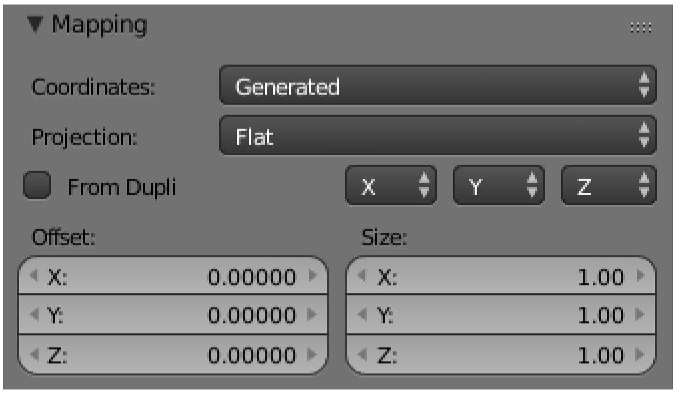
The **color of a texture** can be modified with the ***Brightness, Contrast, and Saturation buttons.*** All textures with RGB-Values, including *Images* and *Environment Maps*, may be modified with the RGB sliders.

R, G, B	Tint the color of a texture by brightening each Red, Green and Blue channel.
Brightness	Change the overall brightness/intensity of the texture.
Contrast	Change the contrast of the texture.
Saturation	Change the saturation of the texture.

Mapping

Textures need mapping coordinates, to determine how they are applied to the object. The mapping specifies how the texture will ultimately wrap itself to the object.

For example, a 2D image texture could be configured to wrap itself around a cylindrical shaped object.



Title-Img 4. 7 Mapping Panel.

Source-blender.org **Link-**

https://docs.blender.org/manual/en/dev/render/blender_render/textures/pro perties/mapping.html

Coordinates

Mapping works by using a set of coordinates to **guide the mapping process**. These coordinates can come from anywhere, usually the object to which the texture is being applied to.

Global	The scene's global 3D coordinates. This is also **useful for animations**; if you move the object, the texture moves across it. It can be useful for letting objects appear or disappear at a certain position in space.
Object	Uses an object as source for coordinates. Often used with an *Empty*, this is **an easy way to place a small image** at a given point on the object. This object can also be animated, to move a texture around or through a surface.
Object	Select the name of an object.
Generated	The original unreformed coordinates of the object. This is the **default option** for mapping textures.
UV	UV mapping is a very precise way of mapping a **2D texture to a 3D surface**. Each vertex of a mesh has its own UV co-ordinates which can be unwrapped and laid flat like a skin. You can almost think of UV coordinates as a mapping that works on a 2D plane with its own local coordinate system to the plane on which it is operating on. This mapping is especially useful when using 2D images as textures, as seen in UV Mapping. You can use multiple textures with one set of UV coordinates.
Layer	UV layer to use for mapping.
Strand/Particle	Uses normalized 1D strand texture coordinate or particle age (X) and trail position (Y). Use **when texture is applied to hair strands or particles.**
Window	The rendered image window coordinates. This is well suited to blending two objects.
Normal	Uses the direction of the surface's normal vector as coordinates. This is very useful when creating certain special effects that depend on viewing angle.
Reflection	Uses the direction of the reflection vector as coordinates. This is useful for adding reflection maps. You will need this input when Environment Mapping.
Stress	Uses the difference of edge length compared to original coordinates of the mesh. This is useful, for example, when a mesh is deformed by modifiers.
Tangent	Uses the optional tangent vector as texture coordinates.
Flat	

Flat mapping gives the best results on **single planar faces**. It does produce interesting effects on the sphere, however, compared to a sphere-mapped sphere the result looks flat. On faces that are not in the mapping plane the last pixel of **3D Animation 121** the texture is extended, which produces stripes on the cube and cylinder.

Cube **Cube Cube mapping** often gives the most **useful results** when the objects are not too curvy and organic (notice the seams on the sphere).

Tube **Tube mapping** maps the texture around an object like a label on a bottle. The texture is therefore more stretched on the cylinder. This mapping is of course very good for making the label on a bottle or assigning stickers to rounded objects. However, this is not a cylindrical mapping so the ends of the cylinder are undefined.

Sphere **Sphere mapping** is the best type for mapping a sphere, and it is perfect for making planets and similar objects. It is often very useful for creating organic objects. It also produces interesting effects on a cylinder.

Inheriting coordinates from the parent object

From Dupli

Duplis instance from vertices, faces, or particles, inherit texture coordinates from their parent.

Coordinate Offset, Scaling and Transformation

Offset

The texture co-ordinates can be translated by an offset. Enlarging of the Offset moves the texture towards the top left.

Size

These buttons allow you to change the mapping of axes between the texture's own coordinate system, and the mapping system you choose (Generated, UV, and etcetera.) More precisely, to each axis of the texture corresponds one of four choices that allow you to select to which axis in the mapping system it maps! This implies several points:

- For **2D textures** (such as images), only the first two rows are relevant, as they have no Z data.
- You can **rotate a 2D picture** a quarter turn by setting the first row (i.e. X texture axis) to Y, and the second row (Y texture axis) to X.
- When you map **no texture axis** (i.e. the three "void" buttons are set), you will get a solid uniform texture, as you use zero dimension (i.e. a dot, or pixel) of it (and then Blender extends or repeats

this point's color along all axes.)

- When you only **map one texture axis** (i.e. two "void" buttons are enabled) you will get a "striped" texture, as you only use one dimension (i.e. a line of pixel) of it, (and then Blender stretches this line along the two other axes).
- The same goes, for **3D textures** (i.e. procedural ones), when one axis is mapped to nothing, Blender extends the plan ("slice") along therelevant third axis.

Texture Blending Modes

Blending Modes are different methods of controlling how the texture influences Material properties. While a blending mode defines, the specific operation performed, blending factor controls the amount, the **overall "strength"** of this operation. For textures, such blending factor is set via sliders in the **Influence Panel**.
Blend Blending operation to perform.

RGB to Intensity

With this option enabled, an RGB texture (affects color) is used as an intensity texture (affects a value).

Blend Color

If the texture is mapped to Color, what color is blended in according to the intensity of the texture?

Negative

The effect of the Texture is negated. Normally white means on, black means off, Negative reverses that.

Stencil

The active texture is used as a mask for all following textures. This is useful for semitransparent textures and "Dirt Maps". Black sets the pixel to "untexturable". The Stencil mode works similar to a layer mask in a 2D program. The effect of a stencil texture cannot be overridden, only extended. You need an intensity map as input.

Destination Value

The value (not for RGB) with which the Intensity texture blends with the current value. Two examples:

- The **Emit value** is normally 0. With a texture mapped to Emit you will get maximal effect, because **DVar is 1 by default**. If you set DVar to 0 no texture will have any effect.
- If you want transparent Material, and use a texture mapped to **Alpha**, nothing happens with the default settings, because the Alpha value in the Material Panel is 1. So you have to set **DVar to 0** to get transparent Material (and of course Z Transparency also). This is a common problem for beginners. Or do it the other way round: set **Alpha to 0** and **leave Dvar on 1**. Of course, the texture is used inverted then.

Types of Maps

There are **two types** of Maps.

1. Bump Maps
2. Normal Maps

Bump Maps and Normal Maps both serve the **same purpose**: they simulate the impression of a detailed 3D surface, by modifying the shading as if the surface had **lots of small angles**, rather than being completely flat. Because it is just **modifying the shading** of each pixel, this will not cast any shadows and will not obstruct other objects. If the camera angle is too flat to the surface, you will notice that the surface is not really shaped.

Both Bump Maps and Normal Maps work by **modifying the normal angle** (the direction pointing perpendicular from a face), which influences how a pixel is shaded. Although the terms Bump Map and Normal Map are often used synonymously, there are certain differences.

Bump maps

These are textures that store an intensity, the relative height of pixels from the viewpoint of the camera. The pixels seem to be moved by the required distance in the direction of the face normal. (The "bump" consists **only of a displacement**, which takes place along the existing, and unchanged, normal-vector of the face.) You may either use grayscale pictures or the intensity values of a RGB-Texture (including images).

Normal maps

These are images that store a direction, the direction of normal directly in the **RGB values of an image**. They are much more accurate, as rather than only simulating the pixel being away from the face along a line, they can simulate that pixel being moved at any direction, in an arbitrary way. The **drawbacks** to normal maps are that unlike bump maps, which can easily be **painted by hand**, normal maps usually must be generated in some way, often from higher resolution geometry than the geometry you are applying the map to.

Normal maps in Blender store a normal as follows:

- **Red** maps from (0 - 255) to X (-1.0 - 1.0)
- **Green** maps from (0 - 255) to Y (-1.0 - 1.0)
- **Blue** maps from (0 - 255) to Z (0.0 - 1.0)

Since normal all points towards a viewer, negative Z-values are not stored (they would be invisible anyway). In Blender, we store a full blue range, although some other implementations also map **blue colors** (128 - 255) to (0.0 - 1.0). The latter convention is used in "**Doom 3**" for example.

Workflow

The steps involved in making and using Bump and Normal Maps are:

Step 1: Model a highly detailed ("hi-poly") model.

Step 2: Bake the Bump and/or Normal maps.

Step 3: Make a low-poly, less detailed model.

Step 4: Map the map to the low-poly model using a common coordinate system.

Consult the **Modeling** section for how to model a highly detailed model using the Mesh tools. How much detail you put in is totally up to you. The more ridges and details (knobs, creases, protrusions) you put in, the more detailed your map will be. **(Step 1)**

Baking a map, simply put, is to take the detail of a high polygon mesh, and apply it to a similar object. The similar object is identical to the high-poly mesh except with less vertices. Use the Render Bake feature in Blender to accomplish this. **(Step 2)**

Modeling a low-poly using Blender's Mesh editing tools. In general, the same or similar faces should exist that reflect the model. For example, a highly detailed ear may have 1000 faces in the high-poly model. In the low-poly model, this may be replaced with a single plane, oriented in the same direction as the detailed ear mesh. (Tip: Blender's multi-resolution mesh modeling feature can be used to good effect here.) **(Step 3)**

Mapping is the process of applying a texture to the low-poly mesh. Consult the Textures Mapping section for more information on applying a texture to a mesh's Material. Special considerations for Bump and Normal Maps is: **(Step 4)**

- When using a **Bump map,** map the texture to Normal and enable No RGB.
- When using a **Normal map**, map the texture to Normal.

The coordinate systems of the two objects must match. For example, if you bake using a UV map of the high-poly model, you must UV map the low poly model and line up its UV coordinates to match the outline of the high-poly image.

Displacement Maps

Displacement mapping allows a texture input to manipulate **the position of vertices** on rendered geometry. Unlike Normal or Bump mapping, where the shading is distorted to give an illusion of a bump (discussed on the previous page), Displacement Maps create **real bumps, creases, ridges, etc in the actual mesh**. Thus, the mesh deformations can cast shadows, occlude other objects, and do everything that changes in real geometry can do, however,, on the other hand, requires **a lot more vertices** to work.

Options

In the Influence Panel, the strength of the displacement is controlled by the
Displace and Normal sliders:

- If a texture provides only **normal information** (e.g. Stucci), vertices move according to the texture's normal data. The normal displacement is controlled by the **Normal slider**.

- If a texture provides only **intensity information** (e.g. Magic, derived from color), vertices move along the directions of their normal (a vertex has no normal itself, it is the resulting vector of the adjacent faces). White pixels move outward in the direction of the normal, black pixels move in the opposite direction. The amount of displacement is controlled with the **Displace slider**.

The two modes are not exclusive. Many texture types provide both information (Clouds, Wood, Marble, and Image). The amount of each type can be mixed using the respective sliders. **Intensity displacement** gives a smoother, more continuous surface, since the vertices are displaced only outward. **Normal displacement** gives a more aggregated surface, since the vertices are displaced in multiple directions.

The depth of the displacement is scaled with an **object's scale**, however, not with the relative size of the data. This means if you **double the size** of an object in object mode, the **depth** of the displacement is also doubled, so the relative displacement appears the same. If you scale inside **Edit Mode**, the displacement depth is not changed, and thus the relative depth appears smaller.

Subdivision Surface Meshes

Rendered face size is controlled with render subdivision level. Displacement really likes smooth normal.

Manually (Edit Mode) subdivided meshes

Control render faces with number of subdivides. (This can be combined with the above methods). Displaces exactly the same Simple Subdivision Surface, however, the overhead of drawing extra faces can slow down editing.

Meta Objects

Control render faces with render wire size. Small wire == more faces.

The following are available, however, currently do not work well. It is recommended that you convert these to meshes before rendering.

Open NURBS Surfaces

Control render faces with U/V Surface Resolution. Higher numbers give more faces. (Note normal errors).

Closed NURBS Surfaces

Control with Surface Resolution controls. (Note the normal errors, and how implicit seam shows).

Curves and Text

Control with Surface Resolution controls. Higher gives more render faces. (Note that the large flat surfaces have few render faces to displace).

Texture Types

The term ***Image Texture*** simply means that a graphic image, which is a **pixel grid** composed of R, G, B, and sometimes Alpha values. It is used as the input source to the texture. As with other types of textures, this information can be used in a number of ways, not only as a simple "decal".

Video textures are some kind of Image textures and based on **movie file** or sequence of successive numbered separate images. They are added in the same way that image textures are.

When the Texture Type *Image or Movie* is selected, **three new Panels** present themselves allowing to control most aspects of how image textures are applied:

1. *Image*,
2. *Image Sampling*, and
3. *Image Mapping*.

UV Textures vs. Procedural Textures

A **Material Texture**, that has a Map Input of UV, and is an image texture that is mapped to Color, is equivalent to a UV Texture. It provides much **more flexibility**, because it can be sized and offset, and the degree to which it affects the color of your object can be controlled in the Map To Panel. In addition, you can have **different images** for each texture channel; one for color, one for alpha, one for normals, one for specularity, one for reflectivity, *etc.*

Procedural textures, like Clouds, are incredibly simple and useful for adding ***realism and details to an image***.

UV Texture	**Procedural Texture**
Image maps to precise coordinates on the **selected faces of the mesh.**	Pattern is generated dynamically, and is mapped to the **entire mesh** (or portion covered by that Material).
Image maps once to a range of mesh faces **specifically selected.**	Maps once to all the faces to which that Material is assigned; either the **whole mesh** or a portion.
Image is mapped **once** to faces.	Size XYZ in the Map Input allows tiling the texture **many times** across faces. Number of times depends on size of mesh.
Affect the **color and The alpha** of the object.	Can also affect normal (bumpiness), reflectivity, emit, displacement, and a dozen other aspects of the mesh's appearance; can even **warp or stencil** subsequent textures.
Can have **many** for a mesh.	Can be layered, **up to 10** textures can be applied, layering on one another. Many mix methods for mixing multiple channels together.
Any Image type (still, video, rendered). Generated test grid available.	Many different types: clouds, wood grain, marble, noise, and even magic.
Provides the UV layout for **animated textures**.	**Noise** is the only animated procedural texture.
Takes very **limited** graphics memory	Uses **no or little** memory; instead uses CPU compute power.

So, in a sense, a single UV texture for a mesh is simpler, however, more limited than using multiple textures (mapped to UV coordinates), because they do one specific thing very well: adding image details to a range of faces of a mesh. They work together if the procedural texture maps to the UV coordinates specified in your layout.

As discussed earlier, you can map **multiple UV textures to different images** using the UV Coordinate mapping system in the Map Input Panel.

Options

Image

In the *Image* Panel, we tell Blender which source file to use.

Image Sampling

In the *Image Sampling* Panel, we can control how the information is retrieved from the image.

 Background image.	 Foreground image.

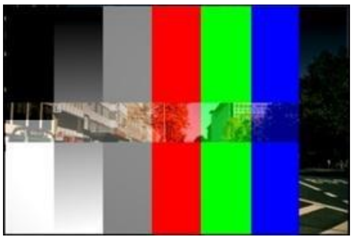
Title-Img 4. 8 Image Sampling

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/textures/type s/image/options.html

The two images presented here are used to demonstrate the different image options.

- ***Background image*** is an ordinary JPG-file,
- ***Foreground image*** is a PNG-file with various alpha and grayscale values.

The vertical bar on the right side of the foreground image is an
Alpha blend, the horizontal bar has **50% alpha**.

<table>
<tr>
<td>
Foreground image with Use alpha. The alpha values of the pixels are evaluated.</td>
<td>
Foreground image with Calculate alpha.</td>
</tr>
</table>

Title-Img 4. 9 Image Sampling

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/textures/type s/image/options.html

Alpha

Options related to transparency.

Use

Works with PNG and TGA files since they can save transparency information (Foreground Image with Use Alpha). Where the alpha value in the image is less than 1.0, the object will be partially transparent and stuff behind it will show.

Calculate

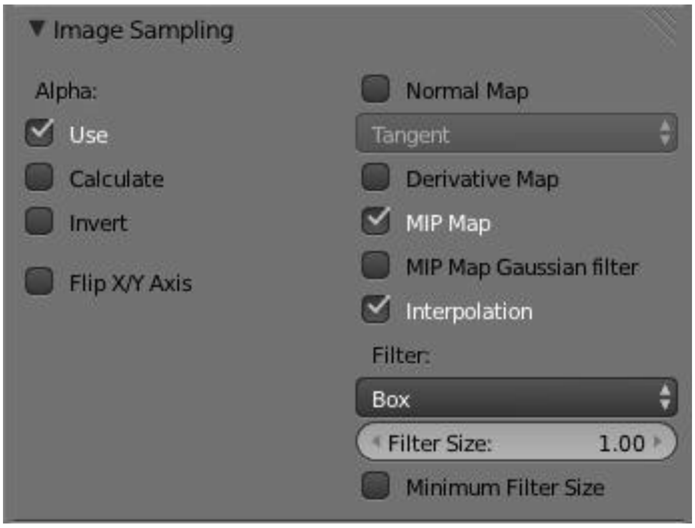
Calculate an alpha based on the RGB values of the Image. **Black (0, 0, 0)** is transparent, **white (1, 1, 1**) opaque. Enable this option if the image texture is a mask. Note that mask images can use shades of gray that translate to semi- transparency, like ghosts, flames, and smoke/fog.

Invert

Reverses the alpha value. Use this option if the mask image has white where you want it transparent and vice-versa.

Flip X/Y Axis

Rotates the image **90 degrees**counterclockwise when rendered.



Title-Img 4. 10 Image Sampling Panel

Source-blender.org **Link-**

https://docs.blender.org/manual/en/dev/render/blender_render/textures/type s/image/options.html

Normal Map

This tells Blender that the image is to be used to create the illusion of a bumpy surface, with each of the three RGB channels controlling how to fake a shadow from a surface irregularity. Needs specially prepared input pictures.

Derivative Map

Use red and green as derivative values.

MIP Map

MIP Maps are pre-calculated, smaller, filtered Textures for a certain size. A series of pictures is generated, each half the size of the former one. This optimizes the **filtering process**. By default, this option is enabled and speeds up rendering (especially useful in the Game Engine). When this option is OFF, you generally get a **sharper image**, however, this can significantly increase calculation time if the filter dimension (see below) becomes large. Without MIP Maps, you may get varying pictures from slightly different camera angles, when the Textures become very small. This would be noticeable in an animation.

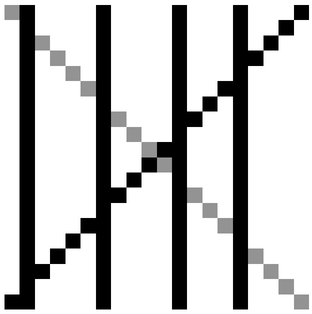
MIP Map Gaussian filter

Used in conjunction with MIP Map, it enables the MIP Map to be made smaller based on color similarities. In the Game Engine, you want your textures, especially your MIP Map textures, to be as small as possible to increase rendering speed and frame rate.

Interpolation

This option interpolates the pixels of an image. This becomes visible when you enlarge the picture.

By default, this option is on. Turn this option off to keep the individual pixels visible and if they are correctly anti-aliased. This last feature is useful for regular patterns, such as lines and tiles; they remain 'sharp' even when enlarged considerably. When you enlarge this**10×10 pixel** Image  the difference with and without Interpolation is clearly visible. Turn this image off if you are using digital photos to preserve crispness.

Enlarged Image texture without and with Interpolation	
	

Title-Img 4. 11Enlarged Image texture without and with *Interpolation*

Source-blender.org **Link-**

https://docs.blender.org/manual/en/dev/render/blender_render/textures/type s/image/options.html

Filter

The filter size used in rendering, and also by the options ***MipMap*** and ***Interpolation***. If you notice gray lines or outlines around the textured object, particularly where the image is transparent, turn this value down from **1.0 to 0.1** or so.

Texture Filter Type

Texture filter to use for **image sampling**. Just like a ***pixel***represents a *pic*ture *el*ement, a ***texel***represents a *tex*ture *el*ement. When a texture (2D texture space) is mapped onto a 3D model (3D model space), different algorithms can be used to compute a value for each pixel based on samplings from several texels.

Box

A fast and simple nearest-neighbor interpolation known as Monte Carlo integration

EWA (Elliptical Weighted Average)

One of the most efficient direct convolution algorithms developed by **Paul Heckbert** and **Ned Greene in the 1980s**. For each Texel, EWA samples, weights, and accumulates texels within an elliptical footprint and then divides the result by the sum of the weights.

Eccentricity

Maximum Eccentricity. Higher values give less blur at distant/oblique angles, however, is slower

FELINE (Fast Elliptical Lines)

Uses several isotropic probes at several points along a line in texture space to produce an anisotropic filter to reduce aliasing artifacts without considerably increasing rendering time.

Probes

Number of probes to use. An integer between **1 and 256**. Further reading: **McCormack, J; Farkas, KI; Perry, R; Jouppi, NP (1999)** Simple and Table Feline: Fast Elliptical Lines for Anisotropic Texture Mapping, WRL

Area

Area filter to use for image sampling.

Eccentricity

Maximum Eccentricity. Higher values give less blur at distant/oblique angles, however, is slower.

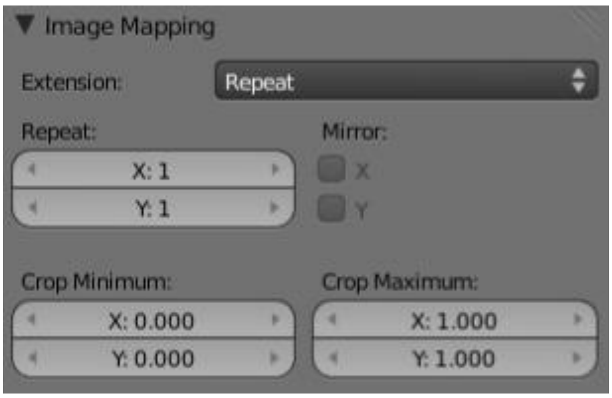
Filter Size

The filter size used by MIP Map and Interpolation.

Minimum Filter Size

Use Filter Size as a minimal filter value in pixels.

Image Mapping



Title-Img 4. 12Image Mapping Panel

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/textures/type s/image/options.html

Extend

In the *Image Mapping*Panel, we can control how the image is **mapped or projected** onto the 3D model

Extension

Outside the image the colors of the edges are extended.

Clip

Clip to image size and set exterior pixels as transparent. Outside the image, an alpha value of 0.0 is returned. This allows you to 'paste' a small logo on a large object.

Clip Cube

Clips to cubic-shaped area around the images and sets exterior pixels as transparent. The same as Clip, however, now the '**Z' coordinate** is calculated as well. An alpha **value of 0.0** is returned outside a cube-shaped area around the image.

Repeat

The image is repeated horizontally and vertically.

Mirror

Mirror on X/Y axes. This buttons allow you to map the texture as a mirror, or automatic flip of the image, in the corresponding X and/or Y direction.

Checker

Checkerboards quickly made. You can use the option size on the Mapping Panel as well to create the desired number of checkers **Even / Odd** *Set even/odd tiles*

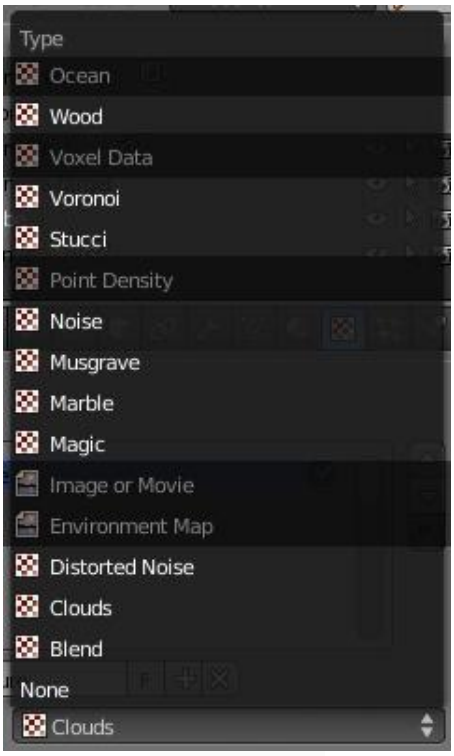
Distance

Governs the distance between the checkers in parts of the texture size.

Crop Minimum / Crop Maximum

The offset and the size of the texture in relation to the texture space. Pixels outside this space are ignored. Use these to crop, or choose a portion of a larger image to use as the texture.Procedural Textures

Introduction



Title-Img 4. 13Texture type list

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/textures/type s/procedural/introduction.html

The Texture Type list in the Texture Panel of the Texture buttons. (Non-procedural textures darkened out)

Procedural textures are textures that are defined mathematically. They are generally relatively simple to use, because they do not need to be mapped in a special way. This does not mean that procedural textures cannot become very complex.

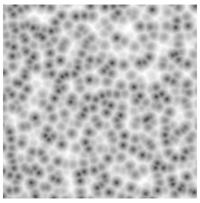
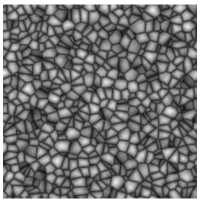
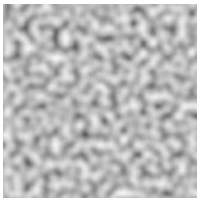
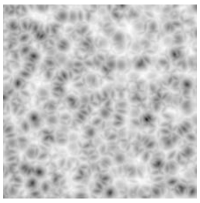
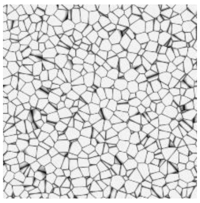
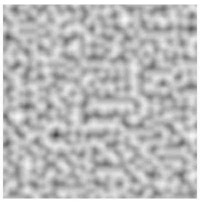
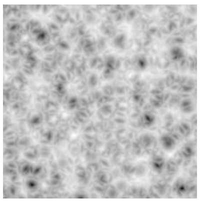
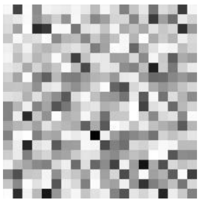
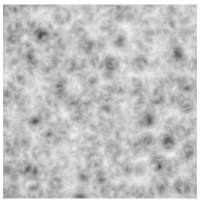
These types of textures are **'real' 3D**. By that, we mean that they fit together perfectly at the edges and continue to look like what they are meant to look like even when they are cut; as if a block of wood had really been cut in two. **Procedural textures** are not filtered or anti-aliased. This is hardly ever a problem: the user can **easily keep** the specified frequencies within acceptable limits.

Common options

Noise Basis

Each noise-based Blender texture (with the exception of Voronoi and simple noise) has a Noise Basis setting that allows the user **to select which algorithm is used** to generate the texture. This list includes the original Blender noise algorithm. The Noise Basis settings makes the procedural textures **extremely flexible** (especially **Musgrave**).

The Noise Basis governs the structural appearance of the texture:

 Blender Original .	 Voronoi F1.	 Voronoi F2-F1.
 Original Perlin.	 Voronoi F2.	 Voronoi Crackle .
 Improved Perlin.	 Voronoi F3.	 Cell Noise.
 Voronoi F4.		

Title-Img 4. 14Noise basis

Source-blender.org **Link-**

https://docs.blender.org/manual/en/dev/render/blender_render/textures/type s/procedural/introduction.html

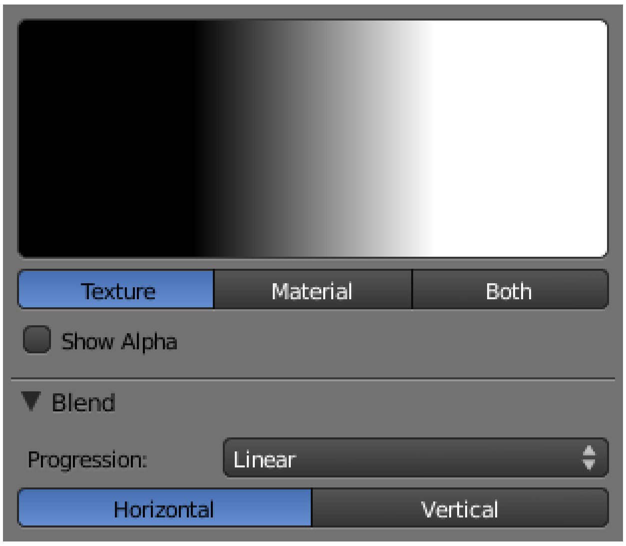
There are two more possible settings for Noise Basis, which are relatively similar to Blender **Original: Improved Perlin**and **Original Perlin**.

Nabla

Almost all procedural textures in Blender use derivatives for **calculating normal** for

Texture Mapping (with an exception Blend and Magic). This is important for Normal and Displacement Maps. The strength of the effect is controlled with the Nabla Number button.

Blend



Title-Img 4. 8 Blend Texture Panels.

Source-blender.org **Link-** https://docs.blender.org/manual/en/dev/render/blender_render/textures/types/procedural/blend.html?highlight=blend%20texture%20panels

Often used for

This is one of the **most frequently used procedural textures**. You can use blend textures to blend other textures together (with Stencil), or to create nice effects (especially with the Mapping: Normal trick).

Note

Remember that if you use a ramp to create a custom blending, you may have to use
No RGB, if the Mapping value needs an intensity input.

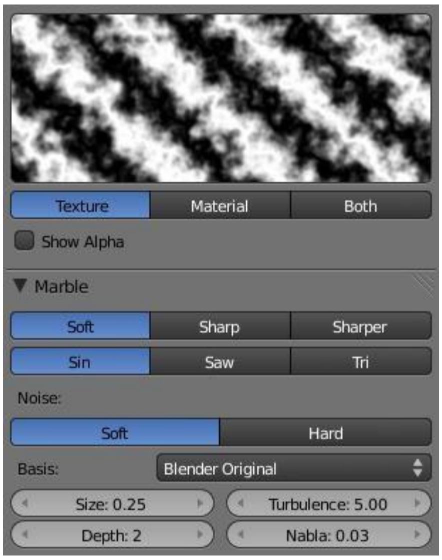
Result(s)Intensity.

The Blend texture generates a smoothly interpolated progression.

Options

Progression	Profile of blend.
Easing	A flowing, non-linear progression.
Spherical	A progression with the shape of a three-dimensional ball.
Quadratic Sphere	A quadratic progression with the shape of a three-dimensional ball.

Radial	A radial progression: Horizontal / Vertical. The direction of the progression is flipped a quarter turn.



Title-Img 4. 9 Marble Texture Panels.

Marble

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/textures/types/procedural/marble.html?highlight=marble%20texture%20panels

- **Often used for**

  Marble, Fire, Noise with a structure.
- **Result(s)**

Intensity value only. *Bands are generated based on the sine, saw, or triangular formula and noise turbulence.*
Bands are generated based on the sine, saw, or triangular formula and noise turbulence.

Options

Marble

Type

Three settings for soft to more clearly defined Marble.

Soft, Sharp, Sharper

Noise basis

Shape of wave to produce bands.

Sine, Saw, Triangle

Noise Type

The noise function works with two methods.

Soft, Hard

Size

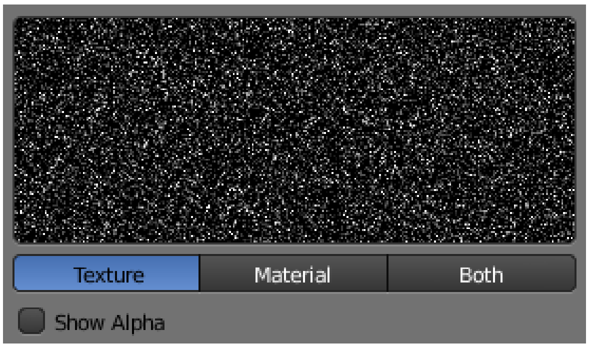
The dimensions of the noise table

Depth

The depth of the Marble calculation. A higher value results in greater calculation time, however, also in finer details.

Turbulence

The turbulence of the sine bands.



Title-Img 4. 10 Noise Texture Panel.

Noise

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/textures/type s/procedural/noise.html

Although this looks great, it is **not Perlin Noise**! This is a true, randomly generated Noise. This gives a different result every time, for every frame, for every pixel.

Options

*There are **no options** for this noise.*

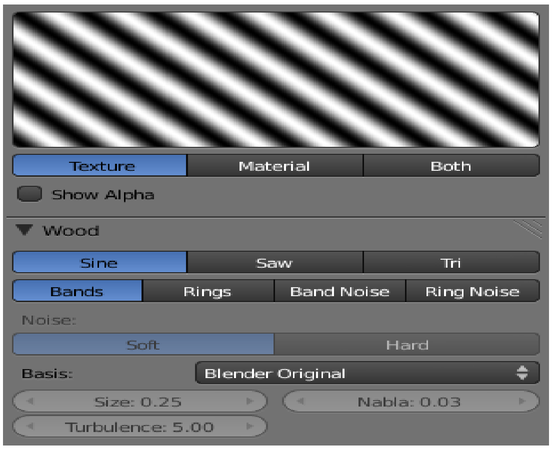
- *Often used for*

White noise in an animation. This is not well suited if you do not want an animation. For Material displacement or bump, use clouds instead.

- *Result(s)*

  Intensity.

Wood



Title-Img 4. 11 Wood Texture Panels.

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/textures/types/procedural/wood.html?highlight=wood%20texture%20panels

- **Often used for**

  Woods and ring-shaped patterns.

- **Result(s)**

  Intensity only.

Options

Noise Basis	Shape of wave to produce bands Sine, Saw, Triangle
Wood Type	Set the bands to either straight or ring-shaped, with or without turbulence. Bands, Rings, Band Noise, Ring Noise
Noise Type	There are two methods available for the Noise function Soft, Hard
Size	Dimension of the Noise table
Turbulence	Turbulence of the Band Noise and Ring Noise types

Environment Maps

Environment maps take a **render of the 3D scene** and apply it to a texture, to use for **faking reflections.** If you want to achieve a very realistic result, raytraced reflections are a good solution. Environment Maps are another way **to create reflective surfaces**, however, they are not so simple to set up.

So why should one use Environment Maps?

- The main reason is probably that they can be much **faster than raytracing** reflections. In certain situation, they need to be calculated only once, and may be reused like any ordinary texture. You may **even modify** the precalculated Environment Map in an image editor.

- Environment maps can also be **blurred** and render **even faster**, because the resolution can then be lowered. Blurring a reflection with the raytracer always adds to the render time, sometimes quite a lot.

- **Halos** (a visualization type for particles) are not visible to raytraced reflections, so you need to setup environment maps to reflect them.

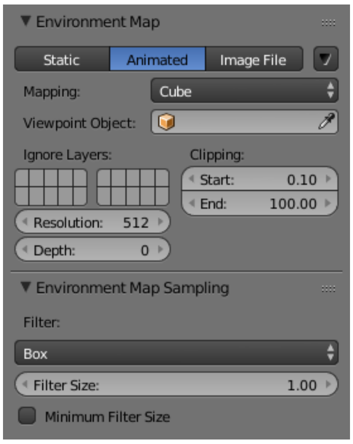
- **Keypoint strands** (another visualization type for particles) are also not visible to raytraced reflections, so you need to setup environment maps to reflect them.

Just as we render the light that reaches the viewing plane using the camera to define a viewpoint, we can render the light that reaches the surface of an object (and hence, the light that might ultimately be reflected to the camera). Blender's environment mapping **renders a cubic image map** of the scene in the six cardinal directions from any point. When the six tiles of the image are mapped onto an object using the Reflection input coordinates, they create the visual complexity that the eye expects to see from shiny reflections.

Options Important

For correct results, the mapping of an environment map texture must be set to Reflection (reflection co-ordinates) in the **Map Input Panel** of the **Material tab.**

Blender allows **three types of environment maps**, as you can see in Img 4.19 Reflecting plane Environment Map settings.:



Title-Img 4. 12 Reflecting plane Environment Map settings.

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/textures/types/environment.html?highlight=reflecting%20plane%20environment%20map%20settings

Static

The map is only calculated once during an animation or after loading a file.

Animated

The map is calculated each time a rendering takes place. This means moving Objects are displayed correctly in mirroring surfaces.

Image File

When saved as an image file, environment maps can be loaded from disk. This option allows the fastest rendering with environment maps, and also gives the ability to modify or use the environment map in an external application.

When using **planar reflections**, if the camera is the only moving object and you have a reflecting plane, the Empty must move too and you must use Animated environment map. If the reflecting object is small and the Empty is in its center, the environment map can be **Static**, even if the object itself rotates since the Empty does not move. If, on the other hand, the Object translates the Empty should follow it and the environment map be of Animated type.

Specials

Clear Environment Map

Clears the currently rendered environment map from memory. This is useful to refresh a Static environment maps and you have changed things in your scene since the last time the environment map was rendered. Animated environment maps do this automatically on every render.

Save Environment Map

Saves the currently stored static environment map to disk as an image file. This can be loaded again with Load.

Clear All Environment Map

Does the same as Free Data, however, with all environment maps in the scene. This is a useful shortcut when using recursive environment maps (when the Depth is greater than 0).

Viewpoint Object

Environment maps are created from the perspective of a specified object. The location of this object will determine how 'correct' the reflection looks, though different locations are needed for different reflecting surfaces. Usually, **an Empty is used** as this object:

- For **planar reflections**, the object should be in a location mirrored from the camera, on the other side of the plane of reflection (see Examples). This is the most accurate usage of Environment maps.
- For **spherical reflections**, the object should be in the center of the sphere. Generally, if the reflecting sphere's object center point is in the center of its vertices, you can just use the name of the actual sphere object as the Viewpoint Object
- For **irregular reflections**, there is no hard and fast rule, you will probably need to experiment and hope that the inaccuracy does not matter.

Ignore Layers

The layers are **to exclude** from the environment map creation. Since environment maps work by rendering the scene from the location of the Viewpoint Object, you will need to exclude the actual reflecting surface from the environment map, otherwise it will occlude other objects that should be reflected on the surface itself.

Eg. If you are rendering an environment map from the center of a sphere, all the environment map will show by default is the **inside of the sphere**. You will need to move the sphere to a separate layer, then exclude that layer from the environment map render, so that the environment map will show (and hence reflect) all the objects outside the sphere.

Resolution

The resolution of the cubic environment map render. Higher resolutions will give a sharper texture (reflection), however, will be slower to render.

Depth

The number of recursive environment map renders. If there are multiple reflecting objects using environment maps in the scene, some may appear solid, as they will not render each other's reflections. In order to show reflections within reflections, the environment maps need to be made multiple times, recursively, so that the effects of one environment map can be seen in another environment map. See Examples.

Clipping Start/End

The clipping boundaries of the virtual camera when rendering the environment map. Sets the minimum and maximum distance from the camera that will be visible in the map.

Minimum Filter Size

Use Filter Size as a minimal filter value in pixels.

Examples

In this example, an empty is used as the **Viewpoint Object** of the reflecting plane's environment map. It is located in the specular position of the camera with respect to the reflecting surface. (This is possible, strictly speaking, only for planar reflecting surfaces.)

Environment Map Sampling

Filter Box

Box Filter

EWA

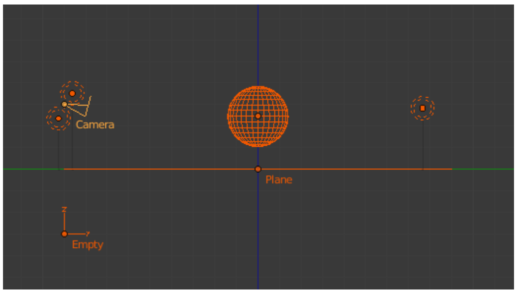
Elliptical Weighted Average. One of the most efficient direct convolution algorithms developed by **Paul Heckbert and Ned Greene in the 1980s.** For each Texel, EWA samples, weights, and accumulates texels within an elliptical footprint and then divides the result by the sum of the weights.

Eccentricity

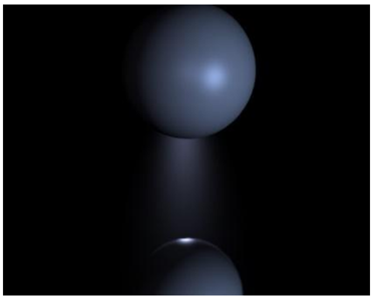
Maximum eccentricity (higher gives less blur at distant/oblique angles, however, is also slower)

FELINE

FELINE (Fast Elliptical Lines), uses several isotropic probes at several points along a line in texture space to produce an anisotropic filter to reduce aliasing artifacts without considerably increasing rendering time.



Planar reflection example.



Sphere on a reflecting surface.

Title-Img 4. 13 Reflecting plane Environment Map settings.

Source-blender.org **Link-**

https://docs.blender.org/manual/en/dev/render/blender_render/textures/type s/environment.html

Probes

Maximum number of samples (higher gives less blur at distant/oblique angles, however, is also slower)

Area Eccentricity

Maximum eccentricity (higher gives less blur at distant/oblique angles, however, is also slower)

Filter Size

The amount of blurring applied to the texture. Higher values will blur the environment map to fake blurry reflections.

Minimum Filter Size

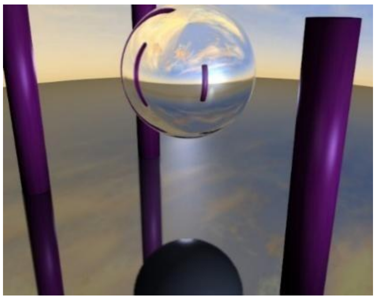
Use Filter Size as a minimal filter value in pixels.

Examples

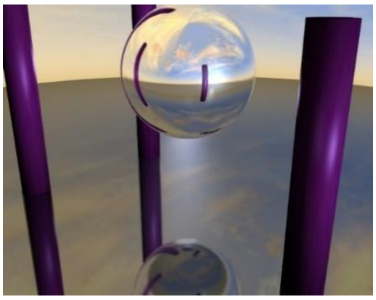
In this example, an empty is used as the **Viewpoint Object** of the reflecting plane's environment map. It is located in the specular position of the camera with respect to the reflecting surface. (This is possible, strictly speaking, only for planar reflecting surfaces.)

Ideally, the location of the empty **would mirror** the location of the camera across the plane of the polygon onto which it is being mapped.

The following images show the **effect of the Depth**. The first render has depth **set to 0**. This means the environment map on the plane has rendered before the environment map of the sphere, so the sphere's reflection is not shown. By raising the Depth, the environment map is rendered recursively, in order to get reflections of reflections.



Reflecting sphere on a reflecting surface.



Reflecting sphere on a reflecting surface with multiple reflections.

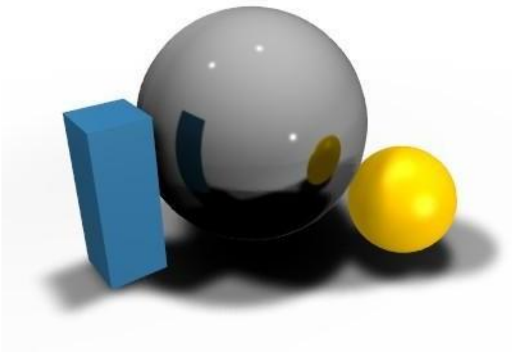
Title-Img 4. 14 Reflecting sphere

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/textures/type s/environment.html

Limitations

Because environment maps are calculated from the **exact location of the Viewpoint Object's object center**, and not from actual reflecting surface, they can often be inaccurate, especially with spheres. In the following image, the rectangular prism and the smaller spheres are touching the sides of the large reflecting sphere; however, because the environment map is calculated from the center of the sphere, the surrounding objects look **artificially far away**.

Title-Img 4. 15 Inaccurate spherical reflection, the colored objects are artificially offset.



Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/textures/type s/environment.html

Introduction to Nodes

In addition to creating Materials as just described using all the settings on all the Materials Panels, Blender allows you to create a Material by routing basic Materials through a **set of nodes.** Each node performs some operation on the Material, changing how it will appear when applied to the mesh, and passes it on to the next node. In this way, **very complex Material** appearances can be achieved.

You should already be familiar with general Material concepts and how to create Materials/textures using the Material menu. You should also have a general understanding of the texture coordinate systems available in Blender (e.g. Generated, UV, etc.). Also, many aspects of a node will be skipped here because in later sections you will see the function expanded upon. Each section builds off the previous.

To start, the node system does not make the Material menu obsolete. Many features and Material settings are still only accessible through the **Material Panel** (e.g. Ray Mirror). However, with the advent of nodes, more complex and fantastic Materials can be created since we now have **greater control**.

Just in case you are not (yet) familiar with the concepts: when you create a system of nodes, you are describing a **data-processing pipeline of sorts**, where data "flows from" nodes which describe various *sources*, "**flows through**" nodes which represent various processing and filtering stages, and finally "**flows into**" nodes which represent outputs or destinations. You can connect the nodes to one another in many different ways, and you can adjust "knobs," or parameters, that control the behavior of each node. This gives you a tremendous amount of creative control. And, it will **very quickly become intuitive**.

Having said all that, let us begin with a **normal Material**.

Here we have the standard Material added to a cube mesh. We could, as we have in the past, add color and other settings to this Material and it would certainly look nice. however, let us say we are just not getting what we are looking for? What if we want to control the creation more tightly or add more complexity? Here is where nodes come in.

Making this **node map** is accomplished by working in a **Node Editor**. This section covers:

- Enabling Material Nodes.
- The Node Editor, its basic controls, and working with nodes.
- The specific types of nodes available for Materials.

Accessing the Node Editor

First, let’s enter the node editor and make sure that the node editor has the Material node button (the sphere icon) pressed, not the composite or texture node buttons.

Enabling Node Materials

Let us take the base Material and hit the Nodes button next to the Material name in the Material Panel or the node editor. You will see a change in the Material Panel.

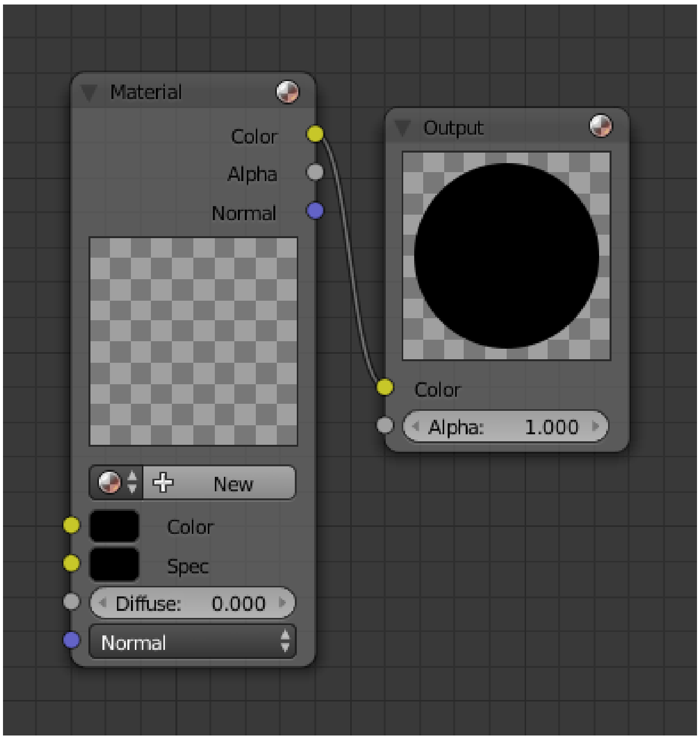
Title-Img 4. 16Use Material nodes button.

Source-blender.org **Link-**

https://docs.blender.org/manual/en/dev/render/blender_render/materials/no des/introduction.html

What you have just done is told Blender to make the Material you were on to become the node tree. Most of the Panels we normally find in the Material menu are now gone.

If you switch to the ***Compositing* screen with Ctrl-Left,** if you are on the default screen, you will find a *Node Editor* on the top half of the screen. When you enabled Material nodes, a Material node and an output node were automatically added to the node editor.



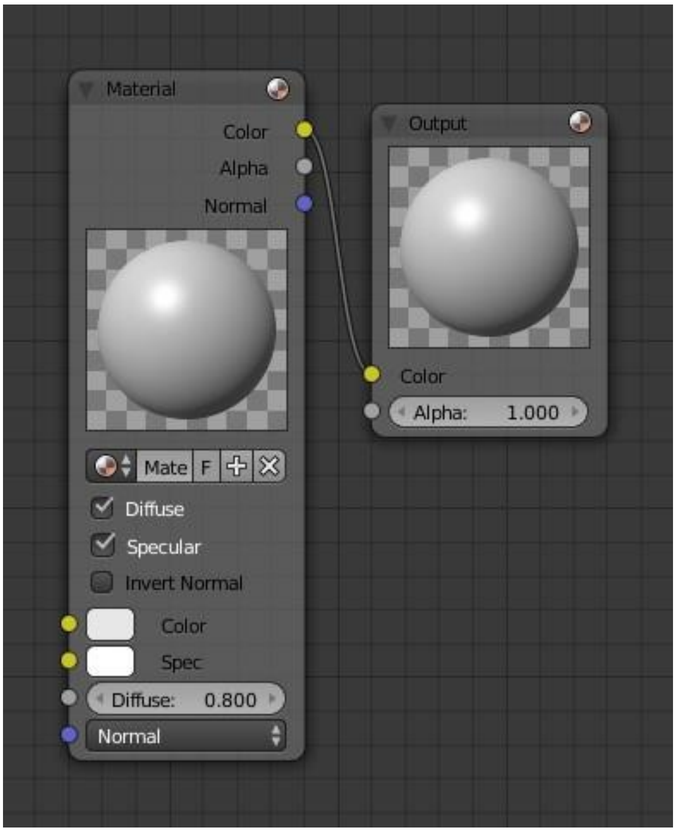
Title-Img 4. 17Default nodes.

Source-blender.org **Link-**

https://docs.blender.org/manual/en/dev/render/blender_render/materials/no des/introduction.html

You can also split the 3D View in the default screen in two and change one into a *Node Editor*.

It is important to note that you can add a new Material (which you can edit and change like any other Material in the Material Panel), add an already created Material or append a Material from another blend-file, and also use the Material that you used to create the node tree.



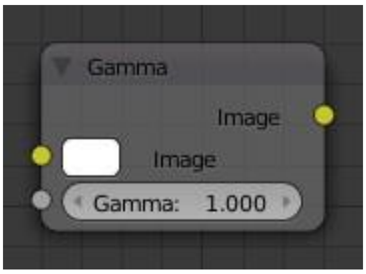
Title-Img 4. 18A first Material added to the node setup.

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/materials/no des/introduction.html

Here, we added a new Material in the *Node editor* “**Material.001**”, and as we did, we can access the properties of this Material in the Material’s menu.

Node Types

Gamma Node



Title-Img 4. 19A first Material added to the node setup.

Source-blender.org **Link-**

https://docs.blender.org/manual/en/dev/render/cycles/nodes/types/color/gamma.html?highlight=gamma%20node

Gamma Node.

Use this node to apply a gamma correction.

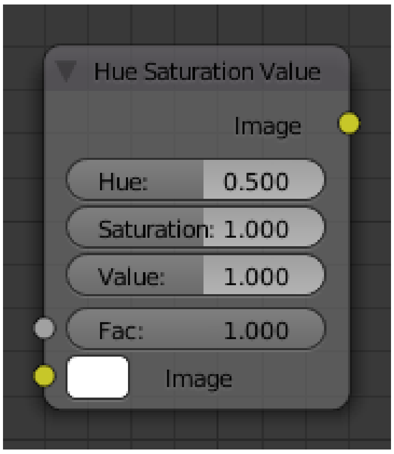
Inputs

Image	Standard image input.
Gamma	An exponential brightness factor.
Properties	This node has no properties.

Outputs

Image	Standard image input.

Examples

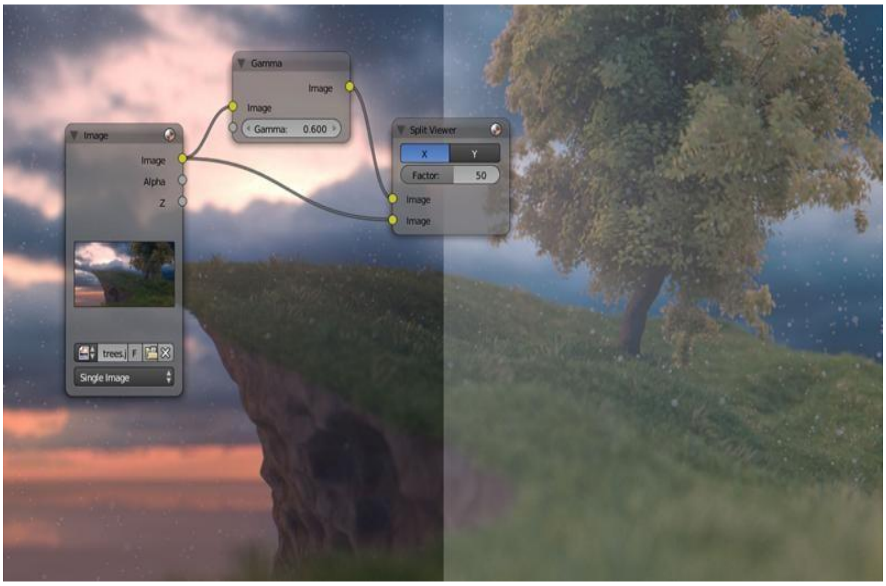


Title-Img 4. 20 Example of Gamma node.

Source-blender.org **Link-**

https://docs.blender.org/manual/en/dev/render/cycles/nodes/types/color/ga mma.html?highlight=gamma%20node

Hue Saturation Value Node



Title-Img 4. 21Hue Saturation Node.

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/materials/nodes/types/color/hue_saturation.html?highlight=saturation%20node

This node applies a color transformation in the **HSV color space**. Called "Hue Saturation Value" in Shader and texture context.

Inputs

Factor Controls the amount of influence the node exerts on the output image.

Image Standard image input.

Properties The transformations are relative shifts. In the Shader and texture context the following properties are available as input sockets.

Hue Specifies how the hue rotation of the image. 360° are mapped to (0 to 1). The hue shift of 0 (-180°) and 1 (+180°) have the same result.

Saturation A saturation of 0 removes hues from the image, resulting in a grayscale image. A shift greater 1.0 increases saturation.

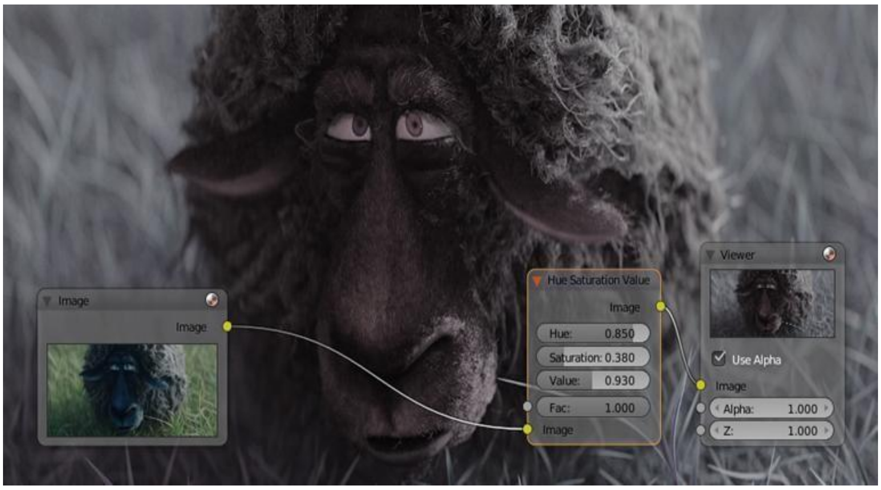
Value Value is the overall brightness of the image. De/Increasing values shift an image darker/lighter.

Outputs

Image Standard image output.

Hue/Saturation Tips	Some things to keep in mind that might help you use this node better:
Hues are vice versa	A blue image, with a Hue setting at either end of the spectrum (0 or 1), is output as yellow (recall that white, minus blue, equals yellow). A yellow image, with a Hue setting at 0 or 1, is blue.
Hue and Saturation work together.	So, a Hue of 0.5 keeps the blues the same shade of blue, however, Saturation can deepen or lighten the intensity of that color.
Gray & White are neutral hues	A gray image, where the RGB values are equal, has no hue. Therefore, this node can only affect it with *Value*. This applies to all shades of gray, from black to white; wherever the values are equal.
Changing the effect over time	The Hue and Saturation values can be animated with a *Time Node* or by animating the property.

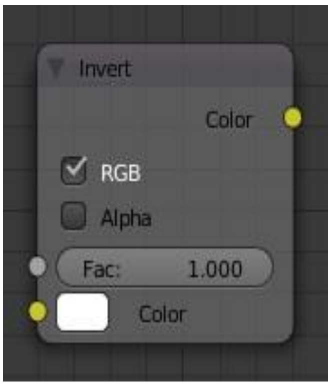
HSV Example



Title-Img 4. 22 A basic example.

Source-blender.org
Link-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/nodes/types/color/hue_saturation.html?highlight=saturation%20node

Invert Node



Title-Img 4. 23Invert Node.

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/compositing/types/color/invert.html? highlight=invert%20node

This node **inverts the colors** in the input image, producing a negative**.**

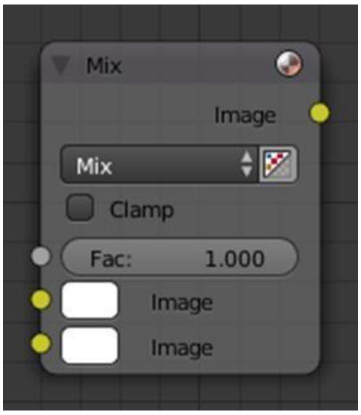
Inputs

Factor	Controls the amount of influence the node exerts on the output image.
Color	Standard image input.
Properties	In the compositing context, this node has the following properties.
RGB	De/activation of the color channel inversion.
Alpha	De/activation of the alpha channel inversion.

Outputs

Color	Standard image output.

Mix Node



Title-Img 4. 24Mix Node

Source-blender.org
Link-
https://docs.blender.org/manual/en/dev/render/blender_render/materials/nodes/types/color/mix_rgb.html?highlight=mix%20node

This node **mixes images** by working on the individual and correspondingpixelsofthetwoinput images.Called“**MixRGB**”in the Shader and texture context.

Inputs

Factor	Controls the amount of influence the node exerts on the output image.
Image	The background image. The image size and resolution sets the dimensions of the output image.
Image	The foreground image.

Properties

Mix	The Blend types could be selected in the select menu. Add, Subtract, Multiply, Screen, Divide, Difference, Darken, Lighten,

Overlay, Dodge, Burn, Hue, Saturation, Value, Color, Soft Light, Linear Light

Use Alpha If activated, by clicking on the *Color and Alpha* icon, the Alpha channel of the second image is used for mixing. When deactivated, the default, the icon background is a light gray. The alpha channel of the base image is always used.

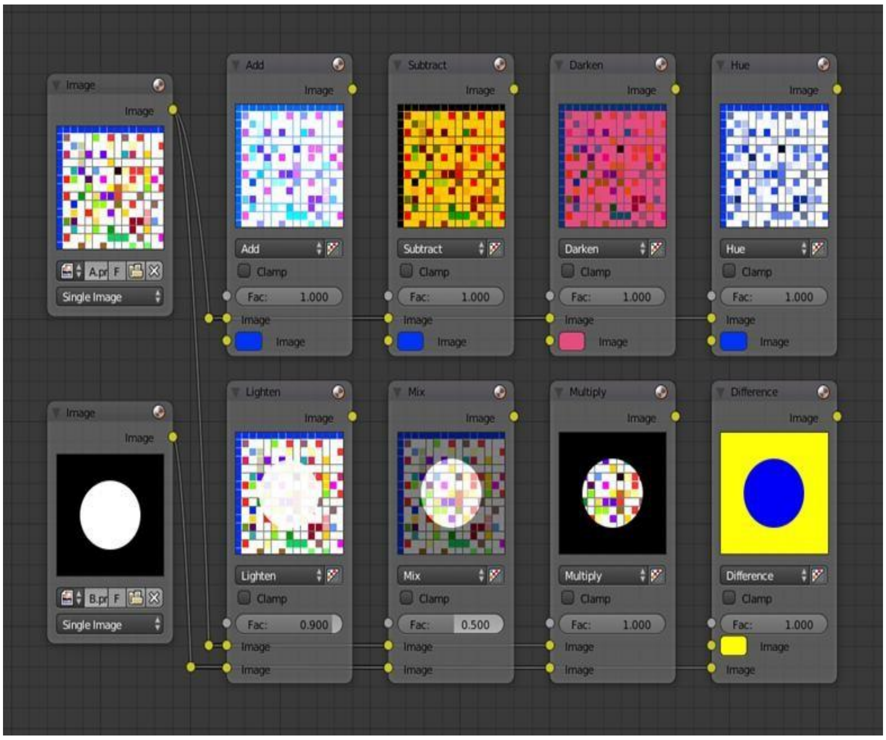
Clamp Limit the highest color value to not exceed 1.

Output

Image Standard image output.

Examples

Below are samples of common mix modes and uses, mixing a color or checker with a mask.



Title-Img 4. 25 Some explanation of the mixing methods above might help you use the Mix node effectively.

Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/render/blender_render/materials/nodes/types/color/mix_rgb.html?highlight=mix%20node

Add Adding blue to blue keeps it blue, however, adding blue to red makes purple. White already has a full amount of blue, so it stays white. Use this to shift a color of an image. Adding a blue tinge makes the image feel colder.

Subtract Taking Blue away from white leaves Red and Green, which combined make Yellow. Taking Blue away from Purple Leaves Red. Use this to desaturate an image. Taking away yellow makes an image bluer and more depressing.

Multiply Black (0.00) times anything leaves black. Anything times White (1.00) is itself. Use this to mask out garbage, or to colorize a black-and-white image.

Hue Shows you how much of a color is in an image, ignoring all colors except what is selected: makes a monochrome picture (style '**Black & Hue'**).

Mix Combines the two images, averaging the two.

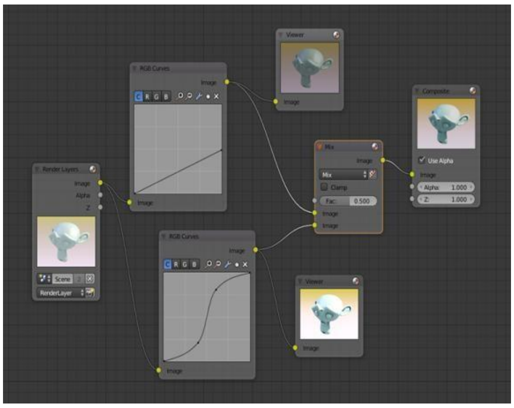
Lighten Like bleach makes your whites whiter. Use with a mask to lighten up a little.

Difference Kinda cute in that it takes out a color. The color needed to turn Yellow into White is Blue. Use this to compare two very similar images to see what had been done to one to make it the other; sorta like a change log for images.

Darken With the colors set here, is like looking at the world through rose-colored glasses.

Contrast Enhancement

Here is a **small map** showing the effects of two other common uses for the **RGB Curve**: *Darken* and *Contrast Enhancement*. You can see the effect each curve has independently, and the combined effect when they are *mixed* equally.



Title-Img 4. 26 Example node setup showing "Darken", "Enhance Contrast" and "Mix" nodes for composition.

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/render/blender_render/materials/nodes/types/color/mix_rgb.html?highlight=mix%20node

As you can hopefully see, our original magic monkey was overexposed by too much light. To cure an overexposure, you must **both darken the image and enhance the contrast**.

In the top **RGB curve, *Darken***, only the right side of the curve was lowered; thus, any **X input** along the bottom results in a geometrically less **Y output.** The *Enhance Contrast* RGB (S shaped) curve scales the output such that middle values of X change dramatically; namely, the middle brightness scale is expanded, and thus, whiter whites and blacker blacks are output. To make this curve, simply click on the curve and a new control point is added. Drag the point around to bend the curve as you wish. The Mix node combines these two effects equally, and Suzanne feels much better.

Watermark images

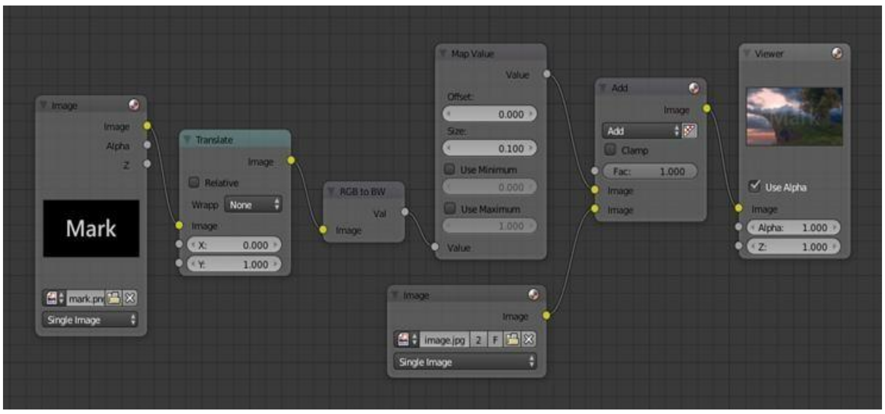
In the olden days, a pattern was pressed into the **paper mesh as it dried,** creating a mark that identified who made the paper and where it came from. The mark was barely perceptible except in just the right light. Probably the first form of subliminal advertising. Nowadays, people **watermark their images** to identify them as personal intellectual property, for subliminal advertising of the author or hosting service, or simply to track their image's proliferation throughout the web.

Blender provides a complete **set of tools** for you to both encode your watermark and to tell if an image has your watermark.

Encoding Your Watermark in an Image

First, construct your own personal watermark. You can use your name, a word, or a shape or image not easily replicated. While neutral gray works best using the encoding method suggested, you are free to use other colors or patterns. It can be a single pixel or a whole gradient; it is up to you. In the example below, we are encoding the watermark in a specific location in the image using the *Translate* node; this helps later because we only have to look at **a specific location for the mark**. We then use the **RGB to BW node** to convert the image to numbers that the Map Value node can use to make the image subliminal. In this case, it reduces the mark to one-tenth of its original intensity. The Add **node** adds the corresponding pixels, make the ones containing the mark ever-so-slightly brighter.

Title-Img 4. 27Embedding your mark in an Image using a Mark and Specific Position.



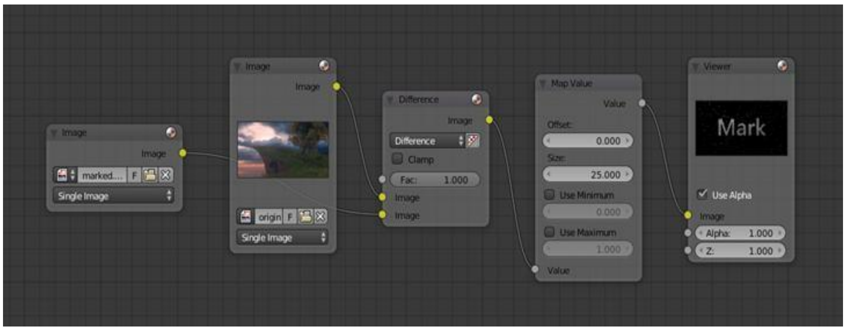
Source-blender.org **Link-**

https://docs.blender.org/manual/en/dev/render/blender_render/materials/nodes/types/color/mix_rgb.html?highlight=mix%20node

Of course, if you *want* people to notice your mark, **do not scale it so much**, or make it a **contrasting color**. There are also many other ways, using other mix settings and fancier rigs. Feel free to experiment!

Decoding an Image for your Watermark

When you see an image that you think might be yours, use the node map below **to compare it to your stock image** (pre-watermarked original). In this map, the **Mix node** is set to Difference, and the Map Value node amplifies any difference. The result is routed to a viewer, and you can see how the original mark stands out, clear as a bell:

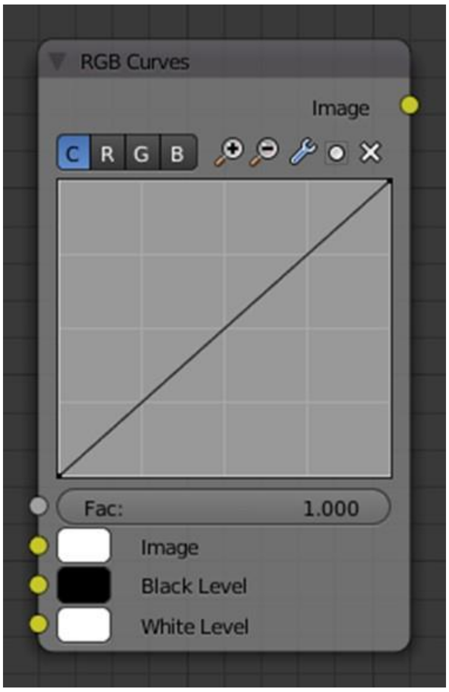


Title-Img 4. 28 Checking an image for your watermark.

Source-blender.org **Link-** https://docs.blender.org/manual/en/dev/render/blender_render/materials/nodes/types/color/mix_rgb.html?highlight=mix%20node

Various image compression algorithms lose some of the original; the difference shows as noise. Experiment with different compression settings and marks to see which works best for you by having the **encoding map** in one scene, and the **decoding map** in another. Use them while changing Blender’s image format settings, reloading the watermarked image after saving, to get an acceptable result. In the example above, the mark was clearly visible all the way up to **JPEG compression of 50%.**

RGB Curves Node



Title-Img 4. 29RGB Curves Node**.**

Source-blender.org **Link-**

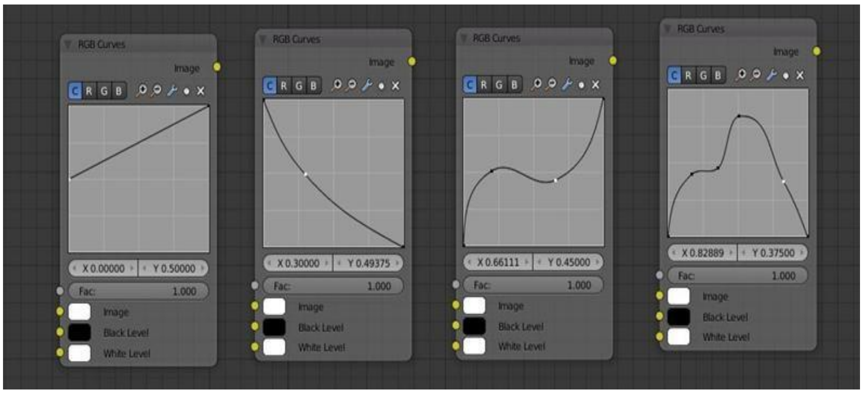
https://docs.blender.org/manual/en/dev/compositing/types/color/rgb_curves. html?highlight=rgb%20curves%20node

This node allows **color corrections** for each color channel and levels adjustments in the compositing context.

Inputs	
Factor	Controls the amount of influence the node exerts on the output image.
Image	Standard image input.
Black Level	Defines the input color that is (linear) mapped to black.
White Level	Defines the input color that is (linear) mapped to white.
Properties	
Channel	Clicking on one of the channels displays the curve for each. C (Combined RGB), R (Red), G (Green), B (Blue), L (Luminance)
Curve	A Bézier curve that varies the input levels (x-axis) to produce an output level (y-axis).
Outputs	
Image	Standard image output.

Examples

Here are some common curves you can use to achieve desired effects:



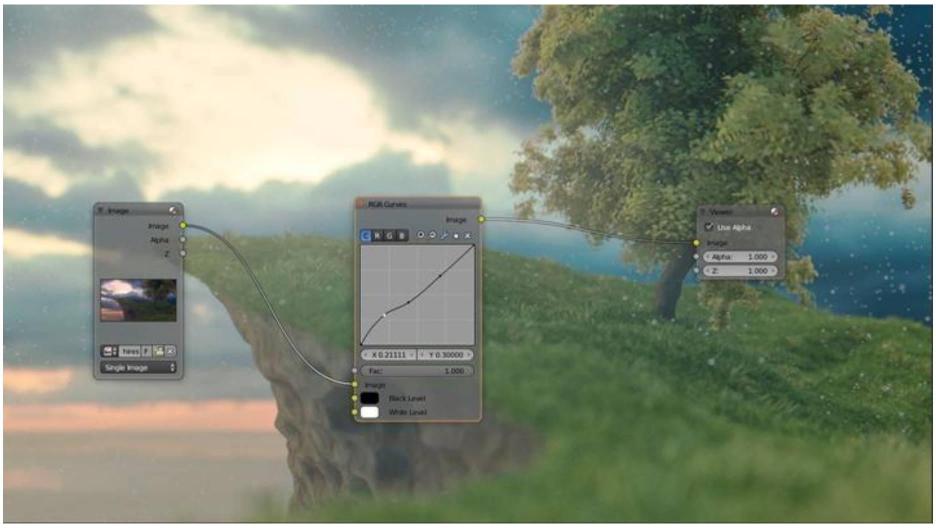
Title-Img 4. 30 From left to right: 1. Lighten 2. Negative 3. Decrease Contrast 4. Posterize.

Attribution- Source-blender.org

Link-

https://docs.blender.org/manual/en/dev/compositing/types/color/rgb_curves.html?highlight=rgb%20curves%20node

Color correction using Curves



Title-Img 4. 31Color correction with curves.

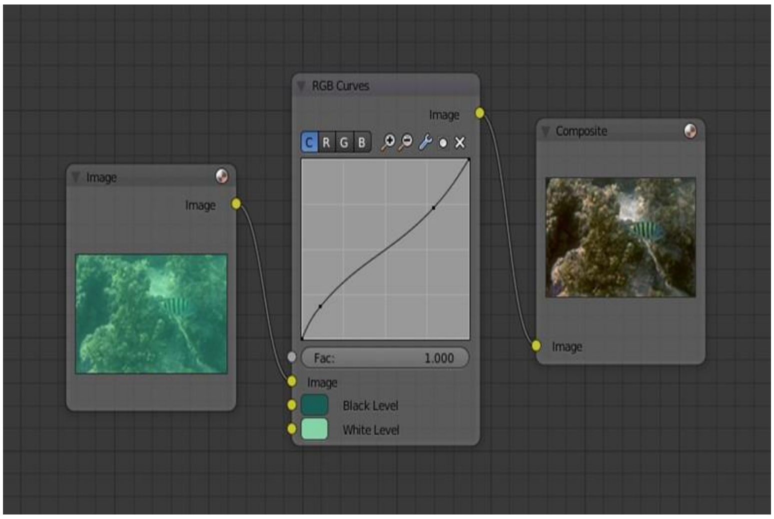
Source-blender.org **Link-**

https://docs.blender.org/manual/en/dev/compositing/types/color/rgb_curves. html?highlight=rgb%20curves%20node

In this example, the image has way **too much red** in it, so we run it through an **RGB node** and reduce the **Red channel by about half**.

We added a **middle dot,** so we could make the line into a sideways exponential curve. This kind of curve evens out the amount of a color in an image as it reaches saturation. Also, read on for examples of the **Darken and Contrast Enhancement** curves.

Color correction using Black/White Levels



Title-Img 4. 32Color correction with Black/White Levels.

Source-blender.org

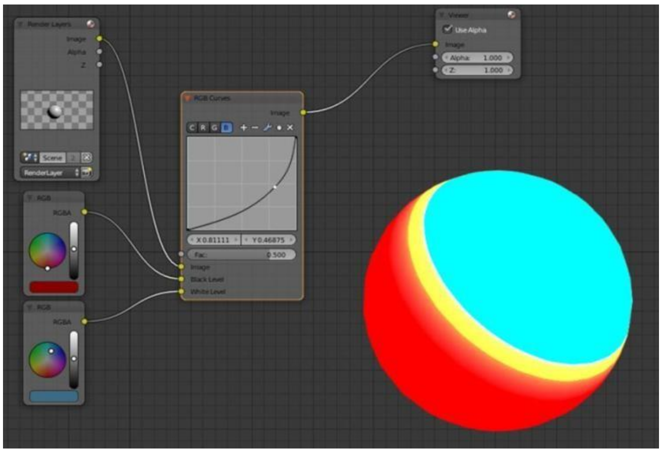
Link-https://docs.blender.org/manual/en/dev/compositing/types/color/rgb_curves.html?highlight=rgb%20curves%20node

Manually adjusting the RGB curves for color correction can be **difficult**. Another option for color correction is to use the **Black and White Levels** instead, which really might be their main purpose.

In this example, the **White Level** is set to the color of a **bright spot of the sand** in the background, and the **Black Level** to the color in the center of the **fish's eye**. To do this efficiently it is best to bring up the **UV/Image editor** showing the original input image. You can then use the levels' color picker to easily choose the appropriate colors from the input image, zooming into pixel level if necessary. The result can be **fine-tuned with the RGB curves** like in the previous example.

The curve for C is used to compensate for the increased contrast that is a side-effect of setting Black and White Levels.

Effects



Title-Img 4. 33Changing colors.

Source-blender.org **Link-**
https://docs.blender.org/manual/en/dev/compositing/types/color/rgb_curves. html?highlight=rgb%20curves%20node

Curves and Black/White Levels can also be used to completely change the colors of an image.

Note that e.g. setting **Black Level to red** and **White Level to blue** does not simply substitute black with red and white with blue as the example image might suggest. Levels do **color scaling,** not substitution, however, depending on the settings they can result in the described color substitution.

(What really happens when setting **Black Level to pure red** and **White Level to pure blue** is that the **red channel gets inverted**, **green gets reduced to zero** and blue remains unchanged.)

Because of this, the results of setting arbitrary Black/White Levels or RGB curves is hard to predict, however, can be fun to play with.

Unit summary

In this Unit, we have learnt what is Texture and how to

- map those textures onto your 3D Objects
- use texture Panels and assign textures with various mapping types
- create complex shading texture using blending techniques both with colors and maps making it more procedural and along with environmental mapping with reflection and refractions.

After learning of this Unit, you can download the Open Source Software available on the internet for free of cost to practice the possibilities of creating Materials and Texturing.

Assignment

- *Texture **the 3D Scene** appropriately with good high-resolution maps available online, make it more personalized the way you would **decorate your room**.*
- *Use these keywords **"bedroom designs"**, **"bedroom furniture"** on*www.google.com *to collect the reference image to build your shading scene.*

Assessment

- Explain the process of assigning a Texture to 3D Object
- Write a note on Mapping and Warping
- List and Explain the projection types in Texture map
- Differentiate Bump and Normal Maps
- Write a note on Displacement Map
- List any five types of Procedural Textures.
- Name the different types of Node in Blender
- Decode an image for your Watermark

Resources

While studying this course, you can browse the following internet links for video tutorials and to download the relevant texture maps to assign on the objects that you have created and use the same for your assignments.

Links to Download Open Projects

The iconic Blender Institute Open Movies. Featuring all the production files, assets, artwork, and never-seen-before content.

https://cloud.blender.org/open-projects

- wiki.blender.org
- archive.org
- www.blender.org
- docs.blender.org

DMA-201

3D Animation

Block – III: 3D Animation & Rigging (Practical)

Unit-1 Introduction to Rigging

Introduction

Rigging is a process done prior to the Animation. Rigging is a process of taking a static mesh, creating an internal digital skeleton, creating a relationship between the mesh and the skeleton (known as skinning, enveloping or binding) and adding a set of controls that the animator can use to push and pull the character around as if he/she is a puppeteer.

Most commonly, characters are Rigged before they are animated because if a character model doesn't have a Rig, they can't be deformed and moved around. Process of Rigging also involves Rigging character or creatures and Objects like car, plane, or a robot.

In this Unit, you will learn about the process of Rigging and how it is important in designing 3D animation.

Outcomes

Upon completion of this unit you will be able to

- Explain the Usage of Constraints
- Plan for Adding or Removing Constraints
- Describe the Functions of Header
- Explain the term Header, Target, Space, Influence
- Create IK Constraint
- Create Spline IK Constraint

Terminology

Constraints	:	Constraints are a fantastic way to add sophistication and complexity to a Rig
Header		A Header sits at the top of every Constraint.
Target	:	The Target field lets you link the Constraint to a Target Object of your choosing
Space	:	The frame of reference is called the “space” of the Constraint
World space		Transformation, Rotation and Scale are oriented to the world axes
Local Space	:	Transformation, Rotation and Scale are oriented to the parent Object axe

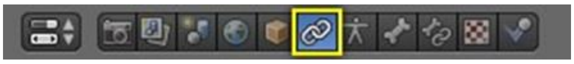
Influence	:	The influence slider determines how much the Constraint will affect the constrained Object
IK Solver Constraint	:	The Inverse Kinematics Constraint implements the inverse kinematics armature posing technique
Spline IK Constraint	:	The Spline IK Constraint aligns a chain of Bones along a curve
Stretch to Constraint	:	The Stretch To Constraint causes its owner to rotate and scale its Y axis towards its Target.
Action Constraint	:	It allows you to control an Action using the transformations of another Object.
Child of Constraint	:	Child of Constraint is the Constraint version of the standard parent/children relationship

Working with Constraints

Constraints control the behavior of one Object with data from another. It can make the eyes of a tennis player track a tennis ball bouncing across the court. It allows the wheels on a bus to all rotate together. It helps a dinosaur's legs bend at the knee automatically. It makes it easy for a hand to grip the hilt of a sword and the sword to swing with the hand.

Constraints, in Blender, work with Object and Bone.

Object Constraint

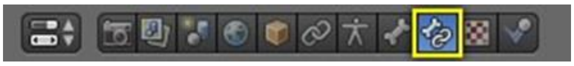


Title-Img 1. 1 Object Constraints

Source-blender.org

Link :https://docs.blender.org/manual/en/dev/rigging/constraints/introduction.html

Bone Constraint

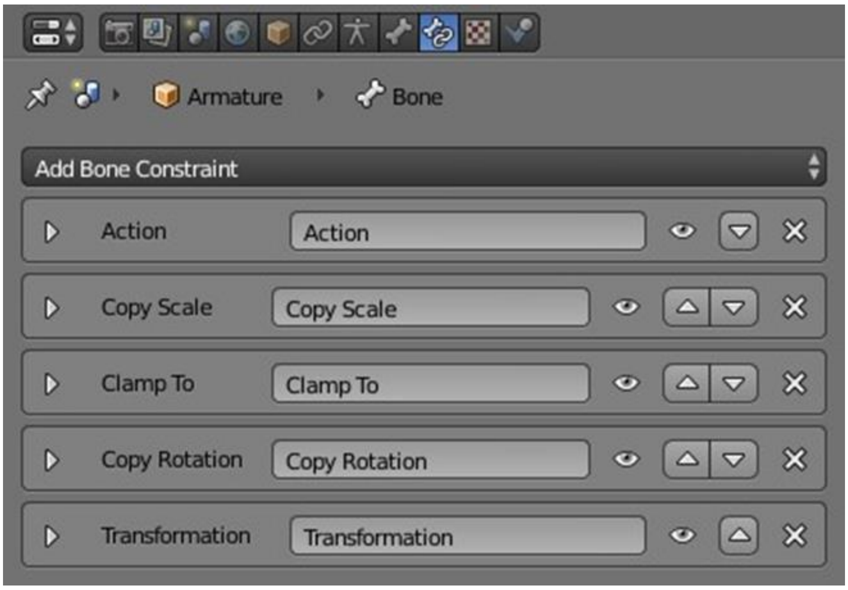


Title-Img 1. 2 Bone Constraints

Source-blender.org

Link https://docs.blender.org/manual/en/dev/rigging/constraints/introduction.html

Constraints work in combination with each other to form a **Constraint Stack**.



Title-Img 1. 3 Constraint Stack

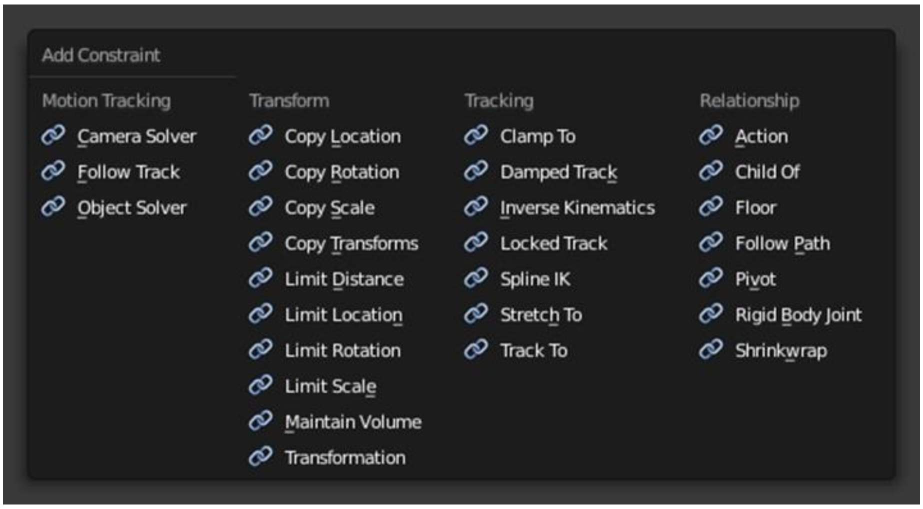
Source-blender.org

Link : https://docs.blender.org/manual/en/dev/rigging/constraints/introduction.html

The **Constraint Stack** is evaluated from top to bottom.

Constraints are a fantastic way to add sophistication and complexity to a Rig. However, be careful not to rush in too quickly, piling up Constraint upon Constraint until you lose all sense of how they interact with each other.

Adding/Removing a Constraint



Title-Img 1. 4 Adding/Removing Constraint

Source-blender.org

Link:https://docs.blender.org/manual/en/dev/rigging/constraints/interface/adding_
removing.html

To add a Constraint in the Constraints Panel:

- Step 1: Click on the "Add Constraint" menu. (Refer Img 1.4)

To add a Constraint in 3D View:

- Step 2: Select the Object you would like to constrain.
- Step 3: Press Ctrl-Shift-C and choose a Constraint from the pop-up menu.

If the chosen Constraint needs a Target, Blender will add **an empty automatically** as the Target and position it **at the center** of the constrained Object.

To add a Constraint in 3D View and simultaneously give it a Target:

- Step 1: Select the Target first and then shift-select the Object you would like to constrain.
- Step 2: Press Ctrl-Shift-C and choose a Constraint from the pop-up menu.

To remove a Constraint:

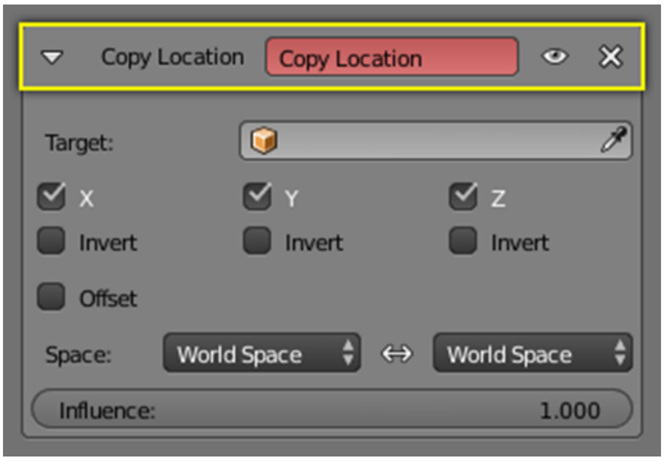
- Step 1: Click on the “X” button in the header.

To remove all Constraints from all selected Object(s):

- Step 2: Click Object ‣ Constraints ‣ Clear Object Constraints in 3D View Header.
- Step 3: Or Pose ‣ Constraints ‣ Clear Pose Constraints (for Bone Constraints).
- Step 4: Or, press Ctrl-Alt-C.

Header

Every Constraint has a header. The interface elements of the header are explained below using a Copy Location Constraint as an example. (Refer Img 1.5)



Title-Img 1. 2 A Header sits at the top of every Constraint.

Source-blender.org

Link : https://docs.blender.org/manual/en/dev/rigging/constraints/interface/header.

Expansion Arrow (pointing down or Right)

Show or Hide the settings of the Constraint. Tidy up the Constraint stack by hiding Constraints that do not currently need attention. Constraints will continue to affect the scene even when hidden.

- ## “Copy Location” (first occurrence)

  The type of Constraint is determined when a new Constraint is created to help in the process of Rigging.

- ## “Copy Location” (second occurrence)

  Give the Constraint a meaningful name in this field, something that describes its intent. Meaningful names help to understand what each Constraint is supposedto do.

The **red background** is a warning that the Constraint is not yet functional. The background will turn **grey** when the Constraint is functioning. When this Copy Location Constraint has a valid Target in the “**Target Field**” it will turn **grey** and begin to function.

- ## Eyeball (open or closed)

  Enable or Disable (Mute/Unmute) the Constraint. Disabling a Constraint will stop its effect on the scene.

Disabling a Constraint is useful for turning off a Constraint without losing all its settings. Disabling means you can enable the Constraint later with the settings intact. Disabling is like setting the influence slider to 0.0.

- ## Up/Down Arrows

  Move a Constraint up or down in the Constraint stack. Since the stack is evaluated from top to bottom, moving a Constraint in the stack can significantly affect the final outcome of the stack.

  If there is **only one Constraint** in the stack, the arrows will not be drawn. If the Constraint is at the **top** of the stack, only the **down arrow** will be drawn. If the Constraint is at the **bottom** of the stack, only the **up arrow** will be drawn.

  Delete the Constraint from the stack. The settings will be lost. The Constraint will no longer affect the final outcome of the stack.

Target

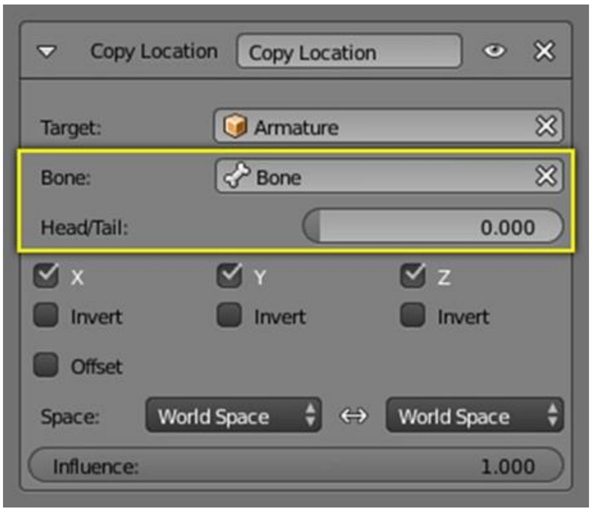
The Target field lets you **link the Constraint** to a Target Object of your choosing. This link provides data to the Constraint so that it can begin to function. For example, the **Copy Location Constraint** needs location data to function. Fill in the Target field, and the Copy Location Constraint will begin to use location data from the Target Object.

The **Target field** must be filled in for the Constraint to function. (Refer Img 1.6)

By default, the Target will use the **Object Center** as the **Target point**.

- If the Target field links to a **Mesh or Lattice Object**, a **Vertex Group field** will appear. Enter the name of a vertex group and the Constraint will Target the median point of this vertex group instead of the Object center.

- If the Target field links to **an Armature**, a **Bone field** will appear along with a Head or Tail slider. Enter the name of a Bone and the Constraint will Target the Bone instead of the entire armature Object center. Slide the slider and the Constraint will Target the head, the tail or somewhere in-between.

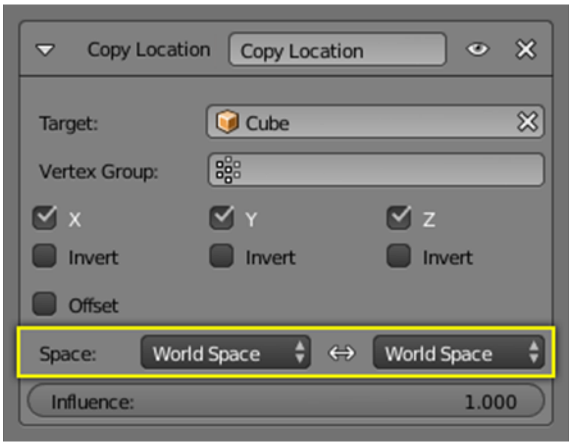


Title-Img 1. 3 Target Field.
Source-blender.org
Link-https://docs.blender.org/manual/en/dev/rigging/constraints/inter face/common.html

Space

Constraints need a **frame of reference** in order to function. This frame of reference is called the "**space**" of the Constraint. Choosing **one space vs. another** will change this frame of reference and substantially alter the behaviour of a Constraint. (Refer Img 1.7)

To understand how changing the space will change the behaviour of the Constraint, consider experimenting with two empties. Makesure they display **as arrows** so that you can see the **local axes for each empty**. Make sure to size one empty a little larger than the other so that they are both always visible even if directly on top of each other. Then add a Constraint to one empty that Targets the other and experiment thoroughly by moving, rotating and scaling the Target in many different ways.



Title-Img 1. 4. Space

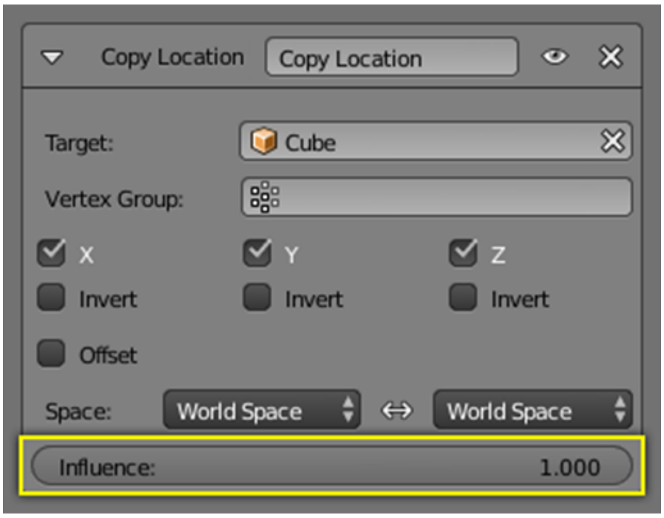
Source-blender.org

Link:https://docs.blender.org/manual/en/dev/rigging/constraints/interface/c ommon.html

*This Constraint is set to use **World Space** as the frame of referencefor both its **Target Space** and its **Owner Space**.*

Influence

The influence slider determines **how much the Constraint** willaffect the constrained Object.



Title-Img 1. 5 Influence

Source-blender.org

Linkhttps://docs.blender.org/manual/en/dev/rigging/constraints/interface/c ommon.html

- An influence of **0.0** will have **no effect**.
- An influence of **1.0** will have the **full effect**.
- Values **between (0.0 and 1.0)**, will have a **partial effect**, however, be careful. These partial effectscan be difficult to control, especially as the Constraint stack grows in complexity.

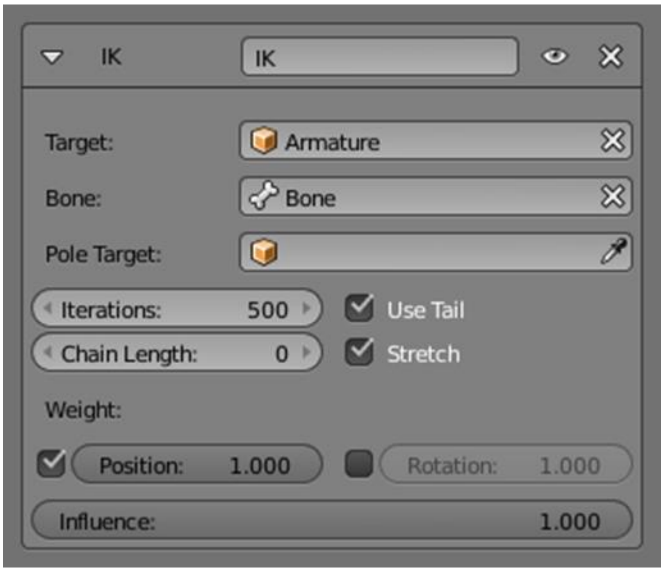
The influence value is animatable, allowing Constraints to be **turned off**, or partially on as needed. (Refer Img 1.8)

IK Solver Constraint

The **Inverse Kinematics Constraint** implements the inverse kinematics armature posing technique. Hence, it is only available **for Bones**. (Refer Img 1.9)

- To quickly create an IK Constraint with a Target, select a Bone in pose mode, and press **Shift-I**.

Options



Title-Img 1. 6Inverse Kinematics panel.

Source-blender.org

Link-https://docs.blender.org/manual/en/dev/rigging/constraints/tracking/ik_solver.html

- **Target**

  Must be an armature.

- **Bone**

  A Bone in the armature.

- **Pole Target**

  Object for pole rotation.

- **Iterations**

  Maximum number of solving iterations.

- **Chain Length**

  How many Bones are included in the IK effect? Set to 0 toinclude all Bones.

- **Use Tail**

Include Bone’s tail as last element in chain.

- **Stretch**

  Enable IK stretching.

- **Weight**
- **Position**
  - For Tree-IK: Weight of position control for thisTarget.
- **Rotation**
  - Chain follow rotation of Target.
- **Target**

  Disable for Target-less IK.

- **Rotation**

  Chain follows rotation of Target.

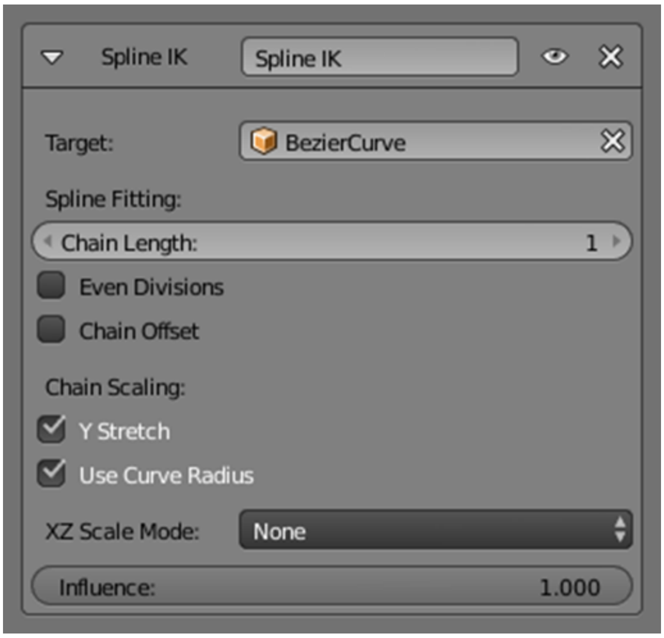
Spline IK Constraint

The Spline IK Constraint aligns a **chain of Bones** along a curve. By leveraging the ease and flexibility of achieving aesthetically pleasing shapes offered by curves and the predictability and well- integrated control offered by Bones, **Spline IK** is an invaluable tool in the **Riggers’ toolbox**. It is particularly well suited for Rigging flexible body parts such as **tails, tentacles, and spines, as well as inorganic items such as ropes.** (Refer Img 1.10)

To set up Spline IK, it is necessary to have a **chain of connected Bones** and a curve to constrain these Bones to:

- **Step 1:** With the **last Bone in the chain** selected, add a Spline IK Constraint from the Bone Constraints tab in the Properties Editor.
- **Step 2:** Set the ‘**Chain Length**’ setting to the number of Bones in the chain (starting from and including the selected Bone) that should be influenced by the curve.
- **Step 3**: Finally, set **Target** to the curve that should control the curve.

Options



Title-Img 1. 7. Spline IK panel.

Source-blender.org

Link :https://docs.blender.org/manual/en/dev/rigging/constraints/tracking/s pline_ik.html

- **Target**

  The type of the Target curve.

- **Spline Fitting**
  - **Chain Length**

  How many Bones are included in the chain.

- **Even Division**

  Ignore the relative length of the Bones when fitting to thecurve.

- **Chain Offset**

Offset the entire chain relative to the root joint.

- **Chain Scaling**
  - **Y stretch**

  Stretch the Y axis of the Bones to fit the curve.

- **XZ Scale Mode**
  - **None**

  Do not scale the X and X axes.

  - **Bone Original**

  Use the original scaling of the Bones.

  - **Volume Preservation**

Scale of the X and Z axes is the inverse of the Yscale.

- **Use Curve Radius**

  Average radius of the endpoints is used to tweak the X andZ scaling of the Bones, on top of the X and Z scale mode.

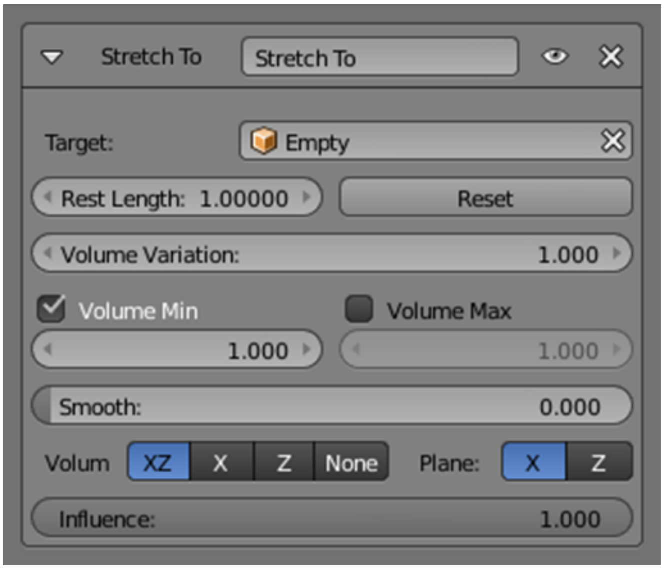
Stretch to Constraint

The Stretch To Constraint causes its **owner to rotate** and **scale itsY axis** towards its Target. So, it has the same tracking behavior as the **Track To Constraint**. However, it assumes that the Y axis willbe the tracking and stretching axis, and does not give you the option of using a different one.

It also optionally has some **raw volumetric features**, so the owner can **squash down** as the Target moves **closer**, or **thin out** as the Target moves **farther** away. Note that it is not the real volume of the owner which is thus preserved, however, rather the virtual one defined by its scale values. Hence, this feature works evenwith **non-volumetric Objects**, like empties, 2D meshes or surfaces,and curves.

With Bones, the "**volumetric**" variation scales them along their own local axes (remember that the local Y axis of a Bone is aligned with it, from root to tip). (Refer Img 1.11)

Options



Title-Img 1. 8 Stretch To panel.

Source-blender.org

Link: https://docs.blender.org/manual/en/dev/rigging/constraints/track ing/stretch_to.html

- **Target (Mesh Object Type)**

This Constraint uses one Target, and is not functional (redstate) when it has none.

- **Vertex Group**

When Target is a mesh, a new field is display where avertex group can be selected.

- **Target (Armature Object Type)**

This Constraint uses one Target, and is not functional (redstate) when it has none.

- **Bone**

When Target is an armature, a new field for a Bone isdisplayed.

- **Head/Tail**

When using a Bone Target, you can choose where alongthis Bone the Target point lies.

- **Rest Length**

This number button sets the rest distance between theowner and its Target, i.e. the distance at which there is no deformation (stretching) of the owner.

- **Reset**

When clicked, this small button will recalculate the Rest Length value, so that it corresponds to the actual distance between the owner and its Target (i.e. the distance before this Constraint is applied).

- **Volume**

These buttons control which of the X and/or Z axes should be affected (scaled up/down) to preserve the virtual volume while stretching along the Y axis. If you enable the none button, the volumetric features are disabled.

- **Plane**

These buttons are equivalent to the Up ones of the TrackTo Constraint: they control which of the X or Z axes should be maintained (as much as possible) aligned with the global Z axis, while tracking the Target with the Y axis.

Relationship

Action Constraint

The Action Constraint is **powerful**. It allows you to **control anAction** using the transformations of another Object.

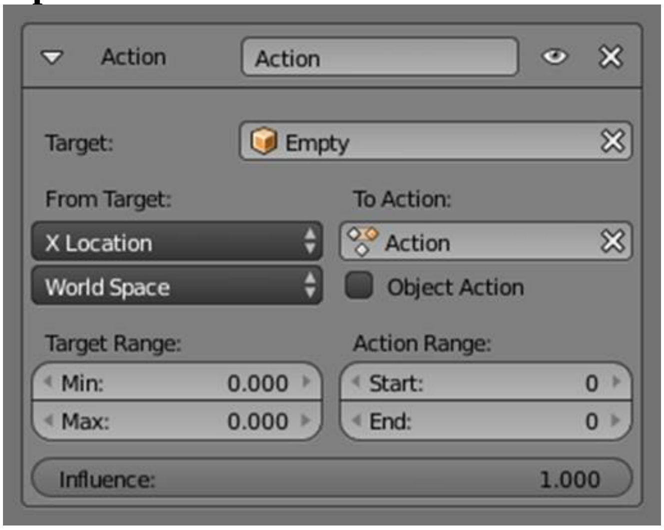
The underlying idea of the Action Constraint is very similar to the one behind the Drivers, except that the former uses a whole action (i.e. a bunch a F-Curves of the same type), while the latter controls a **single F-curve** of their “owner”

Note that even if the Constraint accepts the **Mesh action** type, only the Object, Pose and Constraint types are really working, as Constraints can only affect Objects’ or Bones’ transform properties, and **not meshes’ shapes**. Also, note that only the **Object transformation (location,**

rotation, scale) is affected by the action, if the action contains keyframes for other properties they are ignored, as Constraints do not influence those.

As an example, let us assume you have defined an **Object action** (it can be assigned to any Object, or even no Object at all), and have mapped it on your owner through an **Action Constraint**, so that moving the Target in the (0.0 to 2.0) range along its X-Axis maps the action content on the owner in the (0 to 100) frame range. This will mean that when the Target's X property is **0.0** the owner will be as if in **frame 0** of the linked action; with the Target's X property at **1.0** the owner will be as if in **frame 50** of thelinked action, etc. (Refer Img 1.12)

Options



Title-Img 1. 9 Action panel.

Source-blender.org

Linkhttps://docs.blender.org/manual/en/dev/rigging/constraints/relationship/action.html

- **Target**

This Constraint uses one Target, and is not functional (redstate) when it has none.

- **Bone**

When Target is an armature Object, use this field to selectthe Target Bone.

- **Transform Channel**

This selector controls which transform property (location, rotation or scale along/around one of its axes) from the Target to use as "action driver".

- **Target Space**

This Constraint allows you to choose in which space toevaluate its Target's transform properties.

- **To Action**

Select the name of the action you want to use.

- **Object Action**

Bones only, when enabled, this option will make the constrained Bone use the "Object" part of the linked action, instead of the "same-named pose" part. This allowsyou to apply the action of an Object to a Bone.

- **Target Range Min/Max**

The lower and upper bounds of the driving transform property value.

- **Action Range Start/End**

The starting and ending frames of the action to be mapped.

Child of Constraint

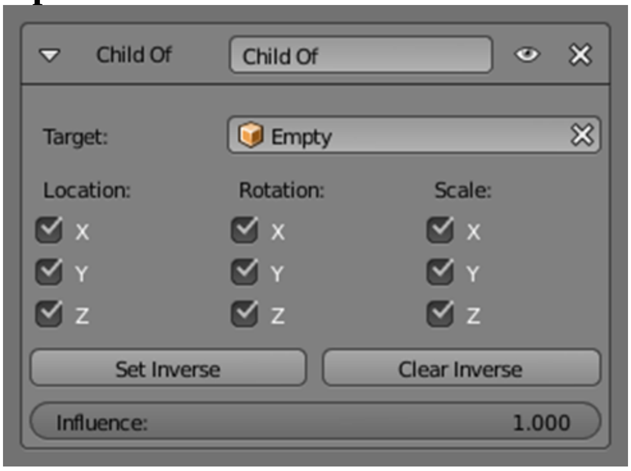
Child of Constraint is the **Constraint version of the standard** parent/children relationship between Objects (the one establishedthrough the **Ctrl-P** shortcut, in **3D Views**).

Parenting with a Constraint has **several advantages** and enhancements, compared to the traditional method: (Refer Img 1.13)

You can have several **different parents** for the sameObject (weighting their respective influence with the Influence slider).

As with any Constraint, you can key (i.e. animate)its Influence setting. This allows the Object which has a Child of Constraint upon it to change over time which Target Object will be considered theparent, and therefore have influence over the Child of Constraint Object.

Options



Title-Img 1. 10 Child Of panel

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/rigging/constraints/relationship/child_of.html

- **Target**

The Target Object that this Object will act as a child of. ThisConstraint uses one Target, and is not functional (red state)when it has none. If Target is an armature or a mesh, a newname field appears where a name of a Bone or a Vertex Group can be selected.

- **Location X, Y, Z**

Each of these buttons will make the parent affect or not affect the location along the corresponding axis.

- **Rotation X, Y, Z**

Each of these buttons will make the parent affect or not affect the rotation around the corresponding axis.

- **Scale X, Y, Z**

Each of these buttons will make the parent affect or not affect the scale along the corresponding axis.

- **Set Inverse**

By default, when you parent your owner to your Target,the Target becomes the origin of the owner's space. This means that the location, rotation and scale of the owner are offset by the same properties of the Target. In other words, the owner is transformed when you parent it to your Target. This might not be desired! So, if you want to restore your owner to its before-parenting state, click on the Set Inverse button.

- **Clear Inverse**

This button reverses (cancels) the effects of the above one,restoring the owner/child to its default state regarding its Target/parent.

Technical Note

If you use this Constraint with all channels on, it will use a **straight matrix multiplication** for the parent relationship, not decomposing the parent matrix into **loc /rot/size**. This ensures any transformation correctly gets applied, also for combinations of**rotated** and **non-uniform** scaled parents.

Unit summary

In this Unit, you have learnt what is Rigging and how to

- Use the Constraints
- Do Adding or Removing Constraints
- Describe the Functions of Header
- Explain the term Header, Target, Space, Influence
- Edit the Properties of the Header panel, working on Parentand Child relationship
- Create IK Constraint
- Create Spline IK Constraint

After learning this Unit, you can download the Open Source Software available on the internet for free of cost to practice the possibilities of creating Rig.

Assignment

- Create a basic Mechanical Rig referring to the YouTube video link

Assessment

- Define Constraints.
- State the Differentiate between Local space and World space.
- Write notes on Adding and Deleting Constraints withexamples.
- Describe the Process of making a Parent Constraint.
- Write a brief note on the uses of Header.
- Explain Parent and Child Constraint.
- Write down the process of Creating Spline IK.
- Define Stretch Constraint

Fill in the Blanks

1. _________ is a good first Constraint to explore in thebeginning.
2. ____________sits at the top of every Constraint.
3. _____________Enables or Disables (Mute/Unmute) theConstraint.
4. _______________allows you to control an Action using thetransformations of another Object.
5. The____________slider determines how much theConstraint will affect the constrained Object.

Resources

While studying this Unit, you can browse the internet links for online video tutorials and several books and training DVDs available in the Blender Store and on the Blender Cloud.

- wiki.blender.org
- archive.org
- www.blender.org
- docs.blender.org

Unit-2 Introduction to Working withArmature

Introduction

An **Armature in Blender** is similar to the **Armature of a real skeleton**. Just like a real skeleton, an Armature can consist of**many Bones**. These Bones can be moved around and anythingthat they are attached to or associated with will move and deform in a similar way. An "**Armature**" is a type of **Object used for rigging**. Armature Object borrows many ideas from real life skeletons.

As Armatures are designed to be posed, either for a **static oranimated** scene, they have a specific state, called "**rest position**". This is the Armature's default "**shape**", the default position/rotation/scale of its Bones, as set in **Edit mode**.

In Edit mode, you will always see your Armature in **rest position**, whereas in Object and Pose mode, you usually get the current "**pose**" of the Armature (unless you enable the Rest Position button of the Armature panel).

This unit will describe how you can **work with Armatures in Blender**.

Outcomes

Upon completion of this unit you will be able to:

- Explain the Usage of Bones
- List the types of Armature structure
- Manage to Edit an Armature
- Arrange Linking Objects to Bone
- Set up Mesh and Armature using Skinning
- Create Poses for the Rigged Character

Terminology

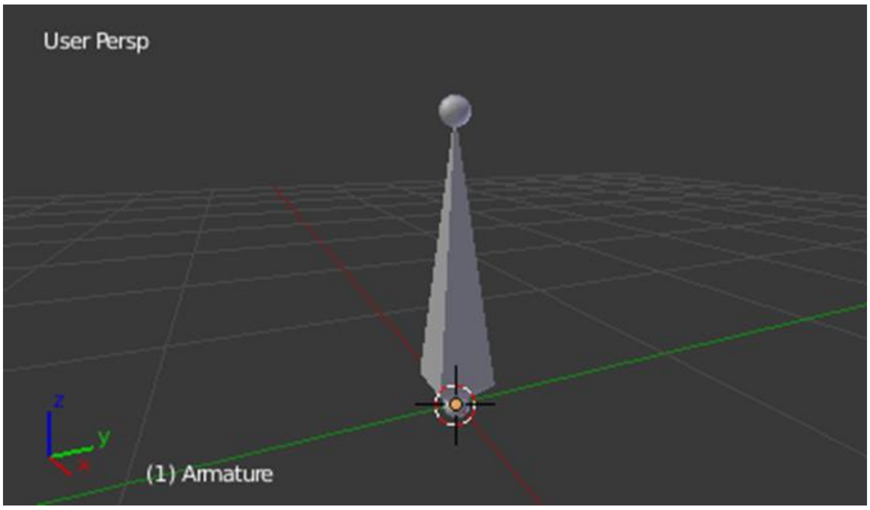
Armatures	:	Armature is the Object type used for rigging and it borrows many ideas from real life skeletons
Roll	:	Activating Axes checkbox on the will show localaxes for each Bone's tip.
Bones Influence	:	Basically, a Bone controls geometry when vertices "follow" the Bone
Armature Layers	:	Each Armature has 32 "Armature layers" which allow you to organize your Armature by "regrouping" sets of Bones into layers.
Octahedral Bone	:	This is the default visualization, well suited formost of editing tasks.
Stick Bone	:	This is the simplest and most non-intrusivevisualization.
B-Bone Bone	:	This visualization shows the curves of "smooth" multi-segmented Bones; see the Bendy Bones for details.
Envelope Bone	:	This visualization materializes the Bone deformation influence.
Pose Library	:	The Pose Library panel is used to save, apply,and manage different

		Armature poses.
Ghost	:	In traditional cartoon creation animators use tracing paper, to see several frames preceding the one they are working.
Shadow	:	Controls how objects using this Material castand receive shadows.
Structure	:	Armatures mimic real skeletons. They are made from Bones, which are (by default) rigid elements.
Chains of Bones	:	Bone can be the parent of several children, andhence be part of several chains at the same time.

Working with Armature

First, let us try to add the **default Armature** in Blender.

- **Step 1:** Open a default scene.
- **Step 2:** Delete all Objects in the scene.
- **Step 3:** Make sure the cursor is in the world originwith Shift-C.
- **Step 4:** Press Numpad1 to see the world in Frontview.
- **Step 5:** Add a Single Bone (Add ‣ Armature ‣ SingleBone).
- **Step 6:** Press Numpad Delete to see the Armatureat maximum zoom.



Title-Img 2. 1 The default Armature.

Source- blender.org

Link- https://docs.blender.org/manual/en/dev/rigging/armatures/intro duction.html

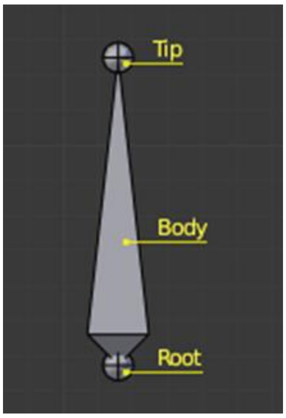
Armature Object

As you can see, an Armature is like any other Object type inBlender:

- It has a **center, a position, a rotation and a scale factor**.

- It has an **Object Data data-block** that can be edited in **Edit Mode.**
- It can be linked to other scenes, and the same Armature data can be **reused** on multiple Objects.
- All animation you do in Object Mode is only working on thewhole Object, not the **Armature's Bones** (use the **PoseMode** to do this).
- As Armatures are designed to be posed, either for a **static or animated scene**, they have a specific state, called "**rest position**". This is the Armature's default "**shape**", the default position/rotation/scale of its Bones, as set in Edit Mode.
- In **Edit Mode**, you will always see your **Armature in rest position**, whereas in **Object Mode and Pose Mode**, you usually get the current "**pose" of the Armature** (unless you enable the Rest Position button of the Armature panel).

Bones Structure



Title-Img 2. 2 The elements of a Bone.

Source- blender.org

Link- https://docs.blender.org/manual/en/dev/rigging/armatures/bones/stru cture.html

They have three elements:

1. "Start joint" named **Root** or Head,
2. "**Body**" itself,
3. "End joint" named **Tip** or Tail.

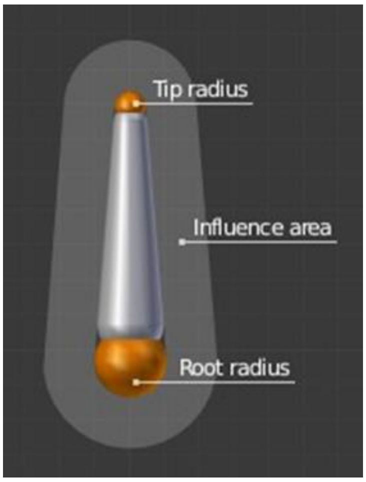
With the default Armature in edit-mode, you can select the root and the tip, and move them as you do with mesh vertices. Both root and tip (the "**joints**") define the Bone by their respective position.

They also have a radius property, only useful for the envelope deformation method.

Roll

Activating Axes checkbox on the Armature tab ‣ Display panel, will show local axes for each Bone's tip. The Y axis is always aligned along the Bone, oriented from root to tip. So, this is the "**roll**" axis of the Bones.

Bones Influence



Title-Img 2. 3 A Bone in Envelope visualization, in Edit Mode.

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/rigging/armatures/bones/stru cture.html

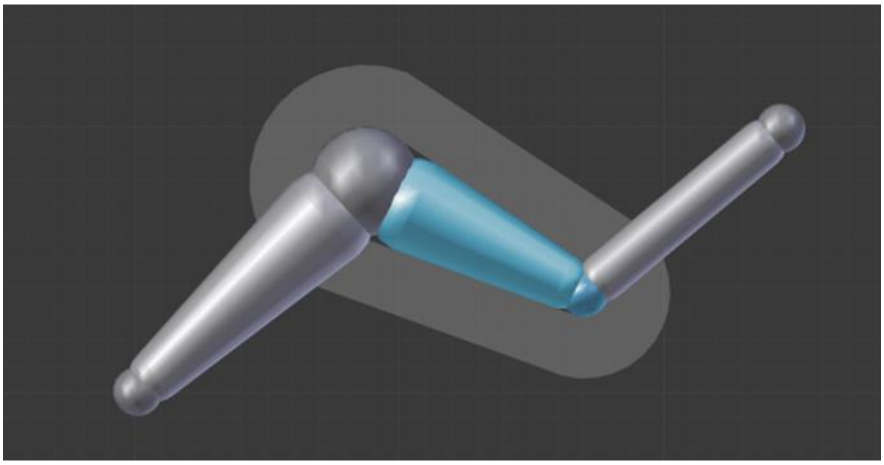
Basically, a Bone **controls geometry** when vertices "follow" the Bone. This is like how the muscles and skin of your finger follow your **finger-Bone when you move a finger**.

To do this, you must define the strength of influences a Bone has on a certain vertex.

The simplest way is to have each Bone affecting those parts of the geometry that are within a given range from it. This is called the **Envelope Technique**, because each Bone can control only the geometry "enveloped" by its own influence area.

If a Bone is visualized as **Envelope**, in **Edit Mode** and in **Pose Mode** you can see the area of influence, which depends on:

- The Distance Property and
- The Root's Radius and the Tip's Radius.



Title-Img 2. 4 Our Armature in Envelope visualization, in Pose Mode.

Source- blender.org

Linkhttps://docs.blender.org/manual/en/dev/rigging/armatures/bones/st ructure.html

Selection of Bones

You can select and edit **Bones of Armatures** in Edit Mode and in Pose Mode. Here, we will see how to select Bones in Edit Mode. Selecting Bones in **Pose Mode** is similar to selecting in **Edit Mode** with a few specific differences that will be detailed in the posing part.

Similar to vertices/edges selection in meshes, there are **two ways** to select whole Bones in Edit Mode:

- Directly, by selecting the Bone's body.
- Selecting both of its joints (roots and tip).

This is an important point to understand, because **selecting Bones' joints** only might lead to non-obvious behavior, with respect to which Bone you actually select.

Selecting Bone Joints

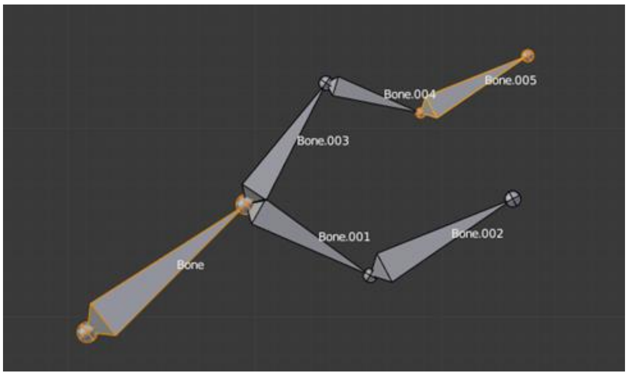
To select Bones' joints, you have the standard selectionmethods.

- ### Inverse selection

As stated above, you must remember that these selection tools are **for Bones' joints** only, not the **Bones' bodies.**

For example, the **Inverse selection** option **Ctrl-I** inverts the selection **of Bones' joints**, not of **Bones.**

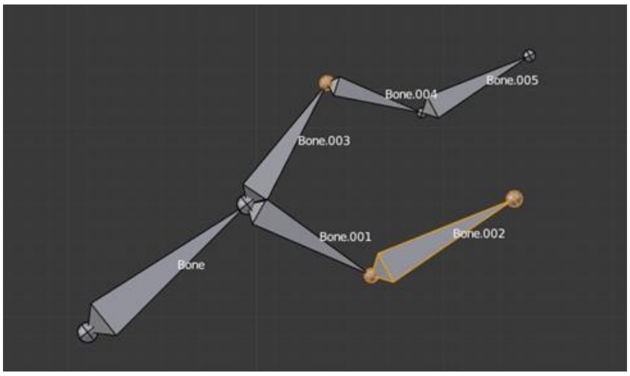
Remember that **a Bone** is selected only if both its joints areselected. So, when the selection status of **Bones' joints** is inverted, a new set of Bones is selected.



Title-Img 2. 5 Two Bones selected.

Source- blender.org

Link- https://docs.blender.org/manual/en/dev/rigging/armatures/bones/se lecting.html



Title-Img 2. 6 The result of the inverse selection Ctrl-I the Bones
joints selection has been inverted, and not the Bones selection.
Source- blender.org
Linkhttps://docs.blender.org/manual/en/dev/rigging/armatures/bones/se lecting.html

Selecting connected Bone Joints

Another Example: when you select the **root of a Bone**connected to its parent, you also **implicitly select the tip** ofits parent (and vice versa).

Selecting Bones

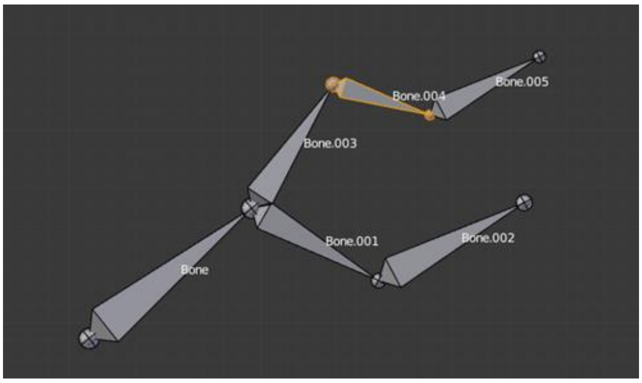
By **RMB** clicking on a **Bone's body**, you will select it (and hence you will implicitly select its root and tip).

Using **Shift-RMB**, you can add to/remove from the selection.

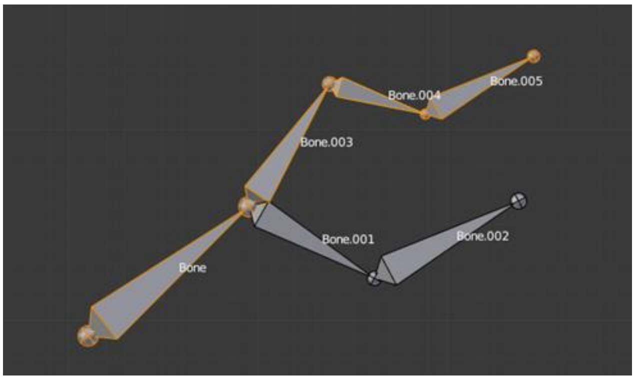
You also have some **Advanced Selection** options, based on their relations.

You can select at once all the Bones in the chain which the active (last selected) Bone belongs to by using the linked **selection tool, L.**

Linked Bones selection



Title-Img 2. 7 A single selected Bone.
Source- blender.org
Link:https://docs.blender.org/manual/en/dev/rigging/armatures/bones/sele cting.html



Title-Img 2. 8 Its whole chain selected with L.

Source- blender.org

Link- https://docs.blender.org/manual/en/dev/rigging/armatures/bone s/selecting.html

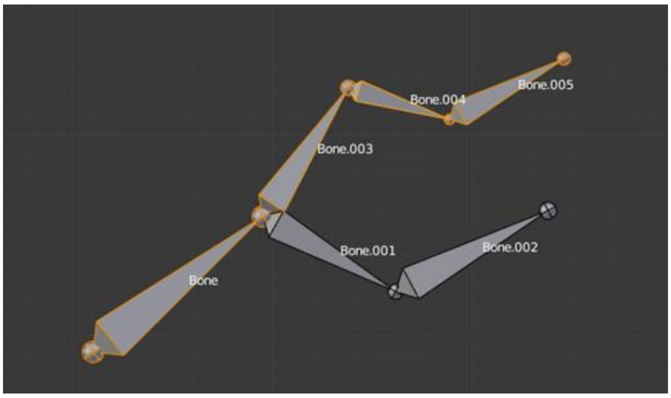
- Mirror Shift-Ctrl-M
- Flip the selection from one side to another.
- Pick Shortest Path Ctrl-RMB
- Selects the path from the active Bone to the Boneunder the mouse
- Deselecting connected Bones

There is a subtlety regarding connected Bones.

When you have several connected Bones selected, if you **deselect one Bone**, its tip will be deselected, however, **not its root**, if it is also the tip of another selected Bone.

To understand this, look at Img 2.9 Bone deselection in a selected chain.

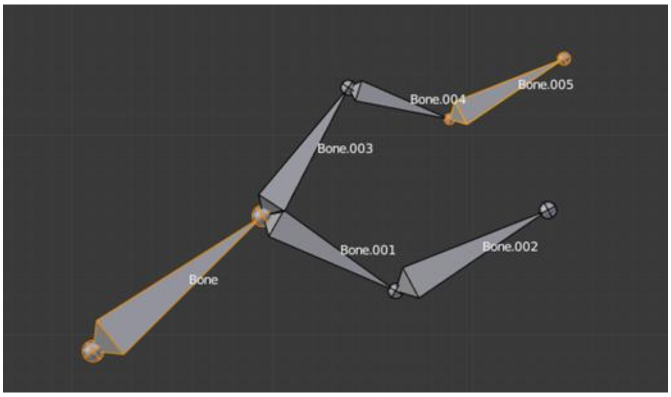
Bone deselection in a selected chain.



Title-Img 2. 9 A selected chain.

Source- blender.org

Link- https://docs.blender.org/manual/en/dev/rigging/armatures/bones/sele cting.html



Title-Img 2. 10 Two selected Bones.

Source- blender.org

Link- https://docs.blender.org/manual/en/dev/rigging/armatures/bones/sele cting.html

- After Shift-RMB -clicking “**Bone.003**”:
- “Bone.003” ‘s tip (which is same as “**Bone.004**” ‘s root) is deselected.
- “Bone” is “Bone.003” ‘s parent. Therefore “Bone.003” ‘s root is same as the tip of “Bone”. Since “Bone” is still selected, its tip is selected. Thus, the root of “Bone.003” remains selected.
- Mouse Clicks
- Reference
- Mode: Edit Mode
- Hotkey: Ctrl-LMB

If at least one Bone is selected, Ctrl-LMB -clicking adds a **new Bone**.

About the new Bone’s tip:

After you Ctrl-LMB -clicked it becomes the **Active Element** in the Armature,

It appears to be right where you clicked, however, (As in mesh editing) it will be on the plane parallel to the viewand passing through the 3D cursor.

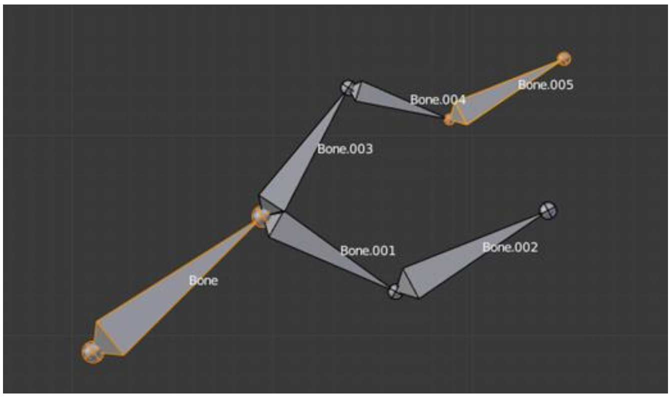
The position of the Root and the parenting of the newBone depends on the **Active Element.**

Active Element

If the Active Element is a Bone

The new Bone’s Root is placed on the **Active Bone’s tip**

The new Bone is parented and connected to the **Active Bone** (check the Outliner in Img 2.11 Ctrl-clicking when the Active Element is a Bone.).



Title-Img 2. 11 Ctrl-clicking when the Active Element is a Bone.

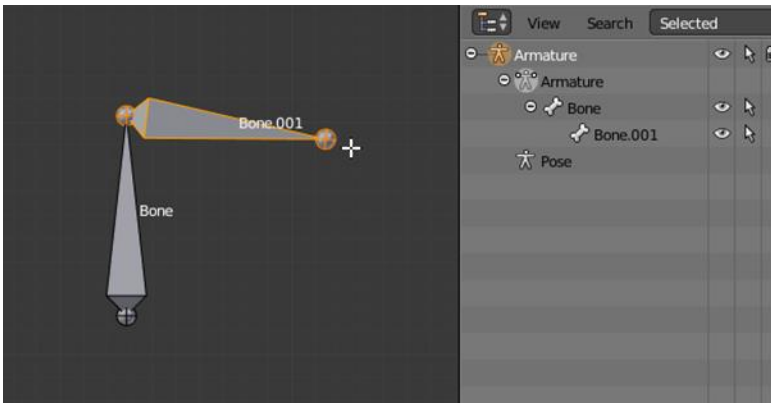
Source- blender.org

Linkhttps://docs.blender.org/manual/en/dev/rigging/armatures/bones/editi ng/bones.html

If the Active Element is a Tip

The new Bone's root is placed on the **Active Tip**

The new Bone is parented and connected to the Bone owning the **Active Tip** (check the Outliner in Img 2.12 Ctrl- clicking when the Active Element is a tip.).



Title-Img 2. 12 Ctrl-clicking when the Active Element is a tip.

Source- blender.org

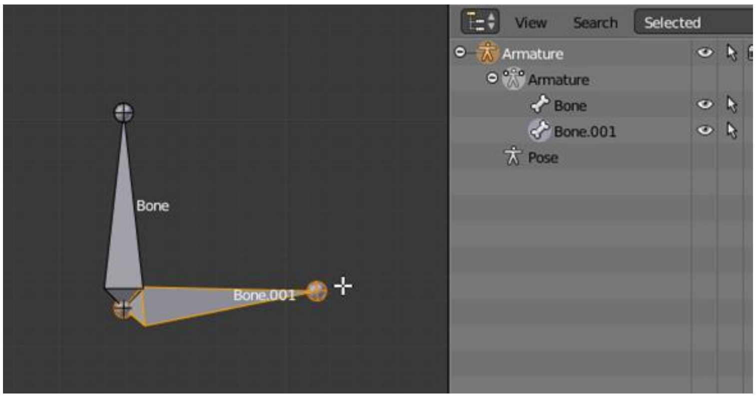
Link- https://docs.blender.org/manual/en/dev/rigging/armatures/bones/editi ng/bones.html

If the Active Element is a Disconnected Root:

The new Bone's root is placed on the **Active Root**

The new Bone is not parented to the Bone owning the Active Root (check the Outliner in Img 2.13 Ctrl-clicking when the Active Element is a disconnected root.).

And hence the new Bone will not be connected to **any Bone**



Title-Img 2. 13 Ctrl-clicking when the Active Element is a disconnected root.

Source-blender.org

Link-https://docs.blender.org/manual/en/dev/rigging/armatures/bone s/editing/bones.html

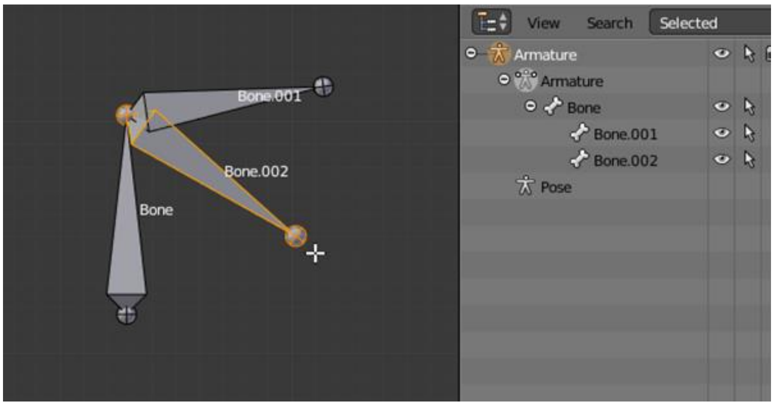
If the Active Element is a Connected Root:

The new Bone's root is placed on the **Active Root**

The new Bone is parented and connected to the parent of the Bone owning the Active Root (check the Outliner in Img 2.14 Ctrl-clicking when the Active Element is a connected root.).

This should be obvious because if the Active Element is a **connected root** then the Active Element is also the tip of the parent Bone, so it is the same as the second case.

As the tip of the new Bone becomes the Active Element, you can repeat these Ctrl-RMB several times, to consecutively add several Bones to the end of the same chain.



Title-Img 2. 14 Ctrl-clicking when the Active Element is a connected root.

Source-blender.org

Link-https://docs.blender.org/manual/en/dev/rigging/armatures/bones/editi ng/bones.html

Delete Selected Bone(s)

X

Hotkey:

This tool **deletes selected Bones,** selected joints are ignored.

If you delete a Bone in a chain, its child(ren) will be automatically **re-parented to its own** parent, however, not connected, to avoid deforming the whole Armature.

Merge Bones

Hotkey: Alt-M

You can **merge together** several selected Bones, as long as they form a chain. Each sub-chain formed by the selected Bones will give one Bone, whose root will be the root ofthe root Bone, and whose tip will be the tip of the tip Bone.

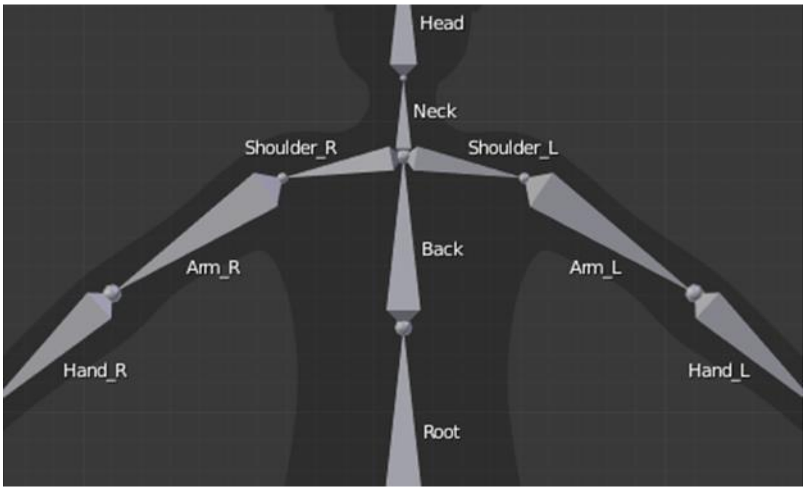
Subdivide Bones

You can **subdivide** Bones, to get two or more Bones where there was just one Bone. The tool will subdivide all selected Bones, preserving the existing relationships: the Bones created from a subdivision always form a connected chain of Bones.

Naming Conventions

Naming conventions in Blender are not only useful for you in finding the right Bone, however, also to tell Blenderwhen any two of them are counterparts.

In case your Armature can be **mirrored in half** (i.e. it is bilaterally symmetrical), it is worthwhile to stick to a **left/right** naming convention. This will enable you to use some tools that will probably save your time and effort(like the **X-Axis Mirror editing tool** we saw above...).



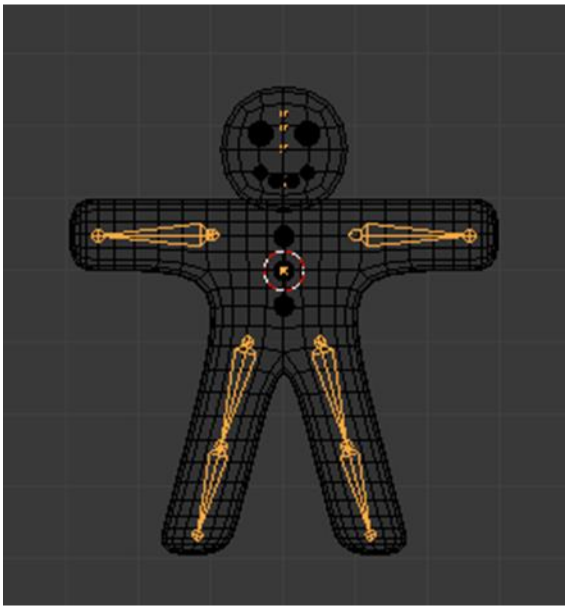
Title-Img 2. 15 An example of left/right Bone naming in a simple rig.

Source-blender.org

Link-https://docs.blender.org/manual/en/dev/rigging/armatures/bones/editi ng/naming.html

Structure

Armatures **mimic real skeletons**. They are made out of Bones, which are (by default) rigid elements. However, you have more possibilities than with real skeletons: In addition to the "natural" rotation of Bones, you can also **translate and even scale** them! And your Bones do not have to be connected to each other; they can be completely free if you want. However, the most natural and useful setups imply that some Bones are related to others, forming so-called "**chains of Bones**".



Title-Img 2. 16 Example of a very basic Armature.

Source-

Link- http://blender-manual- i18n.readthedocs.io/ja/latest/rigging/armatures/structure.html

Chains of Bones

The Bones inside an Armature can be completely **independent** from each other (i.e. the modification of one Bone does not affect the others). However, this is not oftena useful set up: To create a leg, all Bones "after" the thigh Bone should move "with" it in a well-coordinated manner. This is exactly what happens in Armatures by parenting a Bone to the next one in the limb, you create a "**chains of Bones**". These chains can be **ramified**. For example, *five fingers attached to a single "hand" Bone*.

Skinning

In Blender, you have **two main skinning types**:

1. You can **Parent/Constrain Objects to Bones** - then, when you transform the Bones in Pose Mode, their "children" Objects are also transformed, exactly as with a standard parent/children relationship... The "children" are never deformed when using this method.
2. You can Using the **Armature Modifier on entire Mesh**, and then, some parts of this Object to some Bonesinside this Armature. This is the more complex and powerful method, and the only way to really deform the geometry of the Object, i.e. to modify its vertices/control points relative positions.

Armature Deform Parent

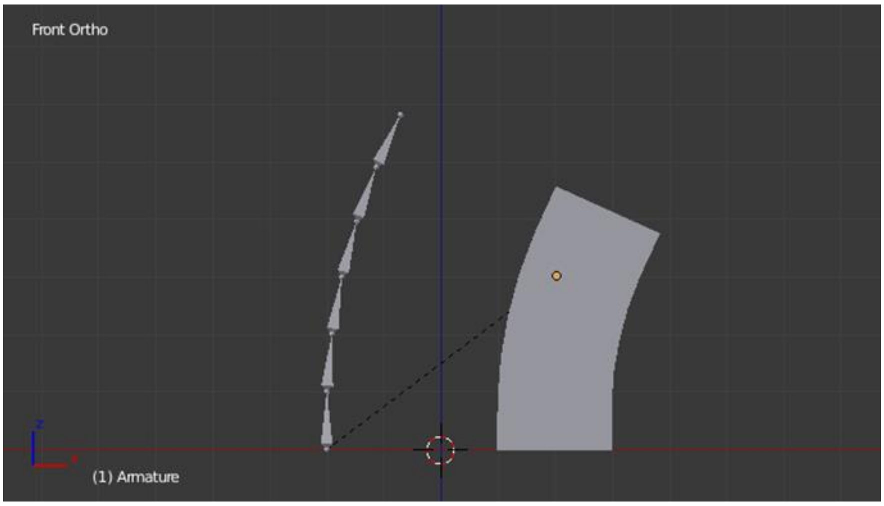
Hotkey: Ctrl-P

Armature Deform Parenting is a way of **creating and setting up** an **Armature Modifier.**

To use Armature Deform Parenting, you must

- **Step 1:** First select all the child Objects that will beinfluenced by the Armature
- **Step 2:** Lastly, select the **Armature Object** itself.
- **Step 3:** Once all the child Objects and the Armatureare selected press Ctrl-P
- **Step 4:** Select Armature Deform in the **Set ParentTo** pop-up menu.

The Armature will be the parent Object of all the other child Objects and each child Object will have an **Armature Modifier** with the **Armature associated** (Object field).



Title-Img 2. 17 Bone associated with Mesh Object.

Source-

Link- https://docs.blender.org/manual/en/dev/rigging/armatures/skinning/pa renting.html

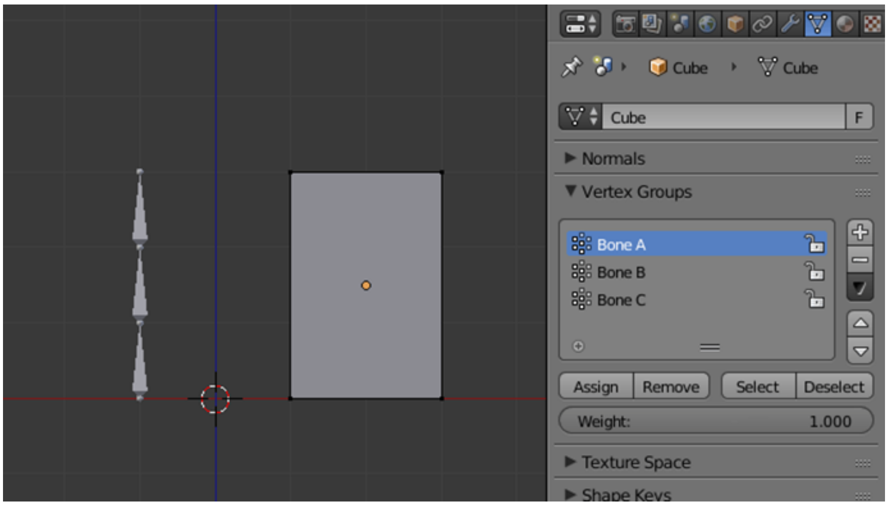
With Empty Groups

When parenting, it will create **empty vertex** groups on the child Objects (if they do not already exist) for and named after each deforming Bone in the Armature. The newly created vertex groups will be empty this means they will **not have any weights assigned**. Vertex groups will only be created for Bones which are setup as deforming **(Properties Editor ‣ Bone ‣ Deform Panel).** You can then manually select the vertices and assign them to a particular vertex group that you are choosing to have Bones in the **Armature influence**.

Choose this option if you have already created (and weighted) allthe vertex groups the mesh requires.

Example

For example, if you have an **Armature** which consists of three Bones named "**Bone A**", "**Bone B**" and "**Bone C**" and cube mesh called "**Cube**". If you parent the cube to the Armature the cube will get three new vertex groups created on it called "Bone A", "Bone B" and "Bone C". Notice that each vertex group is empty.



Title-Img 2. 18 Cube in Edit Mode using Armature Deform with empty groups.

Source

Link- https://docs.blender.org/manual/en/dev/rigging/armatures/skinning/pa renting.html

With Automatic Weights

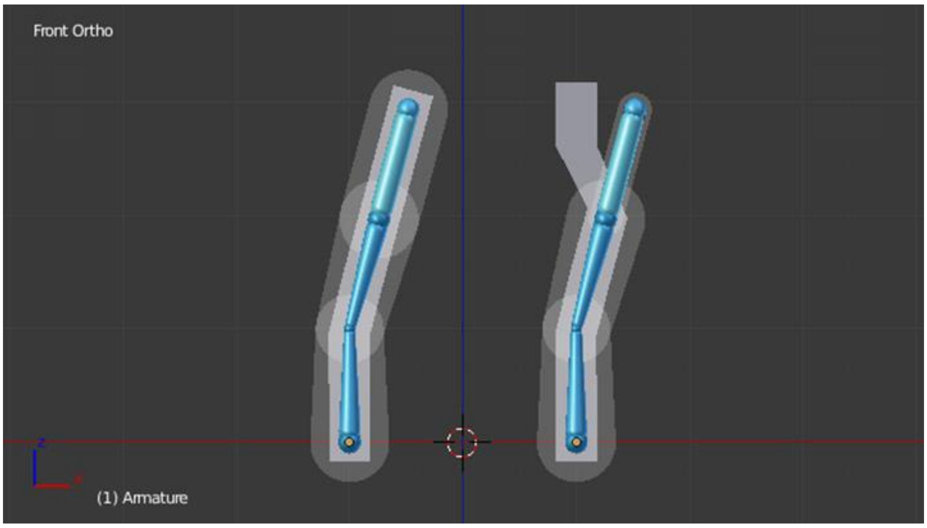
With Automatic Weights, parenting works similar to **With Empty Groups**, however, it will not leave the vertex groups empty. It calculates how much influence a particular Bone would have on vertices based on the distance from those vertices to a particular Bone ("**Bone heat**" algorithm). This influence will be assigned **as weights** in the vertex groups.

This method of parenting is certainly easier setup; however, it can often lead to Armatures which do not deform child Objects in ways you would want. **Overlaps** can occur when it comes to determining which Bones should influence certain vertices when calculating influences for **more complex Armatures** and child Objects. Symptoms of this confusion are that when transforming the **Armature in Pose Mode** parts of the child Objects do not deform as you expect; If Blender does not give you the results you require you will have to manually alter the weights of vertices in relation to the vertex groups they belong to and have influence in.

With Envelope Weights

With Envelope Weights, parenting works in a similar way like **Automatic Weights**. The difference is that the influences are calculated based on the **Bone Envelopes settings**. It will assign to each vertex groups the vertices that are inside its Bone's influence volume, weighted depending on their distance to this Bone.

This means newly included/excluded vertices or new envelope settings will not be taken into account. You will have to apply **Armature Deform** with **Envelope Weights parenting** again.



Title-Img 2. 19 Two sets of Armatures each with three Bones.
Source-
Link-https://docs.blender.org/manual/en/dev/rigging/armatures/skinning/parenting.html

Unit summary

In this Unit, you have learnt

- To Create and edit different types of Bones and apply it todifferent mesh
- Types of Armature structure
- To Edit an Armature
- To Arrange Linking Objects to Bone

- To Set up Mesh and Armature using Skinning
- To Create Poses for the Rigged Character
- To Skin the mesh to the Bones
- To Add and remove influence for a Bone
- After learning this Unit, you can download the Open Source Software available on the internet for free of cost topractice the possibilities of creating 3D Objects.

Assignment

Create a **Basic Primitive Human Rig** referring to the Youtube video link

Assessment

- Explain Armature in Blender
- Describe the Deforming Bones
- Write a brief note on Bone influence
- Explain five different Processes of Editing Bones
- Write a brief note on Bone structure
- Explain the process of skinning with examples

Fill in the Blanks

1. _________are directly involved in altering the positions of vertices associated with their Bones.
2. ____________can be seen when the Bone is in edit mode.
3. Using_______________command on the keyboard, you can add to/remove from the selection.
4. If at least one Bone is selected, clicking_________adds a new Bone.
5. In 3D View, clicking_________________________will add a new Bone to your Armature.

Resources

While studying this Unit, you can browse the internet links for online video tutorials and several books and training DVDs available in the Blender Store and on the Blender Cloud.

- wiki.blender.org
- archive.org
- www.blender.org
- docs.blender.org

Unit-3 3D Animation

Introduction

In 3D Animation and other forms of Computer Animation, the **frames** are generated by **interpolating** between the numerical values that are defined in any two consecutive key frames. Typically, in 3D Animation, this interpolation takes the form of **3D Beziers curves** (paths) which are constructed as a series of control points, allowing for the interactive manipulation of smooth 3D curves.

In this Unit, you will learn about 3D Animation and how animation is making **an object** move or change shape over time. This will be done through different tools and techniques in Blender.

Outcomes

Upon completion of this unit you will be able to:

- Describe Key frame Animation
- Work with Timeline
- Work with F – Curves
- Design the Dope Sheet
- Create Animation on a Motion Path
- Work with Interpolation and Extrapolation

Terminology

Keyframe	:	Normal keyframe for Animation.
Breakdown	:	Breakdown state. e.g. for transitions between key poses.
Moving Hold	:	A keyframe that adds a small amount of motion around a holding pose. In the Dope Sheet, it will also draw a bar between them..
Timeline Editor	:	The Timeline editor, identified by a clock icon, is shown by default at the bottomof the screen.
Time Cursor	:	The Time Cursor is the green line, it is used to set and display the current timeframe.
F Curve Editor	:	After animating some property in Blender using keyframes you can edit their corresponding curves in F-Curve editor
Constant	:	There is no interpolation at all. The curve holds the value of its last keyframe,giving a discrete (stairway) “curve”.
Pose Library	:	The Pose Library panel is used to save, apply, and manage

		different armatureposes.
Linear	:	This simple interpolation creates a straight segment, giving anon-continuous line.
Beziers	:	The more powerful and useful interpolation, and the default one. It gives nicely smoothed curves, i.e. smoothanimations!

Introduction to KeyFrame

Keyframe

A **Keyframe** is a marker of time which stores the value of aproperty.

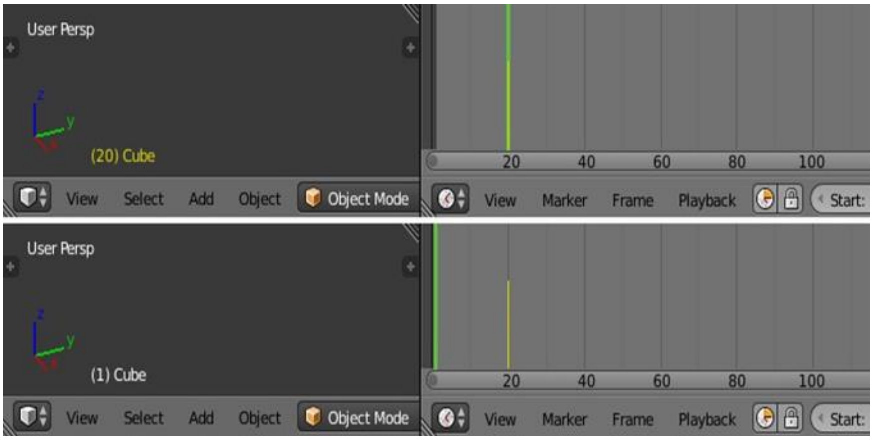
For **example**, a Keyframe might define that the horizontalposition of a cube is at 3m on frame 1.

The purpose of a Keyframe is to **allow for interpolated animation**, meaning, for example, that the user could then add another keyon frame 10, specifying the cube's horizontal position at 20m, and Blender will automatically determine **the correct position** of the cube for all the frames between frame 1 and 10 depending on the **chosen interpolation method** (e.g. Linear, Bézier, Quadratic, etc).

Visualization

There are some important **visualization features** in 3D Views that can help animation.

When the current frame is a keyframe for the current active object, the name of this object (shown in Img 3.1 the bottom left corner of 3D Views) turns **yellow**.



Title- Img 3. 1 Bottom: Current frame at 0. Top: Current frame is a keyframe for Cube.

Source- blender.org

Link-https://docs.blender.org/manual/en/dev/animation/keyframes/introduction.html

Keyframe Types

For **visually distinguish** regular keyframes from differentanimation events or states (extremes, breakdowns, or other in between), there is the possibility of applying different colors on them for visualization.

- **Keyframe (yellow diamond)**

  Normal keyframe.

- **Breakdown (cyan small diamond)**
  Breakdown state. e.g. for transitions between key poses.

- **Moving Hold (slight orange diamond)**
  A keyframe that adds a small amount of motion around a holding pose. In the Dope Sheet, it will also draw a bar between them.

- **Extreme (red big diamond)**
  An ‘extreme’ state or some other purpose as needed.

- **Jitter (green tiny diamond)**
  A filler or baked keyframe for keying on ones, or some other purpose as needed.

Insert Keyframe

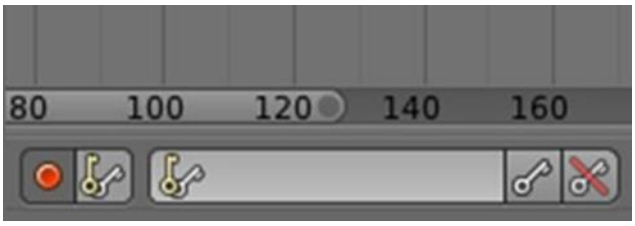
- **Mode:** Object Mode
- **Panel:** Tool Shelf ‣ Animation ‣ Animation ‣ Keyframes: Insert
- **Menu:** Object ‣ Animation ‣ Insert Keyframe...
- **Hotkey: I**

There are several methods of adding new keys, namely:

- In 3D View, pressing “**I”** will bring up a menu to choose what to add a keyframe to.
- Hovering over a property and pressing **“I”** or with the context menu by **RMB** a property and choose Insert Keyframe from the menu.

Auto Keyframe

Auto Keyframe is the **red record button** in the Timeline header. Auto Keyframe adds **keyframes automatically** to the set frame if the value for transform type properties changes.



Title- Img 3. 2 Timeline Auto Keyframe.

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/animation/keyframes/editing.html

Delete Keyframe

Reference

- **Mode:** Object Mode
- **Panel:** Tool Shelf ‣ Animation ‣ Animation ‣ Keyframes: Remove
- **Menu:** Object ‣ Animation ‣ Delete Keyframes..
- **Hotkey:** Alt-I

There are several methods of removing keyframes:

- In 3D View, Press **Alt-I** to remove keys on thecurrent frame for selected objects.
- When the mouse is over a value press **Alt-I**.
- **RMB** a value and choose Delete Keyframe from themenu.

Clear Keyframe

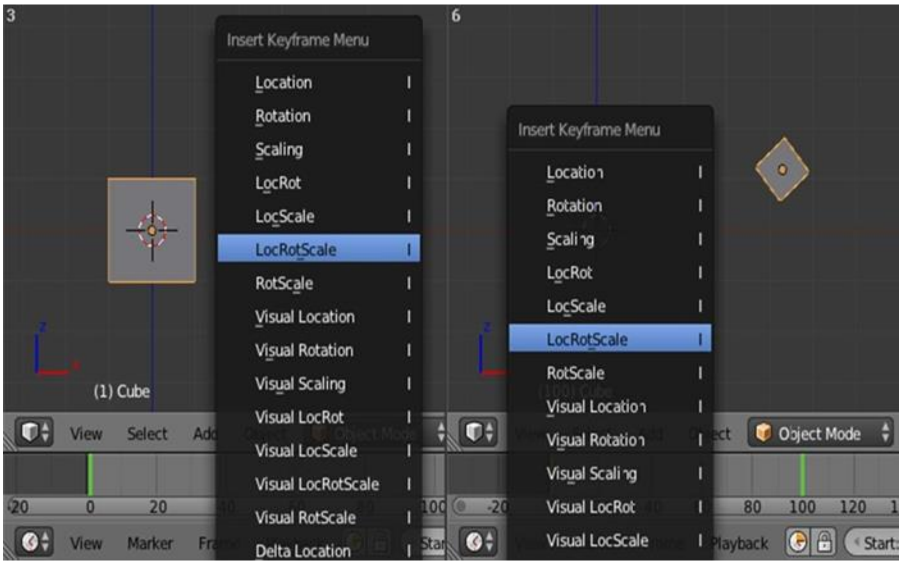
Reference

- **Mode:** Object Mode
- **Menu:** Object ‣ Animation ‣ Clear Keyframes.

KeyFrame Animation

This example shows you how to animate a cubes location, rotation, and scale.(Refer Img 3.3)

- **Step 1:** First, in the Timeline, or other animation editors, set the **frame to 1.**
- **Step 2:** With the Cube selected in Object Mode, press **I** in 3D View.
- **Step 3:** From the Insert Keyframe Menu select **LocRotScale**. This will record the location, rotation, and scale, for the Cube on frame 1.
- **Step 4:** Set the **frame to 100**.
- **Step 5:** Use Grab/Move G, Rotate R, Scale S, to **transform the cube**.
- **Step 6:** Press **I** in 3D View. From the InsertKeyframe Menu, select **LocRotScale**.

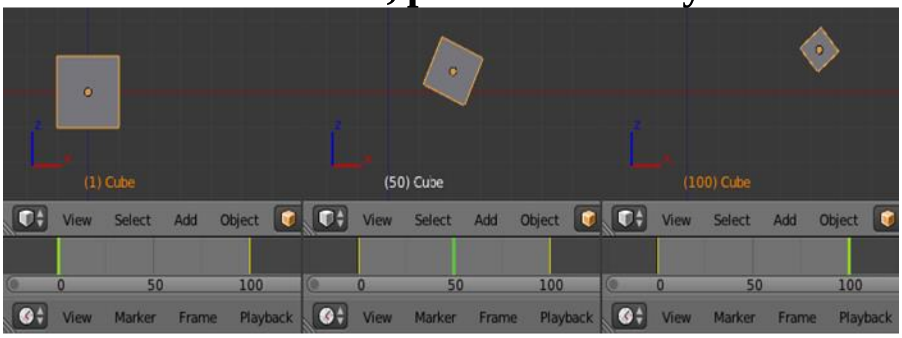


Title- Img 3. 3 Insert Keyframes.

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/animation/keyframes/editing.html

To test the animation, press Alt-A Play



Title- Img 3. 4 The animation on frames 1, 50, 100.

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/animation/keyframes/editing.html

Timeline Editor

The Timeline editor, identified by a **clock icon**, is shown by defaultat the bottom of the screen.

Title- Img 3. 5 The Timeline.

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/editors/timeline.html?highlight=timeline

The Timeline is not much of an editor, but more of an informationand control.

Here, you can have an overview of the animation part of yourscene.

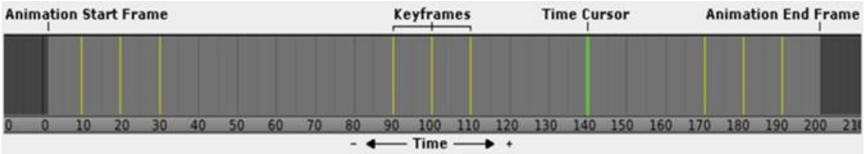
- What is the current time frame, either in frames or in seconds?

- Where are the keyframes of the active object, the start and end frames of your animation, markers, etc.

The Timeline has **Player Controls**, to play, pause the animation, and to skip though parts of the scene. It also has **some tools** for Keyframes, Keying Sets, and Markers.

Main View

The Main Timeline region displays the animation frames over time.



Title- Img 3. 6Timeline Main Area.

Source-blender.org

Link-https://docs.blender.org/manual/en/dev/editors/timeline.html

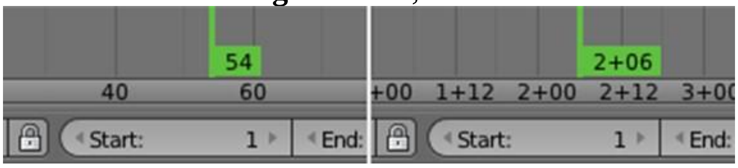
Adjusting the View

The Timeline can be panned by holding **MMB**, then dragging thearea left or right.

You can zoom the Timeline by using **Ctrl-MMB**, the mouse Wheel,or pressing Numpad Minus and Numpad Plus.

Time Cursor

Time Cursor is the **green line**, it is used to **set and display** thecurrent time frame.



Title- Img 3. 7Time Cursor.

Source-blender.org

Link-https://docs.blender.org/manual/en/dev/editors/timeline.html

Time Cursor can be set or moved to a new position by pressing or holding **LMB** in the Timeline editor.

The current frame or second can be displayed on the **Time Cursor**, check the View menu for settings. The Time Cursor can be moved in steps by pressing **Left or Right**, or in steps of 10 frames by pressing **Shift-Up** or **Shift-Down**.

Using F Curve in Animation

After animating some property in Blender using keyframes, youcan edit their corresponding

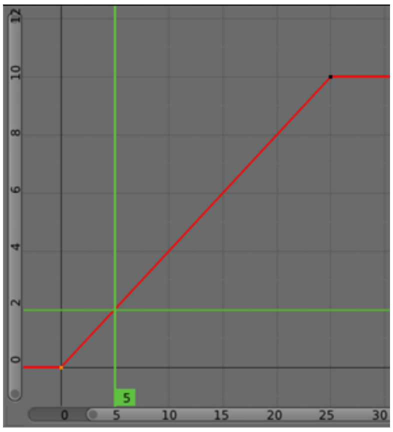
curves. When something is “animated,” it changes over time. This curve is shown as something called an **F-Curve**. Basically, what an F-Curve does is an **interpolation between two animated properties**. In Blender, animating an object means changing one of its properties, such as the object’s location, or its scale.

As mentioned, Blender’s fundamental Unit of time is the “**frame**”, which usually lasts just a fraction of a second, depending on the frame rate of the scene. As animation is composed of incremental changes spanning multiple frames, usually these properties are not manually modified frame by frame, because:

- It would take ages!
- It would be very difficult to get smooth variations of the property (unless you compute mathematical functions and type a precise value for each frame, which would be crazy).

Therefore, nearly all direct animation is done using **interpolation**.

The idea is simple: you define a few Keyframes, which are multiple frames apart. Between these keyframes, the properties’ values arecomputed (interpolated) by Blender and filled in. Thus, the animators’ workload is significantly reduced.



Title- Img 3. 8Example of interpolation.

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/editors/graph_editor/fcurves/introduction.html

For example, if you have:

- A control point of value **0 at frame 0**,
- Another one of value **10 at frame 25**,
- And you use linear interpolation,
- Then, at **frame 5** we get a value of 2.

The same goes for all intermediate frames: with just two points, you get a smooth growth from (0 to 10) along the 25 frames. Obviously, if you would like the frame 15 to have a value of 9, you would have to add another **control point** (or **keyframe**)

Settings

F-Curves have **three additional properties**, which control the interpolation between points, extension behaviour, and the typeof handles.

Interpolation Mode

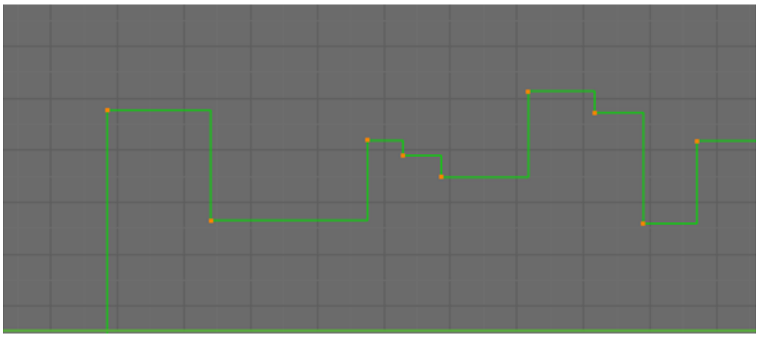
Reference

- **Menu:** Key ‣ Interpolation Mode
- **Hotkey**: T
- **Mode:** for the Interpolation between the currentand next keyframe.

Interpolation

Constant

There is no interpolation at all. The curved holds the value of its last keyframe, giving a discrete(stairway) **"curve"**. Usually only used during the initial "blocking" stage in pose-to-pose animation workflow.



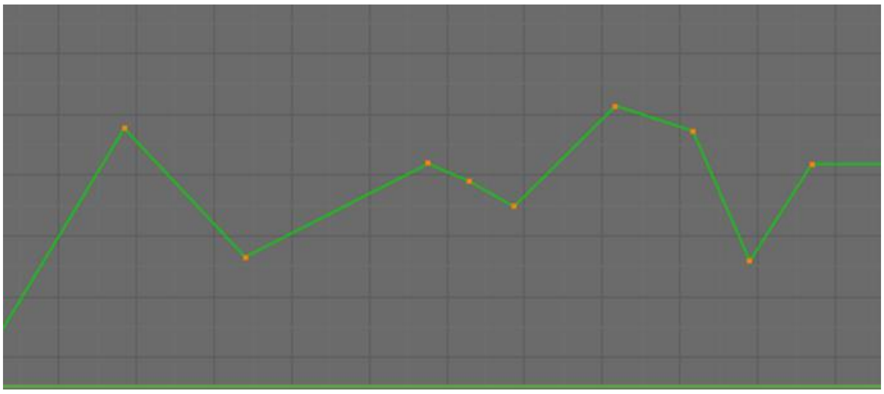
Title- Img 3. 9Example of Constant.

Source-blender.org

Link -https://docs.blender.org/manual/en/dev/editors/graph_editor/fcurves/introdu ction.html

Linear

This **simple interpolation** creates a straight segment, giving a non- continuous line. It can be useful when using only two keyframes and the Extrapolation extend mode, to easily get an infinite straight line (i.e. a linear curve).



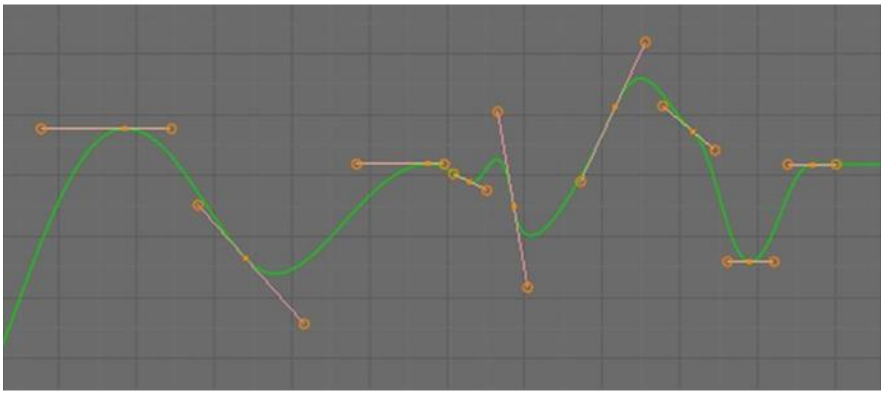
Title- Img 3. 10Example of Linear.

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/editors/graph_editor/fcurves/introduction.html

Bezier

The more **powerful and useful interpolation**, and the default one.It gives nicely smoothed curves, i.e. smooth animations!



Title- Img 3. 11Example of Bezier.

Source-blender.org

Link https://docs.blender.org/manual/en/dev/editors/graph_editor/fcurves/introduction.html

Easing Interpolation (by strength)

There are different methods of easing interpolations for F-Curve segment. The "**Robert Penner easing equations**" (basically, equations which define some preset ways that one keyframe transitions to another) which **reduce the amount of manual work** (inserting and tweaking keyframes) to achieve certain common effects. For example, **snappy movements**.

- Linear
- Sinusoidal
- Quadratic
- Cubic

- Quartic
- Quintic
- Exponential
- Circular

- **Dynamic Effects**

  These additional easing types imitate (fake) physics-based effects like bouncing/springing effects. The corresponding settings can be found in the Properties region ‣ Active Keyframe panel.

- **Elastic**

  Exponentially decaying sine wave, like an elastic band. This is like bending a stiff pole stuck to some surface, and watching it rebound and settle back to its original state.

- **Amplitude**

  The amplitude property controls how strongly the oscillation diverges from the basic curve. At 0.0, there is no oscillation (i.e. it just snaps to the B-value like an extreme exponential transition), and at 1.0 a profile similar to the one shown in the icon occurs.

- **Period**

  The period property controls the frequency with which oscillations occur. Higher values result in denser oscillations.

- **Bounce**

  Exponentially decaying parabolic bounce, like when objectscollide. e.g. for Bouncing balls, etc.

- **Back**

  Cubic easing with overshoot and settle. Use this one when you want a bit of an overshoot coming into the next keyframe, or perhaps for some wind-up anticipation.

- **Back**

  The back property controls the size and direction (i.e. above/below the curve) of the overshoot.

Easing Type

Reference

- **Menu:** Key ‣ Easing Type
- **Hotkey:** Ctrl-E

The Easing Type controls which end of the segment between the two keyframes that the easing effects apply to.

Automatic Easing

The most commonly expected of the below behaviours is used.For the transitional effects, this is basically ease in, while for the physics effects it is ease out.

- **Ease In**
  Effect builds up to the second keyframe.
- **Ease Out**
  Effect fades out from the first keyframe.
- **Ease In Out**
  Effect occurs on both ends of the segment.

Extrapolation

Reference

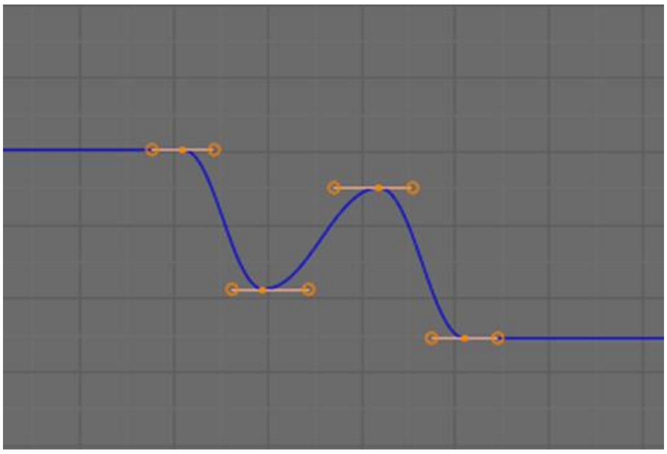
- **Menu:** Channel ‣ Extrapolation Mode
- **Hotkey:** Shift-E

Extrapolation defines the behaviour of a curve before the first andafter the last keyframes.

There are **two basic extrapolation** modes:

Constant

The default one, curves before their first keyframe and after their last one has a constant value (the one of these first and last keyframes)



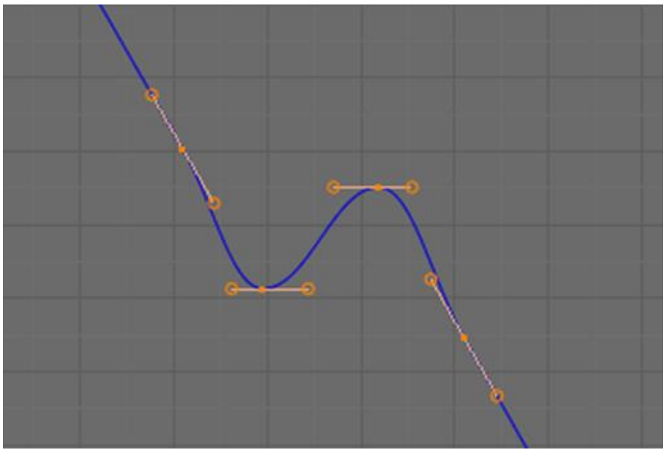
Title- Img 3. 12Constant extrapolation.

Source-blender.org

Link-https://docs.blender.org/manual/en/dev/editors/graph_editor/fcurves/introduction.html

Linear

Curves ends are **straight lines** (linear), as defined by their first twokeyframes (respectively their last two keyframes).



Title- Img 3. 13Linear extrapolation.

Source-blender.org

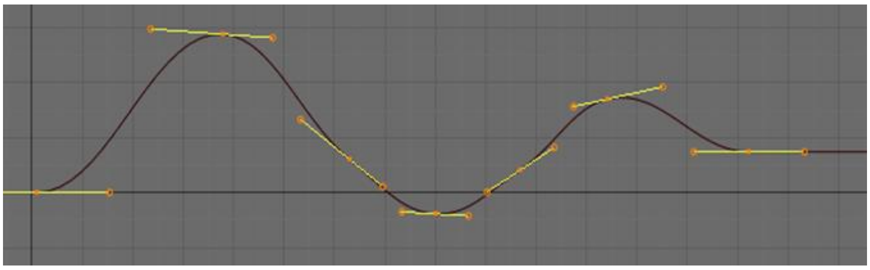
Link- https://docs.blender.org/manual/en/dev/editors/graph_editor/fcurves/introduction.html

Handle Types

There is another curve option quite useful for **Bézier-interpolated curves**. You can set the **type of handle** to use for the curve pointsV

- **Automatic**

  Keyframes are automatically interpolated.



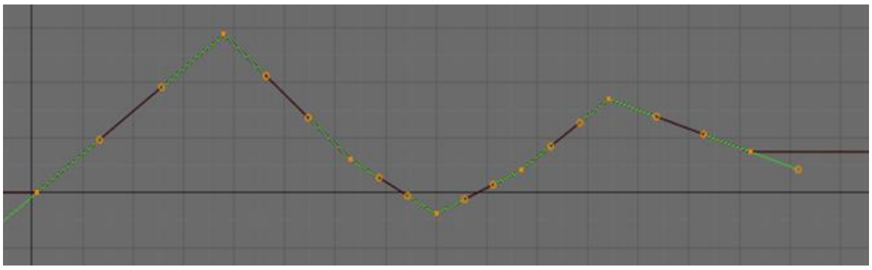
Title- Img 3. 14Auto handles.

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/editors/graph_editor/fcurves/introduction.html

- **Vector**

  Creates linear interpolation between keyframes. The linear segments remain if keyframe centres are moved. If handlesare moved, the handle becomes Free.



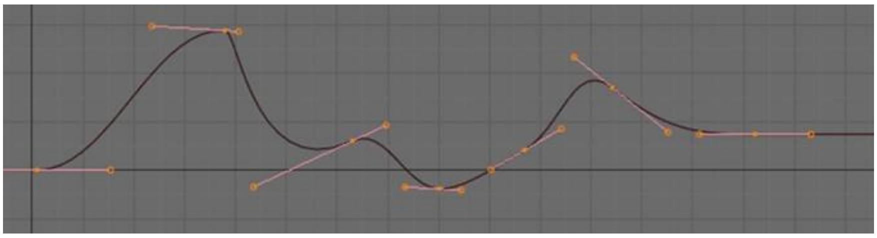
Title- Img 3. 15Vector handles.

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/editors/graph_editor/fcurves/introduction.html

- **Aligned**

  Handle maintain rotation when moved, and curve tangentis maintained.



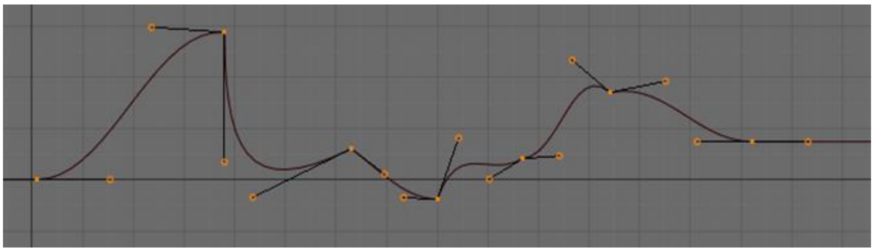
Title- Img 3. 16Aligned handles.

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/editors/graph_editor/fcurves/introduction.html

- **Free**

  Breaks handles tangents.



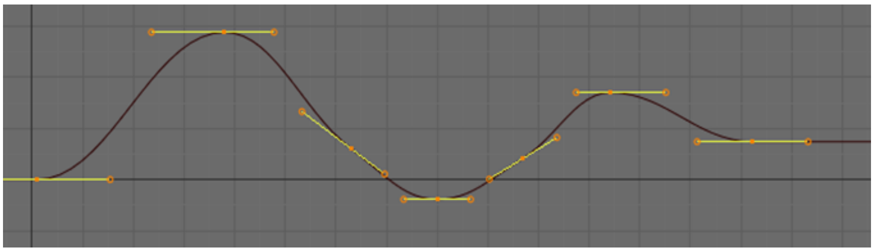
Title- Img 3. 17Free handles.

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/editors/graph_editor/fcurves/introduction.html

- **Auto Clamped**

  Auto handles clamped to not overshoot.



Title- Img 3. 18 Auto clamped handles.

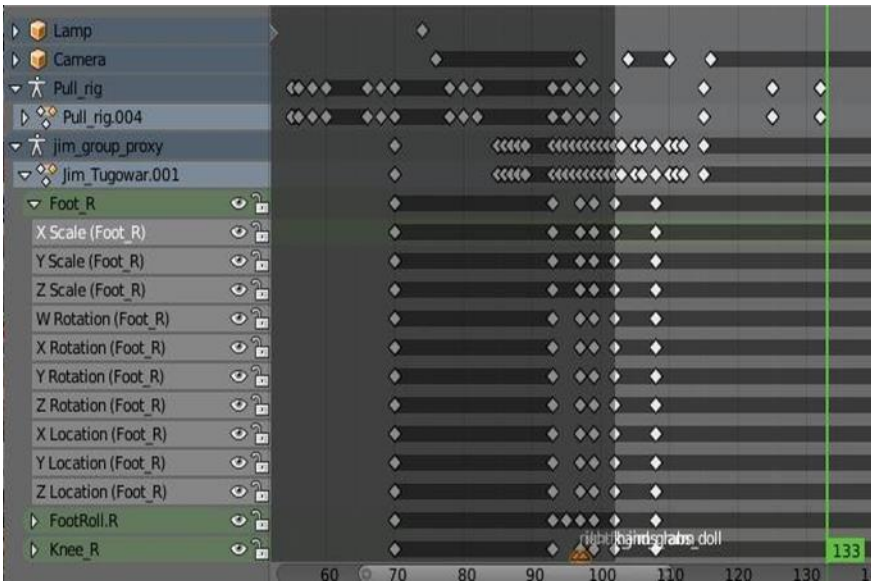
Source-blender.org

Link-https://docs.blender.org/manual/en/dev/editors/graph_editor/fcurves/introduction.html

Using Dope Sheet in Animation

The Dope Sheet

Classical hand-drawn animators often made a chart, showing exactly when each drawing, sound and camera move would occur, and for how long. They nicknamed this the "**dope sheet**". While CG foundations dramatically differ from classical hand-drawn animation, **Blender's Dope Sheet** inherits a similar directive. Itgives the animator a "**birds-eye-view**" of everything occurring within a scene.

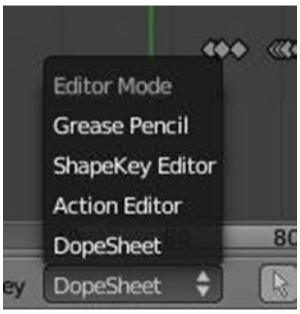


Title- Img 3. 19The Dope Sheet.

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/editors/dope_sheet/introduction.html

Dope Sheet Modes



Title- Img 3. 20Dope Sheet Modes.

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/editors/dope_sheet/introduction.html

- **Dope Sheet**

  The Dope Sheet Mode allow you to edit multiple actions atonce.

- **Action Editor**

  Action Editor is where you can define and control actions.

- **Shape Key Editor**

  ShapeKey Editor is dedicated to the shape key data-blocks.

- **Grease Pencil**

  Grease Pencil Mode is dedicated to the grease pencil tool's keyframes for each grease pencil layer, you have a strip along which you can grab its keys, and hence easily re-time your animated sketches.

- **Mask**

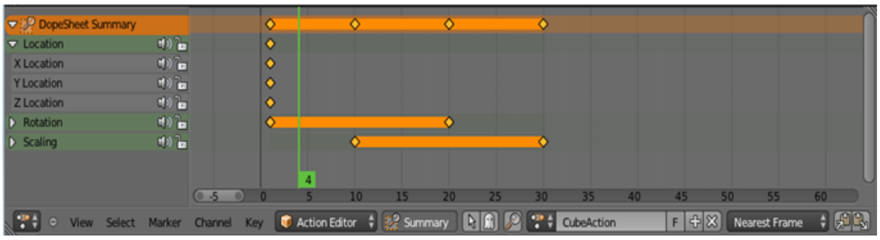
  Mask Mode is dedicated to the mask data-blocks.

- **Cache File**

  To do.

- **Interface**

  The Dope Sheet Editor interface is somewhat similar to theGraph Editor one, it is divided in three regions:



Title- Img 3. 21The Action Editor with object channels.

Source-blender.org

Link- https://docs.blender.org/manual/en/dev/editors/dope_sheet/introduction.html

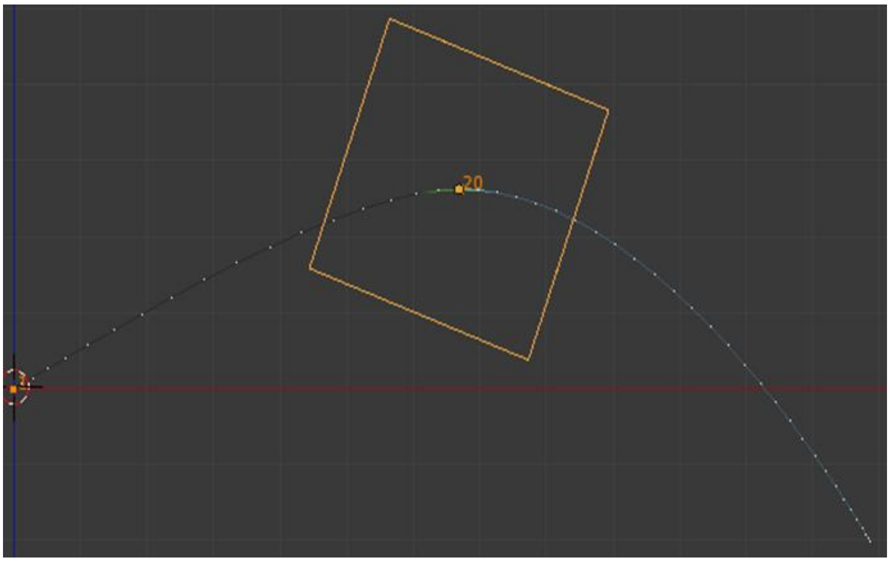
Motion Paths

Reference

- **Mode:Object Mode**
- **Panel:** Tool Shelf ‣ Animation ‣ Animation ‣ MotionPaths: Calculate
- **Panel:** Properties editor ‣ Object ‣ Motion Paths

Reference

- **Mode:Pose Mode**
- **Panel:** Tool Shelf ‣ Tools ‣ Pose Tools ‣ MotionPaths: Calculate
- **Panel:** Properties editor ‣ Armature ‣Motion Paths
- **Menu:** Pose ‣ Motion Paths



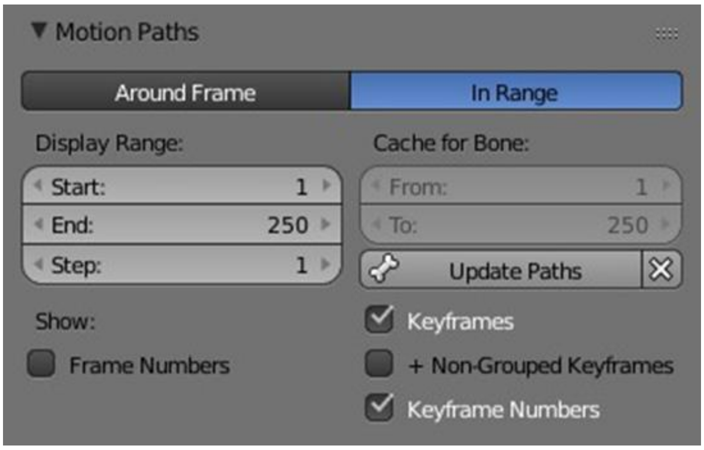
Title- Img 3. 22 An animated cube with its motion path displayed.
Source-blender.org
Link-http://blender-manual.readthedocs.io/en/latest/animation/motion_paths.html

This feature allows you to visualize the motion of points as pathsover a series of frames. These points can be object origins and bone joints.

Before we look at its options, let us first see how to display/hide these paths. Unlike **Ghost,** you must **do it manually** and you have to first **select the bones** you want to show/hide the motion paths. Then,

- To show the paths (or update them, if needed), click on theCalculate Path button.
- To hide the paths, click on the Clear Paths button.

Options



Title- Img 3. 23The Motion Paths Panel in the Armature tab.

Source-blender.org

Link-http://blender- manual.readthedocs.io/en/latest/animation/motion_paths.html

Type

- **Around Frame**

  Display paths of points within a fixed number of frames around the current frame. When you enable this button, you get paths for a given number of frames before and after the current one (again, as with ghosts).

- **In Range**

  Display paths of points within specified range.

Display Range

- **Before, After**

  Number of frames to show before and after the current frame (only for Around Current Frame Onion-skinning method).

- **Start, End**

  Starting and Ending frame of range of paths to display/calculate (not for Around Current Frame Onion- skinning method).

- **Step**

  This is the same as the Step for ghosts. It allows you to onlydisplay on the path one frame for each n ones. Mostly useful when you enable the frame number display (see below), to avoid cluttering 3D Views.

Cache/Cache for Bone

- **From, To**

  These are the start/end frames of the range in which motion pathsare drawn. You cannot modify this range without deleting themotion path first.

- **Calculate/Update Paths**

  If no paths have been calculated, Calculate Paths will create a new motion path in cache based on the options specified in the pop-up menu or Operator panel.

  If a path has already been calculated, Update Paths will update the path shape to the current animation. To changethe frame range of the calculated path, you need to delete the path and calculate it again.

- **Start, End**

  These are the start/end frames of the range in which motion paths are drawn. You must Calculate Paths again if you modify this setting, to update the paths in 3D Views. Note that unlike with ghosts, the start frame is inclusive (i.e. if you set Start to 1, you will really see the frame 1 as starting point of the paths...).

- **Bake Location**

  Bones only – By default, you get the tips' paths. By changing this setting to Tails, you will get the paths of the bone's roots (remember that in Blender UI, bones' rootsare called "heads"). You must Calculate Paths again if you modify this setting, to update the paths in 3D Views.

- **Clear Paths X**

  Clears paths on all objects/bones or just the selected ones when holding Shift.

Show

- **Frame Numbers**

  When enabled, **a small number** appears next to each frame dot on the path, which is of course the number of the corresponding frame.

- **Keyframes**

  When enabled, **big yellow square dots** are drawn on motion paths, showing the keyframes of their bones (i.e. only the paths of keyed bones at a given frame get a yellowdot at this frame).

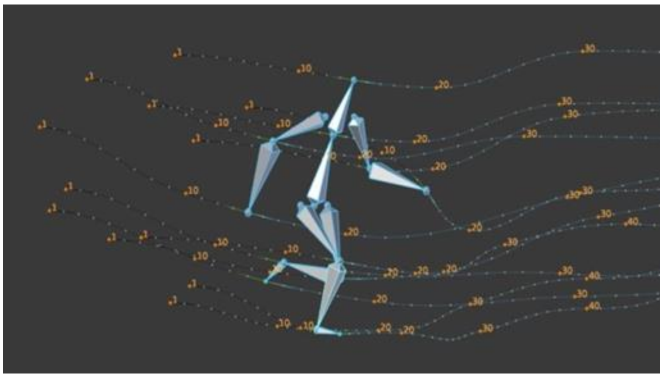
- **+ Non-Grouped Keyframes**

  For bone motion paths, it searches the whole Action for keyframes instead of in groups with matching name only (this is slower).

- **Keyframe Numbers**

  When enabled, you will see the numbers of the displayed keyframes, so this option is obviously only valid when Show Keys is enabled.

Example



Title- Img 3. 24An example of a motion path of an armature.

Source-blender.org

Link-http://blender- manual.readthedocs.io/en/latest/animation/motion_paths.html

Unit summary

In this Unit, you have learnt how to

- Create and edit **Animation** and **Keyframes** using key editor
- Work effectively with **F curve** to change the timing of animation
- Edit the Animation curve using different **Interpolation** method
- Use **Motion Path** for animating objects
- Work on **Dope Sheet** to make your animation more precise andaccurate

After learning this Unit, you can download the Open Source Software available on the internet for free of cost to practice the possibilities of creating 3D Objects.

Assignment

- Create a **Logo or Title Animation** for an existing popular brand like Amazon, Flipkart, Zee Tv etc. Students need to submit the assignment in **MP4 format** with 1920 X 1080 Resolution.

Assessment

- Explain Keyframe Animation
- Describe five types of Keyframes
- Examine the key Interpolation and its types
- Explain the importance of F curve in Animation
- Differentiate between Ease in and Ease out
- Write a note on the uses of Motion Path

Fill in the Blanks

1. The_______________is identified by a clock iconat the bottom of the screen.
2. Pose-to-pose animation workflows can be achieved by_____________________ Interpolation.
3. _______________defines the behaviour of a curve before the first and after the last keyframe.
4. Press_______________to test the animation.
5. The__________________is the green line, it is used to set and display thecurrent time frame.

Resources

While studying this Unit, you can browse the internet links for online video tutorials and several books and training DVDs available in the Blender Store and on the Blender Cloud.

wiki.blender.org

archive.org

www.blender.org

docs.blender.org

Unit-4 Textures and Mapping

Introduction

In this Unit, you will be learning the process of production ofvideos using **Tracking**, such as **2D Tracking, 3D Motion Tracking, Camera Tracking and Object Tracking.** Tracking allows you to import raw footage, track the footage, and mask areas using Camera movements in your **3D scene**. You will also learn about **Stabilizing, Rotoscoping, Mask Editor, Mask Data block, Shape Keyframe and Layers.**

Outcomes

Upon completion of this unit you will be able to:

- Use the Masking
- Describe the Process of Motion Tracking
- Explain the Process of Stabilizing a Clip
- Use the Movie Clip Editor
- Brief the process of Rotoscoping

Terminology

Motion Tracking	:	To Track the motion of Objects and applying that data to 3D Object through the compositor.
Speed	:	To control the speed of sequence Tracking.
Frames Limit	:	Controls how many frames can be Tracked whenthe Track Sequence operator is called.
Margin	:	To disable Tracks when they become too closeto the image boundary.
Sensor Width	:	Width of the CCD sensor in the Camera.
Pixel Aspect Ratio	:	Is the pixel aspect of the CCD Sensor.
Track Path	:	It helps to determine if a Track jumps from itsposition or not.
Display Stabilization	:	This option makes the displayed frame beaffected by 2D stabilization settings.
R, G, B	:	RGB And B/W buttons at the top of this panel are used to control color channels used for frame preview and to make the whole framegray

		scale.
Clip Panel	:	This panel currently contains the single operator Set as background which sets the clip currently being edited as the Camera background for all visible 3D Views.
Solve Panel	:	Camera Motion operator solves the motion of Camera using all Tracks placed on the footage and two keyframes specified on this panel.
Cleanup Panel	:	This panel contains a single operator and its settings. This operator cleans up bad Tracks: Tracks which are not Tracked long enough or which failed to reconstruct accurately

Introduction to Motion Tracking

Motion Tracking is used to Track the **motion of Objects** and applying that **data to 3D Object** through the **compositor**. Blender's motion Tracker supports a couple of very powerful tools for **2D Tracking** and **3D Motion Tracking**, including **Camera Tracking** and **Object Tracking**, as well as some specific featureslike the **Plane Track** for compositing. Tracks can also be used to move and deform masks for **Rotoscoping in the Mask Editor**, which is available as a special mode in the Movie Clip Editor.

Manual Lens Calibration

All Cameras **record distorted video**. Nothing can be done about this because of the way optical lenses work. For accurate Camera
motion, the exact value of the **focal length** and the "**strength**" of distortion are needed.

Currently, **focal length** can be automatically obtained only from the **Camera's settings** or from the **EXIF information**. There are some tools which can help to find approximate values to compensate for **distortion**. There are also fully manual tools where you can use a **grid** which is getting affected by distortion model and deformed cells define straight lines in the footage.

You can also use the **grease pencil** for this – just draw a line, whichshould be straight on the footage using **poly line brush** and adjust the distortion values to make the grease pencil match lines on the footage.

To calibrate your Camera more accurately, use the **Grid Calibration Tool** from **OpenCV**. OpenCV is using the samedistortion model.

Camera and Object Motion Solving

Blender not only supports the solving of Camera motion, including tripod shots, however, also the solving of Object motion in relation to the motion of the Camera. In addition to that there is the

Plane Track, which solves the motion of all markers on one plane.

There are also plans to add more tools in the future, for example more **Automatic Tracking** and solving, multi-Camera solving and constrained solutions.

Tools for Scene Orientation and Stabilization

After Camera solving, you need to **orient the real scene** in 3D scene for more convenient compositing. There are tools to define the floor, the scene origin, and the X/Y axes to perform scene orientation.

Sometimes, the video footage includes spurious jumps and tilting movements, e.g. hand-held Camera. Based on some Tracked image elements, **2D Stabilization** can detect and compensate suchmovements to improve the quality of the final result.

Clip View

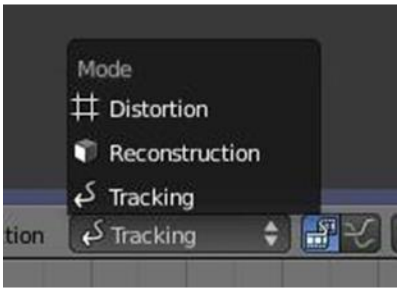
The Clip View is used in the main part of the **Movie Clip Editor**. Almost all Motion Tracking tools are concentrated in the Movie Clip Editor.

It should be mentioned that the Camera solver consists of **threequite separate steps**:

2D Tracking of footage

- Camera intrinsic (focal length, distortion coefficients)specification/estimation/calibration.
- Solving Camera, scene orientation, and scenereconstruction.

Tools in the clip editor are split depending on which step they are used in, so the interface is not cluttered up with scene orientation tools when only 2D Tracking can be done. The currently displayed tool category can be changed using the Mode menu, which is in the editor header.



Title-Img 4. 1Movie Clip Editor Mode Menu.

Source-blender.org

Link-http://blender-manual-i18n.readthedocs.io/ja/latest/motion_tracking/

However, almost all operators can be called from menus, so it is not necessary to change the mode every time you want to use a tool which is associated with a different editor mode.

In Tracking mode, only tools related to Tracking and Camera solving are displayed. Camera solving tools are included here; because, after solving, you will most probably want to re-track existing Tracks or place new Tracks to make solving more accurate.

Tracking Settings Panel

This panel contains all settings for **2D tracking algorithms**. Depending on which algorithm is used, different settings are displayed, however, there are a few that are **common** for all Tracker settings:

- Adjust Frames' controls which patterns get Tracked; to be more precise, the pattern from which frame is getting Tracked. Here is an example which should make thingsclearer.

- The Tracker algorithm receives two images inside the search area and the position of a point to be Tracked in thefirst image. The Tracker tries to find the position of that point from the first image in the second image.

Now, this is how Tracking of the sequence happens. The second image is always from a frame at which the position of marker isnot known (next Tracking frame). However, a different first image (instead of the one that immediately precedes the second imagein the footage) can be sent to the Tracker.

Most commonly used combinations:

- An image created from a frame on which the Track was keyframed. This configuration **prevents sliding** from the original position (because the position which best corresponds to the original pattern is returned by the Tracker), however, it can lead to small jumps and can lead to failures when the feature point is deformed due to Camera motion (perspective transformation, for example). Such a configuration is used if **Adjust Frames is set to 0.**

- An image created from the current frame is sent as first image to the Tracker. In this configuration, the pattern is Tracking between two neighbouringframes. It allows dealing with cases of large transformations of the feature point however, can lead to sliding from the original position, so it should be controlled. Such a configuration is used if **Adjust Frames is set to 1**.

- If **Adjust Frames is greater than 1**, the behaviour of Tracker is: keyframes for Tracks are creating every Adjust Frame, and Tracking between keyframed image and next image is used.

Movie Clip Properties

Objects Panel

Title-Img 4. 2Objects panel in clip editor

Source-blender.org

Link-[*http://blender-manual-i18n.readthedocs.io/ja/latest/motion_tracking/*](http://blender-manual-i18n.readthedocs.io/ja/latest/motion_tracking/)

This panel contains a list of all Objects which can be used for **Tracking, Camera or Object solving.** By default, there is **only one Object** in this list, which is used for Camera solving. It **cannot be deleted** and other Objects cannot be used for Camera solving; all added Objects are used for Object Tracking and solving only. These Objects can be referenced from **Follow Track** and **Object Solver** constraints.

- Follow Track uses the Camera Object by default.
- New Objects can be added using Plus and the activeObject can be deleted with the Minus button. Text field at the bottom of this panel is used to rename the active Object.
- If some Tracks were added and Tracked to the wrong Object, they can be copied to another Objectusing Track ‣ Copy Tracks and Track ‣ Paste Tracks.

The usage for all kind of Objects (used for Camera and Object Tracking) is the same: Track features, set Camera data, solve motion. Camera data is sharing between all Objects and refining ofCamera intrinsic happens when solving Camera motion only.

Track Panel

First of all, **Track name** can be changed in this panel. Track names are used for **linking Tracking data** to other areas, like **a Follow Track constraint**.

- The next thing that can be controlled here is the **marker's enabled flag** (using the button with the eye icon). If a marker is disabled, its position is not used either by solver nor by constraints.

Title-Img 4. 3Track panel in clip editor

Source-blender.org

Link-[*http://blender-manual-i18n.readthedocs.io/ja/latest/motion_tracking/*](http://blender-manual-i18n.readthedocs.io/ja/latest/motion_tracking/)

The button with the **lock icon** to the right of the button with the eye controls whether the Track is locked. Locked Tracks cannot be edited at all. This helps to prevent accidental changes to Tracks which are "finished" (Tracked accurate along the whole footage).

- The next widget in this panel is called "**Track Preview**" and it displays the content of the pattern area. This helps to check how accurately the feature is being Tracked (controlling that there is no sliding off original position) andhelps to move the Track **back to the correct position.** The Track can be moved directly using this widget by mouse dragging.

If **an anchor** is used (the position in the image which is Tracking is different from the position which is used for Parenting), a preview widget will display the area around the anchor position. This configuration helps in masking some things when there is no good feature at position where the mask corner should be placed. Details of this technique will be written later.

There is small area below the preview widget which can be usedto **enlarge the vertical size** of preview widget (the area is highlighted with two horizontal lines).

- The next setting is **channels control**. Tracking happens in gray-scale space, so a high contrast between the feature and its background yields more accurate Tracking. In such cases disabling some color channels can help.

When several Tracks are used for 3D Camera reconstruction or for 2D stabilization, it is possible to assign a reduced weight to some Tracks to control their influence on the solution result. The Weightparameter is used for 3D reconstruction, while the Stab Weight parameter is used to control 2D stabilization. This parameter can (and often need to be) animated.

- The last thing is **custom color**, and the preset for it. This setting overrides the default marker color used in the clip editor and 3D View, and it helps to distinguish different type of features (for example, features in the background vs. foreground and so on). Color also can be used for "**grouping" Tracks** so a whole group of Tracks can be selected by color using the Select Grouped operator.

2D Stabilization

2D video stabilization is a feature built on top of Blender's image feature Tracking abilities: we use some Tracking points to **remove shakiness, bumps and jerks** from video footage. Typically, image stabilization is **part of a 2D workflow** to prepare and improve footage prior to further processing or modeling steps. This page helps to understand how it works, introduces related terms and concepts, describes the available interface controls in detail and finally gives some hints about usage in practice.

Typical usage scenarios of the Stabilizer

- fixing minor deficiencies (shaky tripod, jerk in Camera movement)
- "poor man's steadycam" (when a real steadycam was not available, affordable or applicable)
- preparing for masking, matching and Rotoscoping It is not uncommon for 2D stabilization to have to deal with somewhat imperfect and flawed footage

How it works

To detect spurious movement in the given shot, we'll assume a simplified model about this movement. We then try to fit themovement of Tracked features with this simplified model to derive a compensation. Of course, this works only to the degree ourmodel is adequate – yet in practice, this simplified approach workssurprisingly well even with rather complicated shots, where our basic assumption was just an approximation of much more elaborate movements.

This simplified model underlying 2D stabilization as implemented here assumes movement by an **Affine-Linear Transform**:

- the Camera is pushed up/down/sideways by some translation component
- the image is then tilted and scaled around a Pivot Point (rotation center)

To compensate movement according to this simplified model, **2D stabilizer** proceeds in two steps. First, we try to detect the translation offset from the weighted average of all translation Tracking points. After compensating this translation component, we then use additional **rotation/scale**

Tracking points to detect rotation around a given pivot point. Again, we detect rotation and scale changes through a weighted average of all the rotation/scale Tracking points given.

In the current version, the **Pivot Point** is anchored to the weight center of the translation Tracking points. So effectively the detected translation is already factored out. In some cases, this is not optimal, especially when Tracks have gaps or do not cover the whole duration of the footage – we plan further options to better control the Pivot Point in future releases.

Stabilization Tracks

Thus, as foundation for any image stabilization, we need **Tracked image features** to derive the movements. These Tracking points or"Tracks" can be established with Blender's image feature Tracking component the right choice of points to Track is somewhat tricky, yet crucial for successful image stabilization. Often, we're here because we'll have to deal with **imperfect footage**. In such cases, the averaging of Tracks helps to work around image or Tracking errors at some point. Moreover, when the footage contains perspective induced movements, symmetrically placed Tracking points above and below the horizon can be used to cancel out spurious movement and get stabilization to the focal area in between.

Title-Img 4. 2Diverging movements caused by perspective.

Source-blender.org

Link-
https://docs.blender.org/manual/en/dev/editors/movie_clip_editor/tracking/clip/properties/stabilization/introduction.html

Footage, image and canvas

When talking about the **movement stabilization** video, we must distinguish several frames of reference. The image elements featured by the footage move around irregularly within the footage's original image boundaries – this is the very reason why we are using the **stabilizer**. When our attempt at stabilization was successful, the image elements can be considered stable now,while in exchange the footage's image boundaries have taken on irregular movement and jump around in the opposite way. This is the **immediate consequence** of the stabilizer's activity.

However, when the Camera was moved intentionally, we must consider yet another frame of reference beyond the canvas: namely the **frame (or "cadre")** of the final image we want tocreate. To understand this distinction, let's consider a hand-held, panning shot to the right: Since our Camera was turned towards the **right side**, the actual image contents move towards the **left side** within the original image frame. However, let's assume the stabilizer was successful with "fixing" any image contents relative to the canvas – which in turn means, that the original image boundaries start to move irregularly towards the right side, andthe contents of the image will begin to disappear gradually behind the left boundary of the original image. After some amount of panning, we'll have lost all our original contents and just see an empty black image backdrop. The only solution to deal with that problem is to move the final image frame along to the right, thus following the originally intended panning movement. Of course, this time, we do want to perform this newly added panning movement in a smooth and clean way.

Title-Img 4. 3 Stabilizing a panning shot.

Source-blender.org
Link- *https://docs.blender.org/manual/en/dev/editors/movie_clip_editor/tracking/clip/properties/stabilization/introduction.html*

Title-Img 4. 4Restoring the expected Camera movement.

Source-blender.org
Link
https://docs.blender.org/manual/en/dev/editors/movie_clip_editor/tracking/clip/properties/stabilization/introduction.html

To allow for such compensation and to reintroduce deliberatepanning, or tilting and zoom of the resulting image, the stabilizer offers a dedicated **set of controls**:

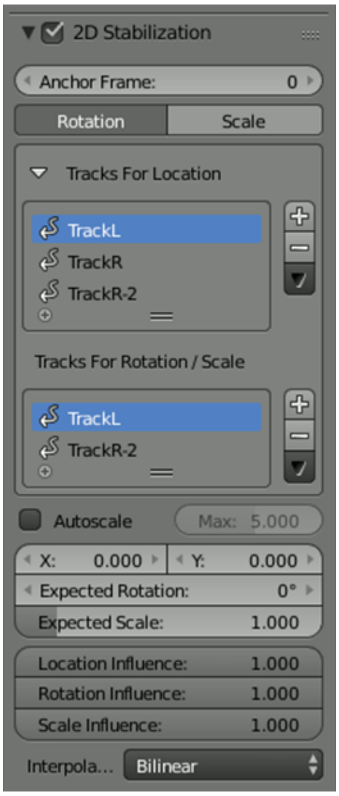
- Expected position,
- Expected rotation and
- Expected scale

These act like the controls of a virtual Camera filming the contents we have fixed onto the canvas. By animating those parameters, we're able to perform all kinds of deliberate Camera movements in a smooth fashion.

The "dancing" black borders

As explained above, when we succeed with stabilizing the image contents, the boundaries of the original footage start to jump around in the opposite direction of the movements compensated. This is inevitable – yet very annoying, since due to the irregular nature of these movements, these “**dancing black borders**” tendto draw away attention from the actual subject and introduce an annoying restlessness. Thus, our goal must be to hide those dancing borders as good as possible. A simple solution is to add a small amount of zoom. Sometimes we’ll also need to animate the parameter Expected position in order to keep the image centered as good as we can – this helps to reduce the amount of zoom necessary to remove those annoying borders.

The **Autoscale function** can be used to find the **minimal amountof zoom** just sufficient to remove those black borders completely. However, if the Camera jumps a lot, the autoscale function often zooms in too much, especially since this calculation aims at findinga single, static zoom factor for the whole duration of the footage. When this happens, you’ll typically get overall better results with animating both the zoom factor and the expected position manually.



Title-Img 4. 5UI of 2D Stabilizer**.**

Source-blender.org
Link *https://docs.blender.org/manual/en/dev/editors/movie_clip_editor/tracking/clip/properties/stabilization/panel.html*

Mask Editor

Previously there was no simple workflow for masks in Blender, compositing a rendered scene with real footage was possible, however, when it came to mask out Objects, defining areas of influence and other scenarios, the workflow was cumbersome.Masks are now natively supported, which allow you to draw masksusing splines, and then have them rasterized for use in the compositor or sequencer.

This feature consists of **different parts**:

- Mask data block containing multiple Mask Layers and splines.
- Mask editing in the image and Movie Clip Editor space using various tools.
- Animation of masks with keyframes, drivers and Tracking data.

Compositing Node and sequencer strip to use mask.

Mask Datablock: Points, Splines and Layers

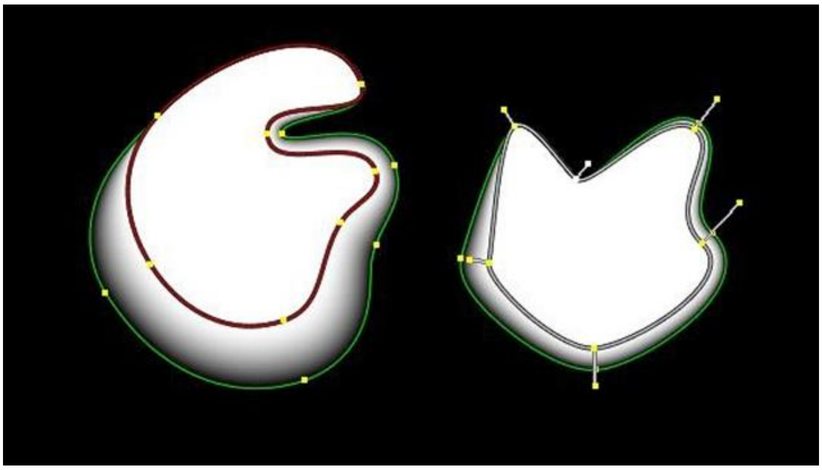
Point

A Point is the most low-level entity used to define mask. It's a simple point with it a coordinate, handles and set of feather points. Points can be parented to **markers** from Motion Tracking.

Spline

Sets of points define a **Spline**. Currently only **Bezier splines** are supported. They create a **smooth curve** from the first to the last point in the spline. Splines, by default, will create a filled area, however, can also create **non-closed curves** with a thickness to mask out Objects such as wires or hair. (Refer Img 4.8)

Layer



Title-Img 4. 6Two splines with feathering.Attribution-Brecht
Source-
Link-*https://wiki.blender.org/index.php/File:Blender2.64_mask.png*

One or several splines can belong to the same **Layer**. Splines belonging to the same layer can be

animated together, for example by an item from motion Tracker footage. By creating overlapping splines holes can be created, and it's the **layer membership** that defines which splines interact to **create holes.**

Mask datablocks are the most high-level entity used for masking purposes. They can be reused in various places, and hold global parameters for all the entities they consist of.

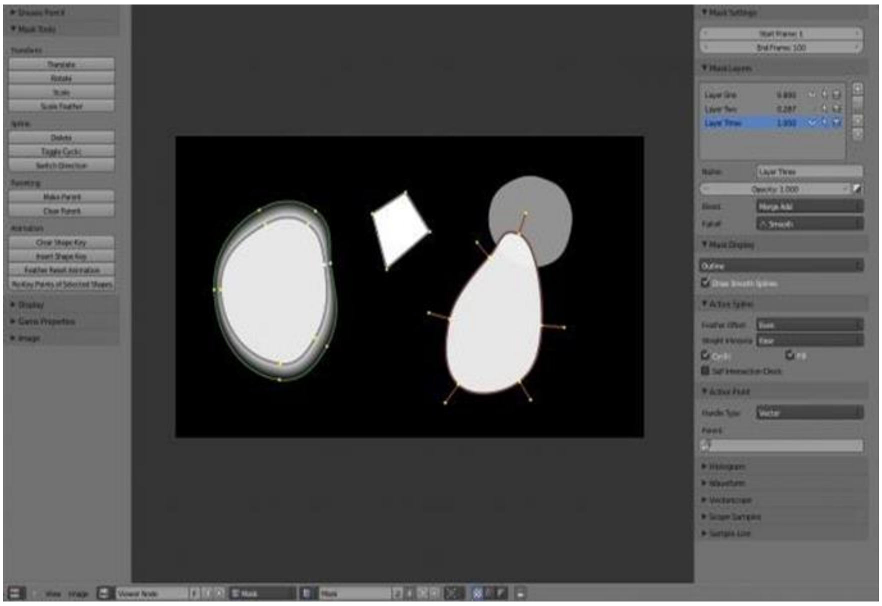
Understanding Layers

The purpose of **Mask Layers** can be explained with an example.

Suppose there are two unwanted people in the footage, and oneof them goes from left to right, and the other in the opposite direction. Two Mask Layers can then be used to mask them separately using a **Single Mask Data block**. At the point of intersection of these shapes they will be added together rather than creating **a hole**, as would happen if they were on the same layer. If the motion is simple enough, a **single motion Tracked point** can be used to drive the location of the entire Mask Layer. Each Mask Layer can consist of **multiple splines** to fit more complex shapes.

Editing Masks

Masks can be created in the image and Movie Clip Editors, by changing the mode from **View to Mask** in the header. This will addvarious tools and properties to the editor panels, while hiding others that are not needed for interacting with masks. The tools and panels available to edit masks are the same in both editors, with the exception that **linking masks** to Motion Tracking data is only possible in the Movie Clip Editor.



Title-Img 4. 7Mask editing in image editor.
Source-Brecht
Link- *https://wiki.blender.org/index.php/File:Blender2.64_mask_editor_overview.png*

Once set to Mask mode, a **Mask datablock** can be added. Any image, movie clip, render or compositing result can be used as a backdrop to draw masks over. To get interactive feedback on the resulting mask, a **Mask Node** can be connected directly to a Viewer Node in the compositor, which will then keep updating the compositing result while editing.

Control Points

Editing of mask splines happens in the same way of editing Bezier curves or paths in **GIMP** or other curve editors: control points are added to define the spline itself, and handles of several types are used to create smooth bends. This makes it possible to define a mask with few points to easily follow an Object in footage.

- **Ctrl + LMB** is used to place new control points and define handle orientations (click to place controlpoint, click followed with slide to place new control point and set smoothness for it).
- **Alt + C**: to close the mask by joining the last control point to the first.
- Existing control points can be translated, scaled androtated with the usual **G, S, R shortcuts.**
- **X** or **Delete** removes control points

Selection

The usual **Selection and Hide/Reveal tools** are available:

- **A**: toggle select all
- **B, C**: border and circle Select
- **Ctrl + L** select linked from selection, L: select linked with mouse
- **Ctrl + Alt + LMB**: lasso select
- **H** hide selected, ⇧ **Shift + H** hide unselected, **Alt + H** Reveal

Curve Handles

- **Alt + C**: cycle toggle spline, to create a close curveor open it again
- **V**: set handle type for selected spline points
- **Ctrl + N**: make normals (handle directions) consistent
- Switch Direction handle directions **in/out**.

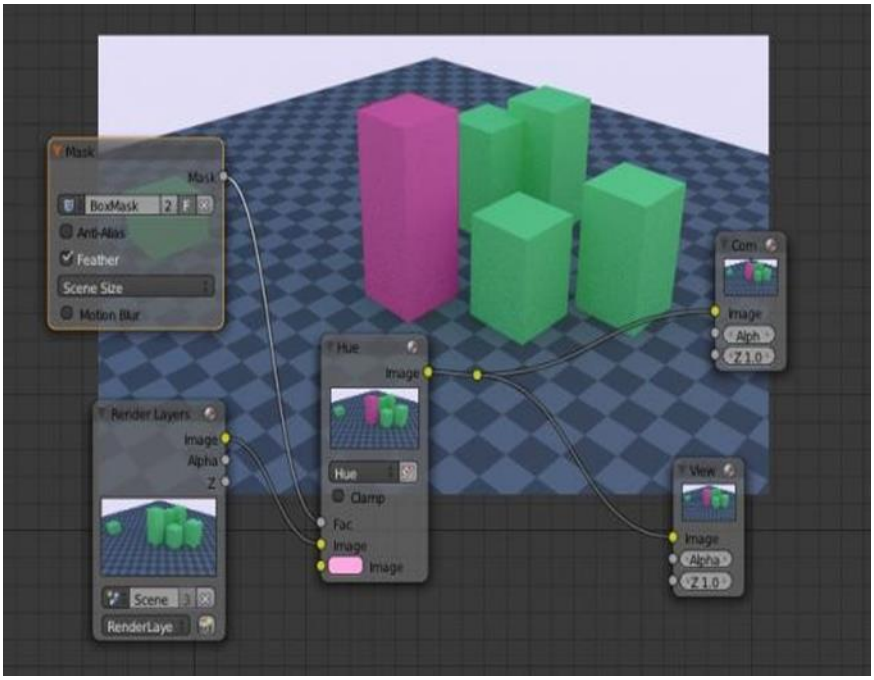
Feather

It's possible to control feather of mask, including a way to define **non-linear feather**. Linear feather is controlled by a slider, non- linear feather is controlled in the same curve-based way to define feather falloff.

- **⇧ Shift + LMB** Template-LMB.png is used to define a feathering outline curve. To create an initial feather, sliding from a spline control point outside or inside will create and position feather points.After this ⇧ Shift + LMB Template-LMB.png will insert new feather point and mouse sliding can be used to move them around.
- **Alt + S** will scale the feather size

Using Masks

Masks have many purposes. They can be used in a **Motion Tracking workflow** to mask out, or influence a particular Object in the footage. They can be used for **manual Rotoscoping** to pull a particular Object out of the footage, or as a rough matte for green screen keying. Masks are **independent** from a particular image of movie clip, and so they can just as well be used for creating **motion graphics** or other effects in the compositor



Title-Img 4. 8Using the Mask Node to isolate an Object in compositing.

Source-Brecht

Link-*https://wiki.blender.org/index.php/File:Blender2.64_mask_compositor_node.png*

Compositing Node

In the compositing Nodes, the **Mask Input Node** can be used to **select a mask datablock**, with as output the raster mask image. This image can be used with other Nodes, for example to **Invert, Multiply or Mix, or use** as a factor input. The Node options are:

- **Anti-Alias**

  Create smooth mask edges rather than hard ones.

- **Feather**

  Use or ignore feather points defined for splines.

- **Size**

  Scene Size will give an image the size of the render resolution for the scene, scaling along when rendering withdifferent resolutions. Fixed gives a fixed size in pixels.

  Fixed/Scene gives a size in pixels that still scales along when changing the render resolution percentage in thescene.

- **Motion Blur**

  For animated masks, creating a motion blurred mask from the surrounding frames, with a given number of samples (higher gives better quality), and a Camera shutter time in seconds.

Animating Masks

Masks can be driven over the time so that they follow some Object from the footage, e.g. a **running actor**. This animation can be done in several ways:

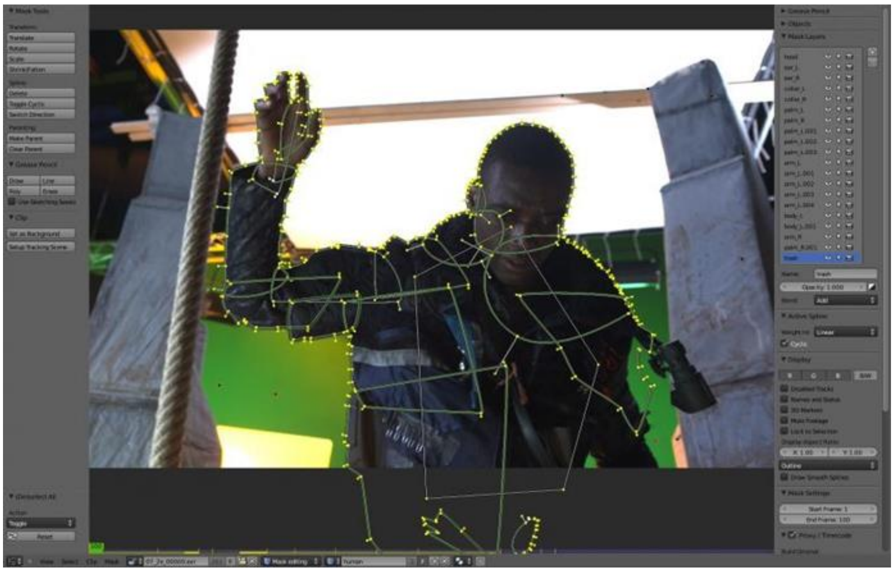
- **Control points** can be parented to motion Tracks. This way is the main way to interact with masks in aMotion Tracking workflow.

- **Keyframe Animation** of control points using a shape keying system. This can be useful when thereare not enough good feature points to Track in the footage, or the mask is not based on footage.

- For **animation**, more complex mask shapes, it isalso possible to do more high-level animation:

- **Splines and Mask Layers** can be animated as whole,instead of individual control points.

- Masks can be parented to Motion Tracking data. Works for both individual mask point parenting andfor overall spline. To select motion Track to be parented to use **Ctrl + RMB** to parent selected maskpoints to active motion Track use **Ctrl + P**.
- **Mask Animation** timing can be edited from the **Dope Sheet** where there is a mask mode wheremask keyframes can be selected and edited.



Title-Img 4. 9Complex masking setup in Movie Clip Editor, from the Mango opn movie project.

https://wiki.blender.org/index.php/File:Blender2.64_mask_mango.png

Shape Keyframe

Masks can be animated with **Shape Keyframing**. This works on thelevel of Mask Layers, so inserting a shape key will keyframe all the splines and points contained in it.

- **Step 1:** Insert a shape key for the active Mask Layer at the current frame.
- **Step 2: Alt + I** will clear the shape key for the active Mask Layer at the current frame.

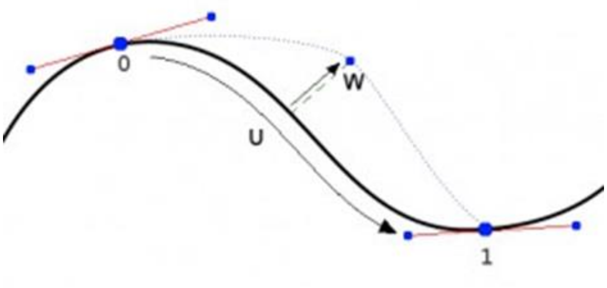
Feather Reset Animation: Resets the feather offset across all animated frames useful if you animate first then add feather after.

Re-Key Points of Selected Shapes: Re-interpolate selected points on across the range of keys selected in the dope sheet. This hasthe same effect of removing and re-inserting keys - however it can be applied selectively to the points you need.

Parenting to Motion Tracks

In the Movie Clip Editor, it's possible to parent spline points to motion Tracks.

- **Ctrl + P** parents one or more selected spline pointsto the active motion Tracker
- **Alt + P** clears any parenting relationship for theselected spline points.
- **S-Curves**



Title-Img 4. 10S-curves

Source-Brecht

Link- *https://docs.blender.org/manual/en/dev/editors/movie_clip_editor/masking/scurve.html*

The curve type used for creating mask splines is almost a **Bezier curve**, however, with some differences. The curve needed to support feathering in a way that stuck to the curve as you edited it, for ease of editing an animation. We call these **S-Curves**.

Besides the handles, every control point also has points that define the feather between the current point and the next pointon the spline. Each feather point is stored in **UV space**, where **U** means position across spline segment, and **V** means distance between main spline and feather points.

This allows for deforming the main spline in almost any way, and the feather will be updated automatically to reflect that change. For example, if there's just **rotation of the spline**, feather would stay completely unchanged. If one point's feather is **moved**, the other feathers will be automatically stretched uniformly along thatsegment and the overall shape will be almost the same as artists would want it to be.

Unit summary

In this Unit, you have learnt how to

- Work effectively with Motion Tracking
- Create scenes for production
- Work with 2D Stabilization in Blender
- Use Rotoscoping in Blender
- Use of S curve
- Animate the mask
- Work with videos of Tracking using 3D virtual Camera andCamera Tracking

After learning this Unit, you can download the Open Source Software available on the internet for free of cost to practice thepossibilities of creating 3D Objects.

Assignment

- Create a **Camera Tracking Shot** in Blender watching the video
- Submit the assignment in **MP4 format** with 1920 X 1080Resolution

Assessment

1. Explain Motion Tracking in Blender
2. Describe the process of 2D Stabilizing
3. Write a brief note on Mask Editing and Animation
4. Explain the importance of S curve
5. Write a brief note on Track Panel
6. Write a note on Clip view

Fill in the Blanks

1. The________________is identified by a clock iconat the bottom ofthe screen.
2. Pose-to-pose animation workflows can be achievedby__ Interpolation.
3. _______________defines the behaviour of a curve before the firstand after the last keyframe.
4. Press________________to test the animation.
5. The_________________is the green line, it is used to set anddisplay the current time frame.

Resources

While studying the Unit , you can browse the internet links for online video tutorials and several books and training DVDs available in the Blender Store and Blender Cloud.

- wiki.blender.org
- archive.org
- www.blender.org
- docs.blender.org

DMA-201

3D Animation

Block – IV: 3D Lighting & Rendering (Practical)

Unit-1 Introduction to 3D Lighting

Introduction

Lighting is a very important topic in **Rendering**, standing equal to modelling, materials and textures. The most accurately modelled and textured scene will yield poor results without a proper lightingscheme, while a simple model can become **very realistic** if skilfully lit.

Lighting plays key role in **3D Animation,** because it convinces the audience that the story is believable psychological and physical of lighting emphasizes the role of lighting on the audience "light dictates activities, influences our frame of mind and affects the way we perceive all manner of things".

Outcomes

Upon completion of this unit you will be able to:

- Plan your 3D Scene for Lighting
- Identify the restrictions between the color of an object andthe lighting of your scene
- Design global influences affecting the lighting in the scene
- Practice setting up the lights
- Apply texture maps to lamp color channels

Terminology

Ambient Light	:	Ambient light means the light that is already present in a scene, before any additional lighting is added. It usually refers to natural light, either outdoors or coming through windows etc. It can also mean artificial lights such as normal room lights.
Ambient	:	Ambient occlusion is a method to approximatehow bright light should be shining on any.
Occlusion:	:	specific part of a surface, based on the light and its environment. This is used to addrealism.
Indirect Lighting	:	Lighting provided by reflection usually from wall or ceiling surfaces. In day lighting, thismeans that the light coming from the sky or the sun is reflected on a surface of high reflectivity like a wall, a window sill or a special redirecting device. In electrical lighting,the luminaries are suspended from the ceiling or wall mounted and distribute light mainly upwards so it gets reflected off the ceiling or the walls.

Direct Lighting : Direct sunlight is when you (or the plant) get the rays directly on it. It is like sitting outside, without a hat, and nothing is between you andthe sun.

Viewing Restrictions

The Color of an object and the lighting of your scene are affectedby:

- Your **ability** to see different colors (partial color blindnessis common).
- The **medium** in which you are viewing the image (e.g. an LCD panel versus printed glossy paper).
- The **quality** of the image (e.g. a jpeg at 0.4 compression versus 1.0).
- The **environment** in which you are viewing the image (e.g.a CRT monitor with glare versus in a dark room, or in a sunshiny blue room).

Your brain's perception of the color and intensity relative to those objects around it and the world background color, which can be changed using color manipulation techniques using Blender Composite Nodes.

Global Influences

In Blender, the elements under your control which affect lighting are:

- The color of the world ambient light.
- The use of Ambient Occlusion to cast that ambient light onto the object.
- The degree to which the ambient light colors the material of the object.
- The use of Indirect lighting, where the color of one object radiates onto another.
- The lamps in your scene.
- The physics of light bouncing around in the real world is simulated by Ambient Occlusion (a world setting), buffer shadows (which approximate shadows being cast by objects), ray tracing (which traces the path of photons from a light source).

Also, within Blender you can use **Indirect lighting.** Ray tracing, Ambient Occlusion, and Indirect Lighting are **computer-intensive processes**. Blender can perform much faster rendering with its internal scan line renderer, which is a very good scan line rendererindeed. This kind of rendering engine is much faster since it does not try to simulate the real behavior of light, assuming many simplifying hypotheses.

Lighting Settings

Only after the above global influences have been considered, do you start adding light from lamps in your scene. The main things under your control are the:

- **Type of light used (*Sun, Spot, Lamp, Hemi,* etc.).**
- **Color of the light.**
- **Position of the light and its direction.**
- **Settings for the light, including energy and falloff.**

Then you are back to how that material's Shader reacts to the light.

This Unit attempts to address the above, including how lights can work together in rigs to light your scene. In this Unit, we willanalyze the **different type of lights** in Blender and their behavior; we will discuss their **strong and weak points**. We will also describemany lighting rigs, including the ever-popular **three-point lightmethod**.

Lighting in the Workflow

In this Unit, you should set up your lighting before assigning materials to your meshes. Since the material Shaders react tolight, without proper lighting, the material Shaders will not look right, and you will end up fighting the Shaders, when it is really thebad lighting that is causing you grief. All the example images in thisUnit do not use any material setting at all on the ball, cube or background.

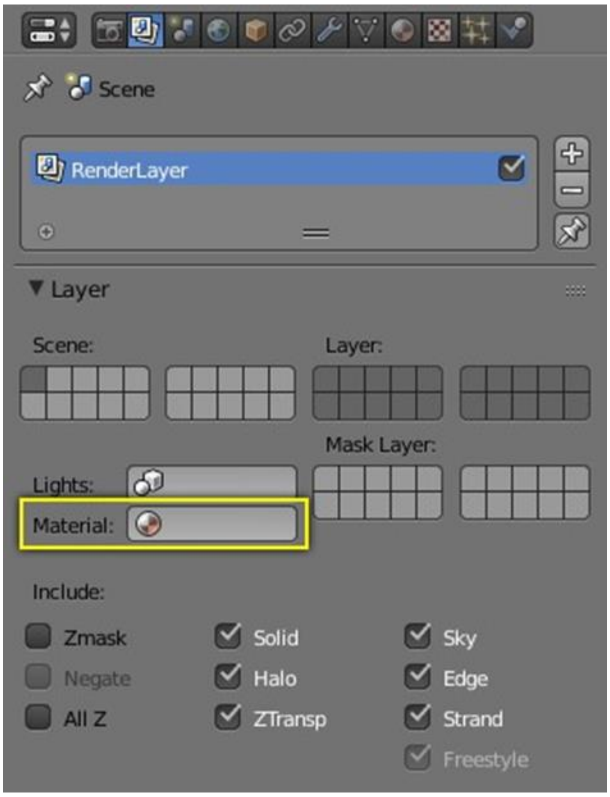
Overriding Materialsto Reset Lighting

If you have started down the road of assigning materials, and arenow fiddling with the lighting, we suggest that you

Step 1: create a default, generic gray material – no *Vertex Color*, no *Face Texture*, no *Shadeless*, justplain old middle gray with RGB (0.8, 0.8, 0.8).

Step 2: Name this **"Gray"**.
Step 3: Next go to the *Render Layer* tab.
Step 4: In the *Layer* panel, select your new "Gray" material in the *Material* field. This will override anymaterials you may have set, and render everythingwith this color. Using this material, you can now goabout adjusting the lighting.

Step 5: Just empty this field to get back to your originalmaterials.



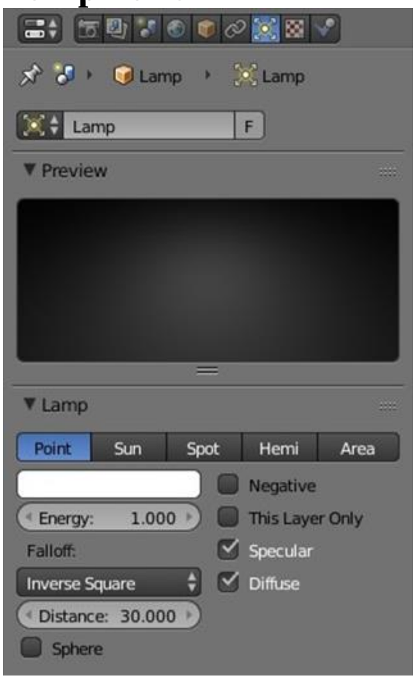
Title-Img 1. 1Material field in the Render Layers panel.

Attribution-

Source-

Link-*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/introduction.html?highlight=overriding%20materials%20reset%20lighting*

Lamp Panel



Title-Img 1. 2Lamp tab.

Link- *https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/la mp_panel.html*

Lamp

A Data-Block Menu. Its list shows all light settings used inthe current scene.

- **Texture Count**

  Shows the count of textures in the lamp texture stack.

- **Preview**

  A quick preview of the light settings

Lamp Type

Types of lamps available in Blender Internal. They share all orsome of the options listed here:

- **Color**

  The color of the light source's illumination

- **Energy**

  The intensity of the light source's illumination from (0.0 to 10.0).

- **Distance**

  The *Distance* number button indicates the number of **Blender Units (BU**) at which the intensity of the current light source will be half of its intensity. Objects less thanthe number of BU away from the lamp will get more light, while objects further away will receive less light. Certain settings and lamp falloff types affect how the *Distance* is interpreted, meaning that it will not always react the same.

  The ***Sun* and *Hemi* Lamps** are another class of Lamps whichuses a constant falloff. Those lamps do not have a *Distance* parameter, and are often called **"Base Lighting Lamps".**

- **Influence**

  Every lamp has a set of switches that control which objects receive its light, and how it interacts with materials.

- **Negative**

  Let the lamp cast negative light. The light produced by the lamp is *subtracted* from the irradiance on the surfaces it hits, which darkens these surfaces instead of brightening them.

- **This Layer Only**

The Lamp only illuminates objects on the same layer the lamp is on. Causes the lamp to only light objects on the same layer.

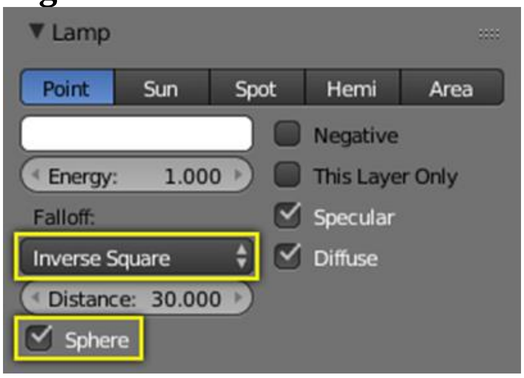
- **Specular**

  The Lamp creates specular highlights.

- **Diffuse**

  The Lamp affects diffuse shading.

Light Attenuation



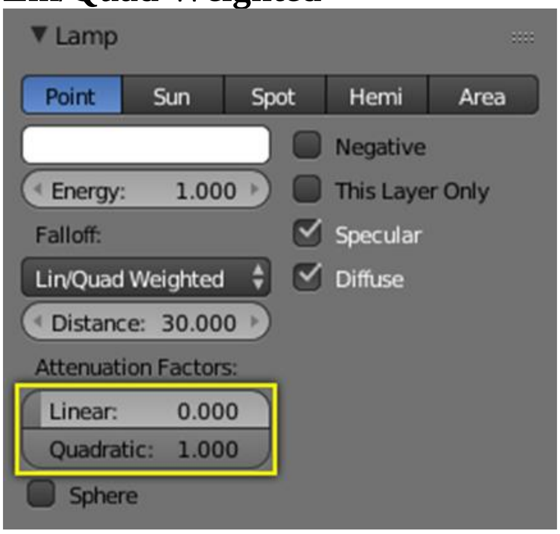
Title-Img 1. 3Lamp panel, falloff options highlighted.
Link- *https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/att enuation.html*

There are **two main controls** for light falloff for *Point* and *Spot* lamps:

1. The lamp ***Falloff***type selector
2. The ***Sphere***checkbox

Falloff Types

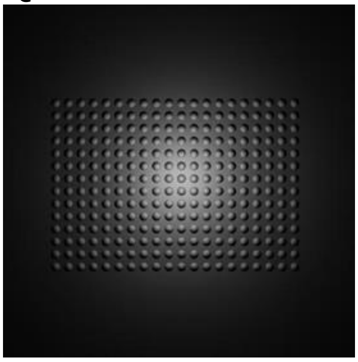
Lin/Quad Weighted



Title-Img 1. 4 Lamp panel with Lin/Quad Weighted Falloff optionshighlighted.
Attribution-
Source-blender.org
Link *https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html*

When this setting is chosen, two sliders are shown, ***Linear***and ***Quadratic*,** which control respectively the "linearness" and "quadraticness" of the falloff curve.
This lamp falloff type is in effect allowing the **mixing of the two light attenuation** profiles (linear and quadratic attenuation types).

Quadratic Attenuation



Title-Img 1. 5 Lamp with Lin/Quad Weighted falloff default settings.
Attribution-
Source-blender.org
Link-[https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/att enuation.html](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html)

This slider input field can have a value between **(0.0 to 1.0)**. A value of **1.0 in the *Quadratic*** field and **0.0 in the *Linear*** field means that the light from this source is completely quadratic.

Quadratic Attenuation type lighting is considered a more accuraterepresentation of how light attenuates (in the real world). In fact, fully quadratic attenuation is selected by default. For ***Lin/Quad Weighted* lamp fallout**. Here again, the light intensity is half when it reaches the *Distance* value from the lamp. Comparing the quadratic falloff to the linear falloff, the intensity decays much slower at distances lower than the set *Distance*, however, it attenuates much quicker after *Distance* is reached.

Zeroing both "Linear" and "Quad"

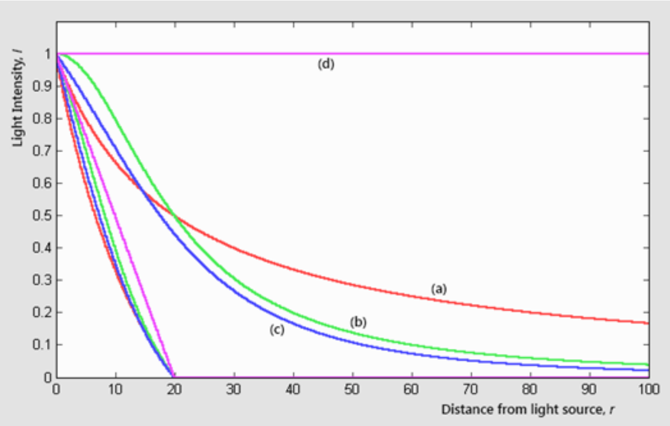
If both the *Linear* and *Quadratic* sliders have 0.0 as their values, the light intensity will not attenuate with distance. This does not mean that the light will not get darker, rather it will, however, onlybecause the energy the light has is spread out over a wider and wider distance. The total amount of energy in the spread-out light will remain the same, though. The light angle also affects the amount of light you see. It is in fact the behavior of light in the deep space vacuum.

If you want a light source that does not attenuate and gives the same amount of light intensity to each area it hits, you need a lightwith properties like the ***Constant* lamp *Falloff*** type.

Also, when the *Linear* and *Quad* sliders are both 0.0 values the *Distance* field ceases to have any influence on the light attenuation, as shown by the equation above.

Graphical Summary

Below is a Graph Summarizing the lin/quad attenuation type, showing attenuation with or without the *Sphere* option (described later).



Title-Img 1. 6 Lin/quad attenuation type

Source-blender.org

Link[*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html*](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html)

Light Attenuation:

Linear (Linear=1.0, Quad=0.0);

Quadratic (Linear=0.0, Quad=1.0);

Linear and quadratic (Linear=Quad=0.5);

Null (Linear=Quad=0.0);

Also, shown in the graph the "same" curves, in the same colors,however, with the Sphere button turned on.

Custom Curve

The ***Custom Curve*** **Lamp** ***Falloff*** type is very flexible.

Most other lamp falloff types work by having their light intensity start at its maximum (when nearest to the light source) and then with some predetermined pattern decrease their light intensity when the distance from the light source increases.

When using the *Custom Curve* Lamp Falloff type, a new panel is created called ***Falloff Curve***. This *Falloff Curve* profile graph allows the user to alter how intense light is at a particular point along a light's attenuation profile (i.e. at a specific distance from the light source).

The *Falloff Curve* profile graph has two axes, the **Distance-axis andthe Intensity-axis**.

1. **Distance axis**

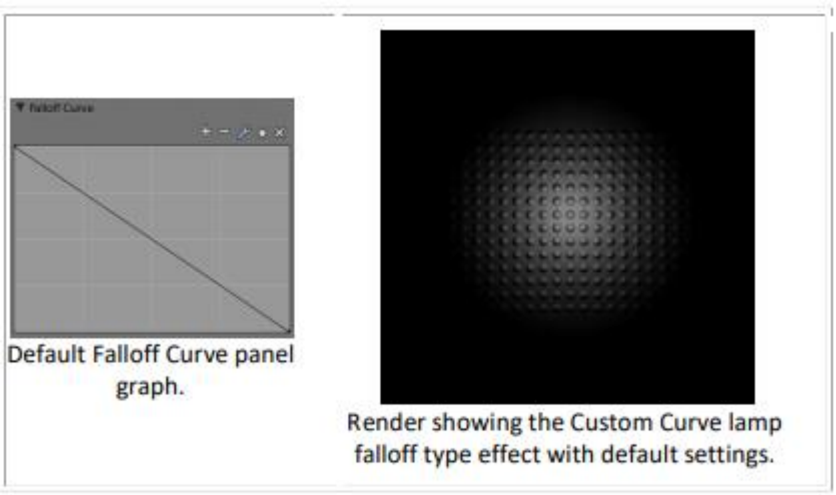
It represents the **position at** a particular point along a light source's attenuation path. The far left is at the position of the light source and the far right is the place where thelight source's influence would normally be completely attenuated.

2. **Intensity axis**

   It represents the **intensity at** a particular point along a lightsource's attenuation path. Higher intensity is represented by being higher up the intensity axis, while lower intensity light is represented by being lower down on the intensity axis.

Altering the *Falloff Curve* profile graph is easy. Just LMB **click** on a part of the graph you want to alter and drag it where you want it to be. If you click over or near one of the tiny black square handles, it will turn white, indicating that this handle is now selected, and you will be able to drag it to a new position. If when you click on the graph you are not near a handle, one will be created at the point that you clicked, which you can then drag where you wish. You can also create handles at specific parts of the graph, clicking with LMB while holding Ctrl ; it will create **a new handle** at the point you have checked.

In the example below (the default for the *Falloff Curve* Profile Graph), the graph shows that the intensity of the light starts off at its maximum (when near the light), and linearly attenuates as it moves to the right (further away from the light source).

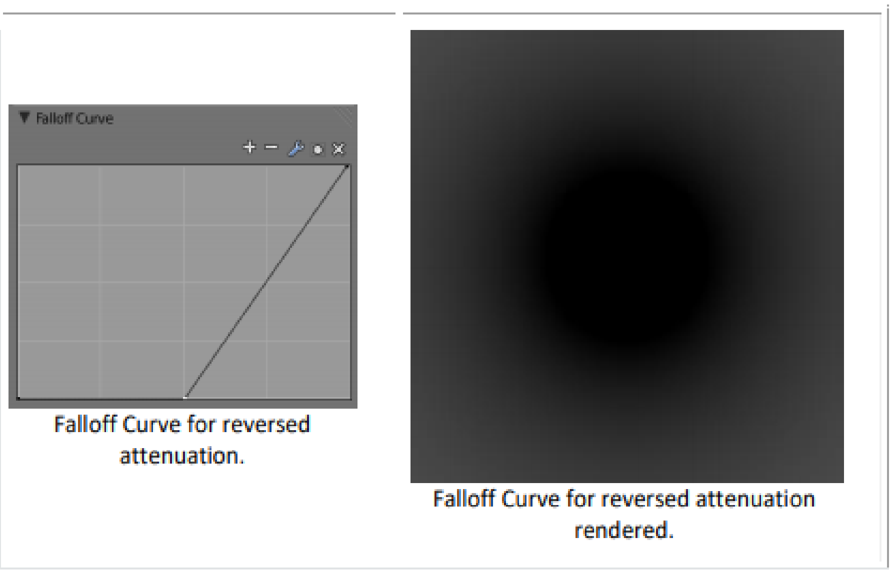


Default Falloff Curve panel graph.

Render showing the Custom Curve lamp falloff type effect with default settings.

Title-Img 1. 7 Falloff Curve Profile Graph
Source-blender.org
Link-[*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/att enuation.html*](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html)

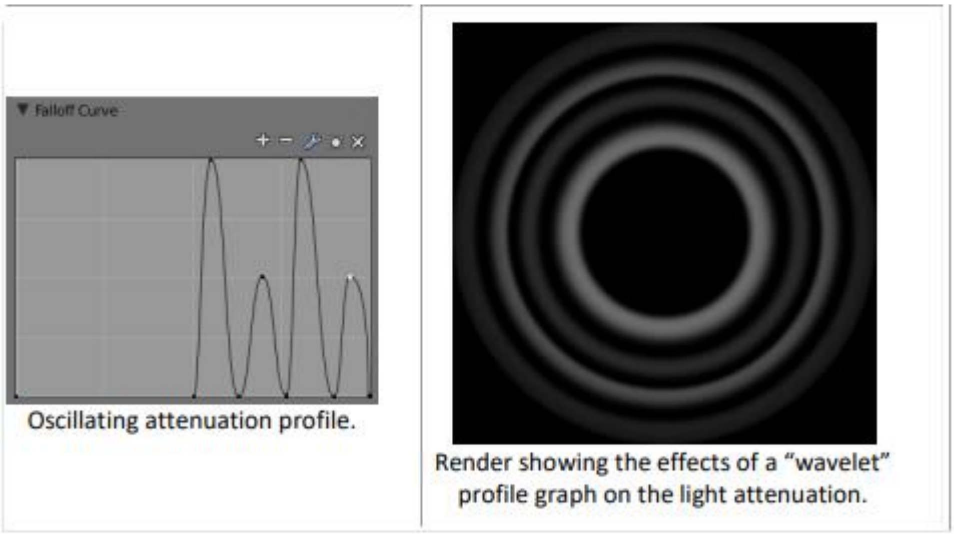
If you want to have a light attenuation profile that gets more intense as it moves away from the light source, you could alter thegraph as below:



Title-Img 1. 8Falloff Curve Profile Graph
Source-blender.org
Link- *https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/att enuation.html*

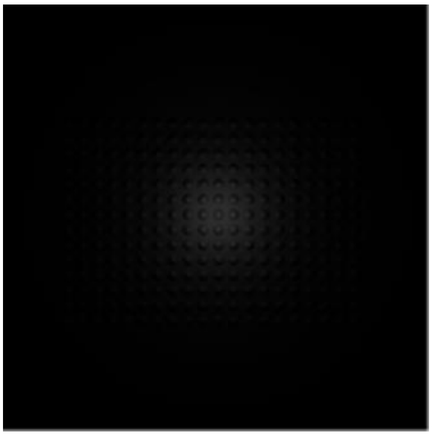
You are obviously not just limited to simple changes such as reversing the attenuation profile, you can have almost any profile you desire.

Here is another example of a **different *Falloff Curve*** profile graph, along with its resultant render output:



Title-Img 1. 9 Falloff Curve Profile Graph
Source-blender.org
Link *https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/att enuation.html*

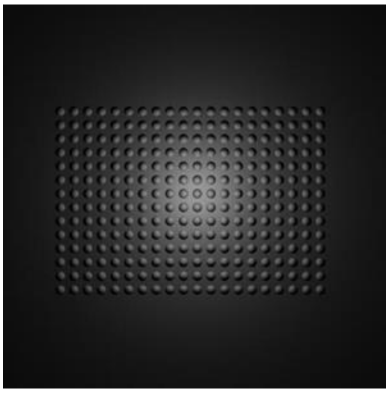
Inverse Square



Title-Img 1. 10 Render showing the Inverse Square lamp falloff type effect withdefault settings.
Source-blender.org
Link-[*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/att enuation.html*](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html)

This lamp falloff type attenuates its intensity according to inverse square law, scaled by the *Distance* value. Inverse square is a sharper, realistic decay, useful for lighting such as desk lamps and street lights. This is similar to the old *Quad* option (and consequently, to the new *Lin/Quad Weighted* option with *Linear* to 0.0 and *Quad* to 1.0), with slight changes.

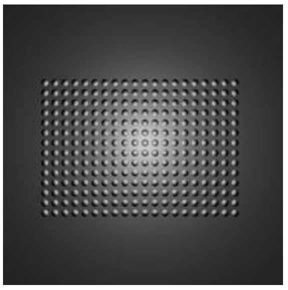
Inverse Linear



Title-Img 1.11Render showing the **Inverse Linear lamp falloff** type effect withdefault settings.
Source-blender.org
Link-[*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html*](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html)

This lamp falloff type attenuates its intensity linearly, scaled by the*Distance* value. This is the default setting, behaving the same asthe default in previous Blender versions without *Quad* switched on, and consequently, like the new *Lin/Quad Weighted* optionwith *Linear* to 1.0 and *Quad* to 0.0. This is not physically accurate, however, can be easier to light with.

Constant



Title-Img 1.12Render showing the **Constant lamp falloff** type effect withdefault settings.

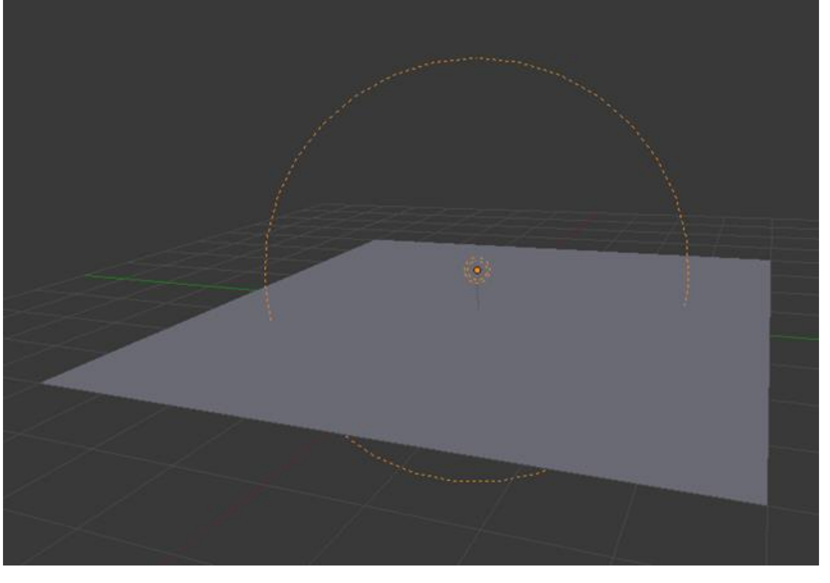
Source-blender.org

Link-[*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/att enuation.html*](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html)

This lamp falloff type does not attenuate its intensity with distance. This is useful for distant light sources like the sun or sky, which are so far away that their falloff is not noticeable. ***Sun* and *Hemi* lamps always have constant falloff.**

Such a falloff model is commonly used in real-time rendering applications via a shading language like GLSL.

Sphere



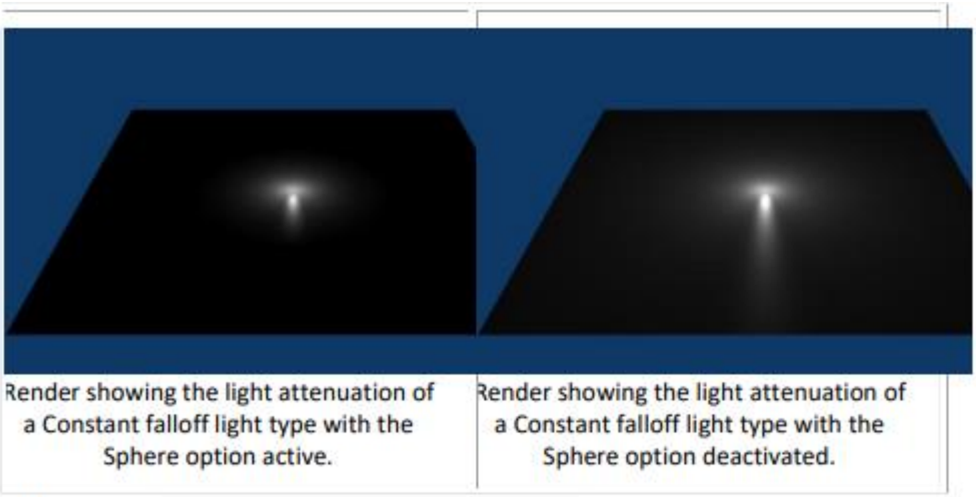
Title-Img 1. 6Screenshot of the 3D View editor, showing the Sphere light clippingcircle.

Source-blender.org

Link-[*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html*](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html)

The *Sphere* option restricts the light illumination range of a *Lamp* or *Spot* lamp, so that it will completely stop illuminating an area once it reaches the number of Blender Units away from the Lamp, as specified in the *Distance* field.

When the *Sphere* option is **active,** a dotted sphere will appear around the light source, indicating the demarcation point at which this light intensity will be null.

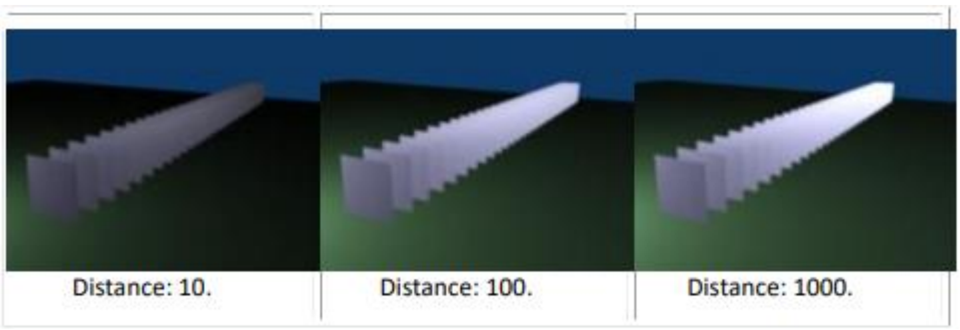


Title-Img 1. 7Lin/Quad Weighted *attenuation option.*
Source-blender.org
Link-[*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/att enuation.html*](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html)

Examples

Distance Example

In this example, the *Lamp* has been set **pretty close** to the groupof planes. This causes the light to affect the front, middle and rear planes more dramatically. Looking at Img 1.15 below, you can see that as the Distance is increased, more and more objects become progressively brighter.



Title-Img 1. 8 Various Distance settings (shadows disabled).
Source-blender.org
Link-[*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html*](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html)

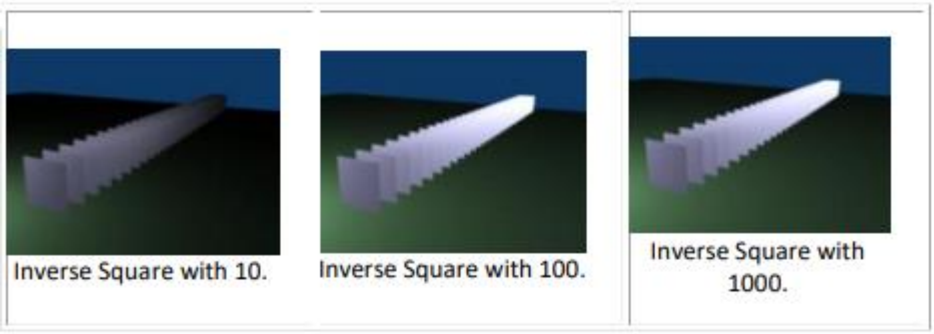
The *Distance* parameter is controlling where the light is falling – at a linear rate by default – to half its original value from the light's origin. As you increase or decrease this value, you are changing where this half falloff occurs. You could think of *Distance* as the surface of a sphere and the surface is where the light's intensity has fallen to half its strength in all directions. Note that the light's intensity continues to fall even after *Distance*. *Distance* just specifies the distance where half of the light's energy has weakened.

Notice in Img 1.15 Distance: 1000., that the farthest objects are very bright. This is because the falloff has been extended far into the distance, which means the light is very strong when it hits the last few objects. It is not until 1000 Units that the light's intensity has fallen to half of its original intensity.

Contrast this with Img 1.15 Distance: 100., where the falloff occursso soon that the farther objects are barely lit. The light's intensity has fallen by a half by time it even reaches the tenth object. You may be wondering why the first few planes appear to be dimmer? This is because the surface angle between the light and the object's surface normal is getting close to **oblique**. That is the nature of a *Lamp* light object. By moving the light infinitely far away you would begin to approach the characteristics of the ***Sun* lamp type**.

Inverse Square Example

Inverse Square makes the light's intensity falloff with a non-linear rate, or specifically, a quadratic rate. The characteristic feature of using *Inverse Square* is that the light's intensity begins to fall off very slowly however, then starts falling off very rapidly. We can see this in Img. 1.16 Inverse Square selected. (with the specified distances). images.



Title-Img 1. 9 Inverse Square selected. (with the specified distances).

Source-blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/att enuation.html

With *Inverse Square* selected, the *Distance* field specifies where the light begins to fall off faster, roughly speaking; see the light attenuation description in Falloff types for more info.

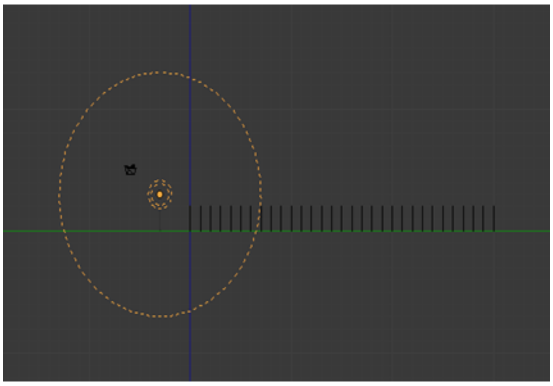
In Img. 1.16 Inverse Square with 10., the light's intensity has fallen so quickly that the last few objects are not even lit.

Both Img. 1.16 Inverse Square with 100. and Img. 1.16 Inverse Square with 1000. appear to be almost identical and that is because the *Distance* is set beyond the farthest object's distance which is at about 40 BU out. Hence, all the objects get almost the full intensity of the light.

As above, the first few objects are dimmer than farther objects because they are very close to the light. Remember, the brightness of an object's surface is also based on the angle between the surface normal of an object and the ray of light coming from the lamp.

This means there are at least two things that are controlling the surface's brightness: intensity and the angle between the lightsource and the surface's normal.

Sphere Example

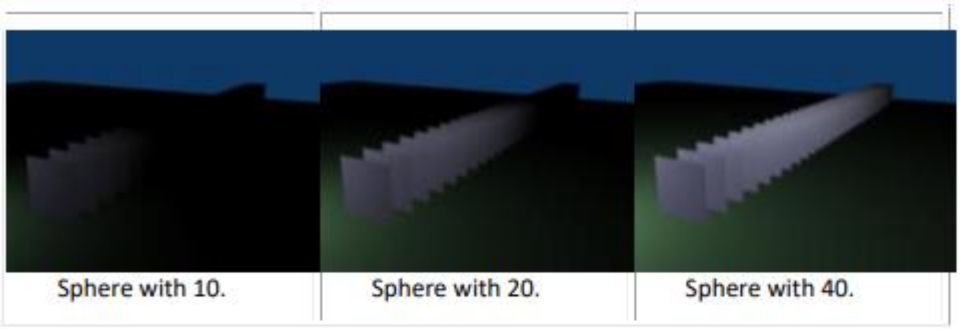


Title-Img 1. 10Clipping Sphere.

Source-blender.org
Link-[*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html*](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html)

Sphere indicates that the light's intensity is null at the *Distance*and beyond, regardless of the chosen light's falloff. In Img 1.17 Clipping Sphere. you can see a side view example of the setup with *Sphere* enabled and a distance of 10.

Any object beyond the sphere receive **no light** from the lamp.



Title-Img 1. 11 Sphere enabled with the specified distances, Inverse Linear lightfalloff.
Source-blender.org
Link- [*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/att enuation.html*](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/attenuation.html)

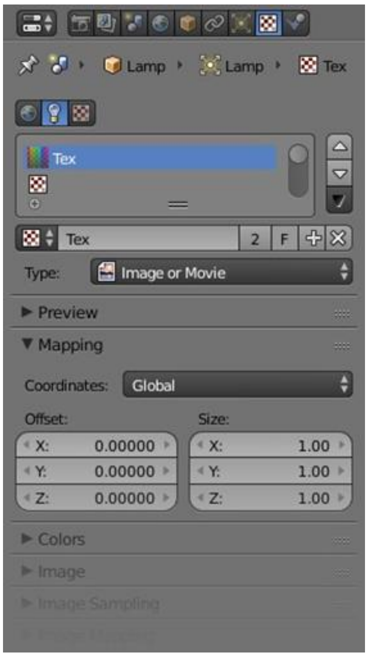
The *Distance* field is now specifying both where the light's rays become null, and the intensity's ratio falloff setting. Note that there is no abrupt transition at the sphere: the light attenuation is progressive (for more details, see the descriptions of the Sphere and Falloff types above).

In Img 1.18 Sphere with 10., the clipping sphere's radius is 10 Units, which means the light's intensity is also being controlled by 10 Units of distance. With a linear attenuation, the light's intensityhas fallen very low even before it gets to the first object.

In Img 1.18 Sphere with 20., the clipping sphere's radius is now 20 BU and some light is reaching the middle objects.

In Img 1.18 Sphere with 40., the clipping sphere's radius is now 40 Units, which is beyond the last object. However, the light does not make it to the last few objects because the intensity has fallen to nearly 0.

Lamps Textures



Title-Img 1. 12Lamp Texture panels.

Source-blender.org

***Link-**https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/te xtures.html*

When a new lamp is added, it produces **light in a uniform, flat color**. While this might be sufficient in simple renderings, more sophisticated effects can be accomplished through the use of textures. Subtle textures can add visual nuance to a lamp, while hard textures can be used to simulate more pronounced effects, such as a disco ball, dappled sunlight breaking through treetops, or even a projector. These textures are assigned to one of ten channels, and behave exactly like material textures, except that they affect a lamp's color and intensity, rather than a material's surface characteristics.

Options

The lamp textures settings are grouped into **two panels**. Here we will only talk about the few things that differ from object material textures.

The **Texture-specific** and the ***Mapping* panels** remain the same. However, you will note there are much fewer *Mapping* options. You can only choose between ***Global*, *View* or another *Object* 's texture *coordinates*** (since a lamp has no texture coordinates by itself), and you can scale or offset the texture.

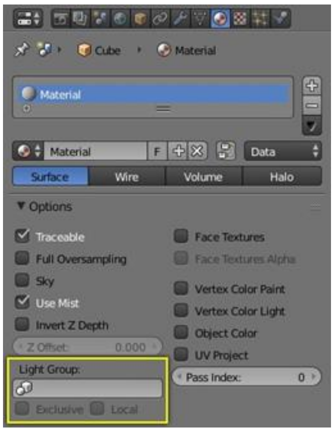
The ***Mapping* panel** is also a subset of its regular material's counterpart. You can only map a lamp texture to its regular, basic *Color* and/or to its *Shadow* color. As you can only affect colors,and a lamp has no texture coordinates on its own, the *Diffuse*, *Specular*, *Shading*, and *Geometry* options have disappeared.

Lamps Related Settings

Here are some options closely related to light sources, withoutbeing lamps settings.

Lighting Groups:

Materials

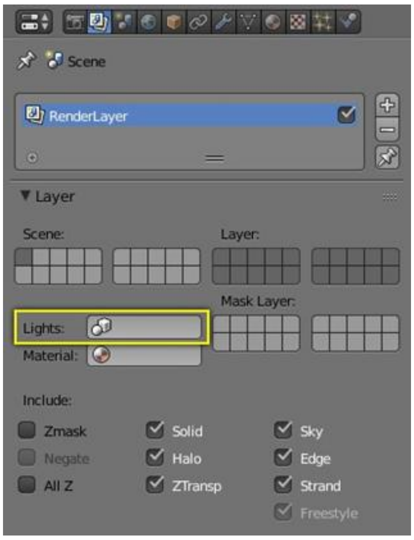


Title-Img 1. 13Light Group options for Materials.
Source-blender.org
Link-*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/in_other_contexts.html*

By default, materials are lit by all lamps in all visible layers, however, a material (and thus all objects using that material) can be limited to a single group of lamps. This sort of control can be incredibly useful, especially in scenes with complex lighting setups.To enable this, navigate to the ***Material* menu's *Options*** panel andselect a **group of lamps** in the *Light Group* field. Note that a light group must be created first.

If the *Exclusive* button is enabled, lights in the specified group will *only* affect objects with this material.

Render Layers



Title-Img 1. 14Light Group options for Render Layers.

Source-blender.org

Link-[*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/in_othercontexts.html*](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lights/in_othercontexts.html)

There is a similar control located in the ***Layer panel*** of the Render Layers tab. If a light group name is selected in this *Light* field, the scene will be lit exclusively by lamps in the specified group.

Unit summary

In this Unit, you have learnt what is 3D Lighting and how to

- Plan your 3D scene for lighting
- View limitations and global influences to setup a perfectlighting angle for your 3D Assets
- Set up the lights using Lamp Panel controlling light intensitywith the help of curve, attenuation.
- Produce subtle visual nuance using texture connecting withchannels

After learning this Unit, you can download the Open Source Software available on the internet for free of cost to practice the possibilities of creating 3D Interface.

Assignment

- Students are expected to experiment the lighting setups andparameters available in the panel.

Assessment

1. Define Indirect Lighting
2. Write a note on Lamp Panel
3. Describe Light Attenuation
4. Describe Sphere Option in Lighting

Write down the steps to create Lamp Texturing

Fill in the Blanks

1. ______________means the light that is already present ina scene.
2. Direct lighting is equal to________ Light.
3. Lamp only illuminates objects on the _________when thelamp is on.
4. There are two main controls for light falloff - Point and ______.
5. The____________option restricts the lightillumination range of a Lamp or Spot lamp

Resources

While studying this Unit, you can browse the internet links for online video tutorials and several books and training DVDs available in the Blender Store and on the Blender Cloud.

- wiki.blender.org
- ia600207.us.archive.org
- archive.org
- www.blender.org
- docs.blender.org

Unit-2 Introduction Understanding Shadows

Introduction

Light would not even exist without its counterpart: **Shadows.** Shadows are a darkening of a portion of an object, because light is being partially or totally blocked from illuminating the object. Theyadd contrast and volume to a scene; there is nearly no place in thereal world without shadows, so to get realistic renders, you will need them. Blender supports the following kinds of shadows:

1. Lamps: Ray-traced Shadows
2. Lamps: Buffered Shadows
3. Ambient Occlusion
4. Indirect Lighting

In this Unit, you will learn about Shadows and the various kinds ofShadows.

Outcomes

Upon completion of this unit you will be able to:

- Compose lighting with relevant shadow type
- Differentiate the types of shadows
- Apply shadow options for the available light setup inBlender software

Terminology

Raytrace	:	In computer graphics, ray tracing is a technique for generating an image by tracing the path of light through pixels in an image plane and simulating the effects of its encounters with virtual objects, such as reflection and refraction,scattering, and dispersion phenomena
Ambient Occlusion	:	Ambient occlusion is a method to approximate how bright light should be shining on any specific part of a surface, based on the light and its environment. This is used to add realism.
Attenuation	:	Length of rays defines how far away other faces may be and still have an occlusion effect. The longer this distance, the greater impact that far-away geometry will have on the occlusioneffect.
Chains of Bones	:	Bone can be the parent of several children, and hence be part of several chains at the same time.

Lamps: Ray-traced Shadows

Ambient Occlusion really is not a shadow based on light *per se*, however, based on geometry. However, it does mimic an effect where light is prevented from fully and uniformly illuminating an object, so it is mentioned here. Also, it is important to mention Ambient Lighting, since

increasing *Ambient* decreases the effectof a shadow.

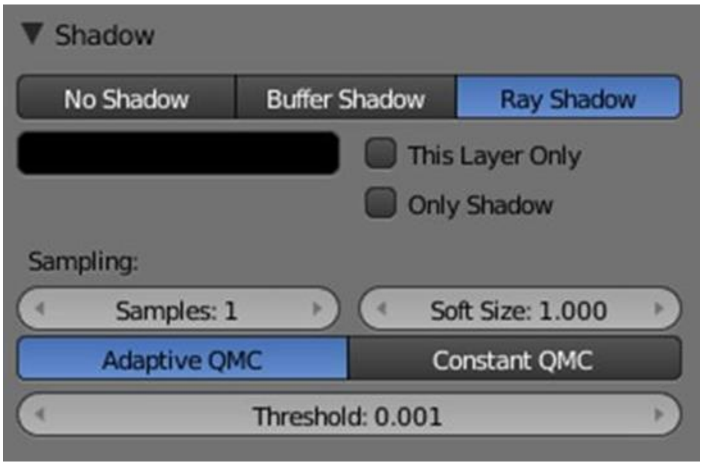
You can use a combination of **ray-traced** and **Buffer Shadows** to achieve different results. Even within ray-traced shadows, different lamps cast different patterns and intensities of shadow. Depending on how you arrange your lamps, one lamp may wipe out or override the shadow cast by another lamp.

Shadows are one of those trifectas in Blender, where multiple things must be set up in different areas to get results:

- The Lamp must cast shadows (ability and direction).
- An Opaque object must block light on its way (position and layer).
- Another object's material must receive shadows (*Shadow* and *Receive Transparent* enabled).
- The render engine must calculate shadows (*Shadow* forbuffered shadows, *Shadow* and *Ray* for ray-traced shadows).

For example, the **simple *Lamp***, *Area*, and *Sun* light have the ability to cast ray shadows, however, not Buffer Shadows. The ***Spot* light** can cast both, whereas the ***Hemi* light** does not cast any. If a ***Sun* lamp** is pointing sideways, it will not cast a shadow from a sphere above a plane onto the plane, since the light is not traveling that way. All lamps able to cast shadows share some common options, described in the Shadow Panel.

Just to give you more shadow options (and further confuse the issue), lamps and materials can be set to respectively **only** castand **receive** shadows, and not light the diffuse/specular aspects of the object. Also, render layers can turn on/off the shadow pass, and their output may or may not contain shadow information.



Title-Img 2. 1Ray Shadow enabled for a lamp.
Source-blender.org
Link-*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/shadows/introduction.html?highlight=ray%20shadow%20enabled%20lamp*

Ray-traced shadows produce very precise shadows with very low memory use, however, at the cost of processing time. This type of shadowing is available to **all lamp types except *Hemi*.**

As opposed to buffered shadows (Lamps: Buffered Shadows), ray- traced shadows are obtained by **casting rays from a regular light source**, uniformly and in all directions. The ray-tracer then records which pixel of the final image is hit by a ray light, and which is not. Those that are not are obviously obscured by a shadow.

Each light casts rays in a different way. For example, a ***Spot* light** casts rays uniformly in all directions within a cone. The ***Sun* light** casts rays from an infinitely distant point, with all ray's parallel to the direction of the *Sun* light.

For each additional light added to the scene, with ray-tracing enabled, the rendering time **increases.** Ray-traced shadows require **more computation** than buffered shadows however, produce **sharp shadow borders** with very less memory resource usage.

To enable Ray-traced shadows, three actions are required:

- **Step 1:** Enable *Shadows* globally in the *Render* Menu's *Shading* panel.
- **Step 2:** Enable *Ray tracing* globally from the same panel.
- **Step 3:** Enable ray-traced shadows for the light using the *Ray Shadow* button in the *Light* menu's *Shadow* panel. This panel varies depending on the type of light.

All lamps able to cast ray-traced shadows share some commonoptions, described in Ray-traced Properties.

Ray-traced shadows can be cast by the following types of lamp:

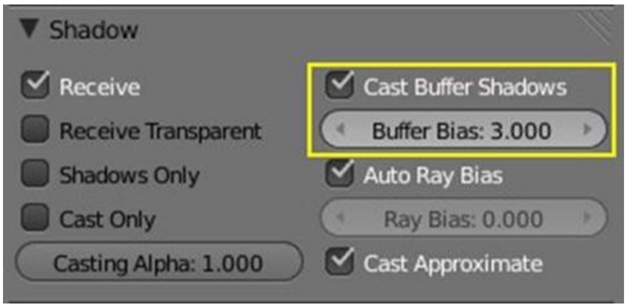
1. **Point lamp**
2. **Spot lamp**
3. **Area lamp**
4. **Sun lamp**

Lamps: Buffered Shadows

Title-Img 2. 2Buffer Shadow enabled for a Spot lamp**.**

Source- blender.org

Link-*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/shadow s/introduction.html?highlight=ray%20shadow%20enabled%20lamp*



Title-Img 2. 3Cast Buffer Shadows enabled for a material.

Source- blender.org

Linkhttps://docs.blender.org/manual/en/dev/render/blender_render/lighting/shadow s/introduction.html?highlight=ray%20shadow%20enabled%20lamp

***Buffered* shadows** provide fast-rendered shadows at the expense of precision and/or quality. Buffered shadows also require **more memory resources** as compared to ray tracing. You must use buffered shadows depending on your requirements. If you arerendering animations or **cannot wait hours** to render a complex scene with soft shadows, Buffer Shadows are a good choice.

For a **scanline renderer** – and Blender's built-in engine *is*, among other things, a scanline renderer – shadows can be computedusing a ***shadow buffer***. This implies that an "image", as seen from the spot lamp's point of view, is "rendered" and that the distance - in the image – for each point from the spot light is saved. Any point in the "rendered" image that is farther away than any of those points in the spot light's image is then considered to be in shadow. The shadow buffer stores this image data.

To enable buffered shadows these actions are required:

- **Step 1:** Enable shadows globally from the *Scene* Menu's *Gather* panel by selecting *Approximate*.
- **Step 2:** Enable shadows for the light using the *BufferShadow* button in the *Lamp* menu's *Shadow* panel.
- **Step 3:** Make sure the *Cast Buffer Shadows* options isenabled in each *Material* 's *Shadow* panel.

The **Spot lamp** is the only lamp able to cast buffered shadows.

Indirect Lighting

Indirect Lighting adds indirect light bouncing of surrounding objects. It models the light that is reflected from other surfaces to the current surface. It is more comprehensive, more physically correct, and produces more realistic images. It is also more computationally expensive.

Title-Img 2. 4Indirect Lighting parameters
Source- blender.org
Link- https://docs.blender.org/manual/en/dev/render/blender_render/lighting/shadows/introduction.html?highlight=ray%20shadow%20enabled%20lamp

Options

***Indirect Lighting* Panel** contains two options:

1. Factor

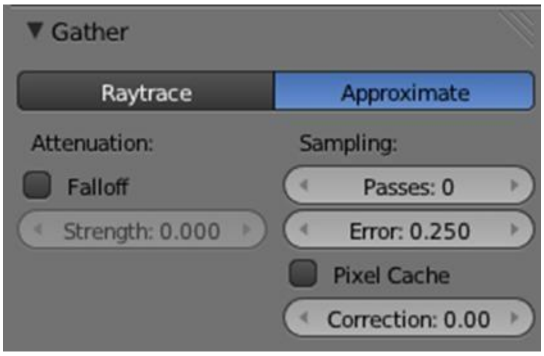
   Defines how much surrounding objects contribute to light.

2. Bounces

Number of indirect diffuse light bounces.

***Gather* Panel** contains settings for the indirect lighting quality. Note that these settings also apply to *Environment Lighting and Ambient Occlusion*.

Approximate



Title-Img 2. 5 The Indirect Lighting panel, Approximate method.
Source- blender.org
Link-https://docs.blender.org/manual/en/dev/render/blender_render/world/indirectlighting.html

The ***Approximate* method** gives a much smoother result for the same amount of render time, however, as its name states, it isonly an approximation of the ***Raytrace* method**, which implies it might produce some artifacts and it cannot use the sky's textureas the base color.

This method seems to tend to "over-occlude" the results. Youhave two complementary options to reduce this problem:

- **Passes**

  Set the number of pre-processing passes, between (0 to10) passes. Keeping the pre-processing passes high will increase render time, however, will also clear someartifacts and over-occlusions.

- **Error**

  This is the tolerance factor for approximation error (i.e. themax allowed difference between approximated result and fully computed result). The lower, the slower the render, however, the more accurate the results... Ranges between (0.0 to 10.0), defaults to 0.250.

- **Pixel Cache**

  When enabled, it will keep values of computed pixels to interpolate it with its neighbors. These further speeds up the render, generally without visible loss in quality...

- **Correction**
  A correction factor is to reduce over-occlusion. Ranges between (0.0 to 1.0) correction.

Ambient Occlusion (AO)

Ambient Occlusion is a sophisticated ray-tracing calculation which simulates soft global illumination shadows by **faking darkness** perceived in corners and at mesh intersections, creases, and cracks, where ambient light is occluded, or blocked.

There is no such thing as AO in real life; **AO is a specific** not- physically-accurate (but generally nice-looking) rendering trick. It basically samples a hemisphere around each point on the face, sees what proportion of that hemisphere is occluded by other geometry, and shades the pixel accordingly.

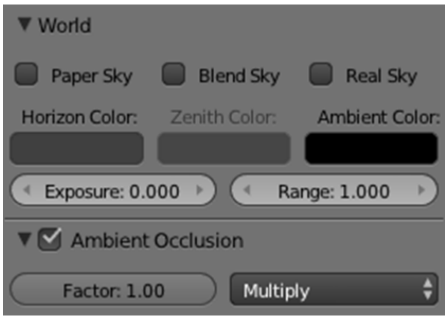
It has got nothing to do with light at all; it is purely a renderingtrick that tends to look nice because generally in real life surfaces that are close together (like small cracks) will be darker than surfaces that do not have anything in front of them, because of shadows, dirt, etc.

The AO process, though, approximates this result; it is not simulating light bouncing around or going through things. That is why AO still works when you do not have any lights in the scene, and it is why just switching on AO alone is a very bad way of “lighting” a scene.

You must have **ray tracing enabled** as a ***Render*** **panel option** in the *Shading* section for this to work.

You must have an ambient light color set as you desire. By default,the ambient light color (world) is black, simulating midnight in the basement during a power outage. Applying that color as ambient will actually darken all colors. A good outdoor mid-day color is RGB(0.9, 0.9, 0.8) which is a whitish yellow sunny kind of color on a bright-but-not-harshly-bright day.

Options



Title-Img 2. 6 The World panel with ambient color sliders highlighted.

Source- blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/world/ambient_occlusion.html?highlight=world%20panel%20ambient%20color%20sliders%20highlighted

- **Factor**

  The strength of the AO effect, a multiplier for addition.

Ambient Occlusion is composited during the render. **Twoblending modes** are available:

I. **Add**

The pixel receives light according to the number of non- obstructed rays. The scene is lighter. This simulates global illumination.

II. **Multiply**

Ambient occlusion is multiplied over the shading, making things darker.

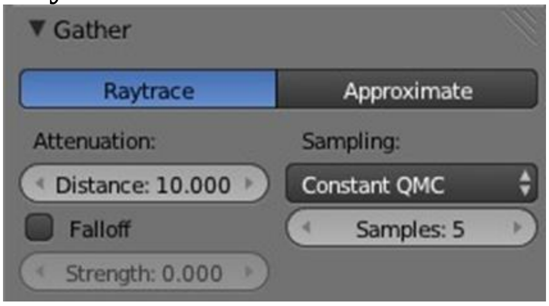
Ambient occlusion has two **main methods of calculation**:

I. *Raytrace* and
II. *Approximate*

Gather

Gather **Panel** contains settings for the Ambient occlusion quality. Note that these settings also apply to *Environment Lighting and Ambient Occlusion*.

Raytrace



Title-Img 2. 7 The Amb Occ panel, Raytrace method.

Source- blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/world/ambient_occlusion.html?highlight=world%20panel%20ambient%20color%20sliders%20highlighted

The *Raytrace* method gives the **more accurate**, however, also the more noisy results. You can get a nearly noiseless image, however,at the cost of render time... It is the only option if you want to use the colors of your sky's texture.

Attenuation

Length of rays defines how far away other faces may be and still have an occlusion effect. The longer this distance, the greaterimpact that far-away geometry will have on the occlusion effect. A high *Distance* value also means that the renderer must search a greater area for geometry that occludes, so render time can be optimized by making this distance as short as possible for the visual effect that you want.

Sampling Method

- **Constant QMC**

  The base Quasi-Monte Carlo, gives evenly and randomly distributed rays.

- **Adaptive QMC**

  An improved method of QMC, that tries to determine when the sample rate can be lowered or the sample skipped, based on its two settings:

- **Threshold**

  The limit below which the sample is considered fully occluded ("black") or un-occluded ("white"), and skipped.

- **Adapt to Speed**

  A factor to reduce AO sampling on fast-moving pixels. As it uses the *Vector* render pass, that must also be enabled.

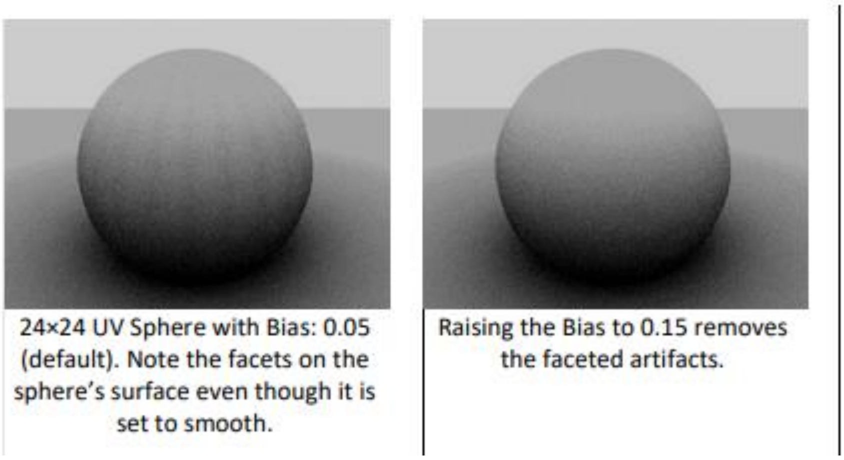
- **Constant Jittered**

The historical sample method, more prone to "bias" artifacts...

- **Bias**

  The angle (in radians) the hemisphere will be made narrower (i.e. the hemisphere will no longer be a real hemisphere: its section will no longer be a semicircle, however, an arc of a circle of: pi - *bias* radians).

  The bias setting allows you to control how smooth"smooth" faces will appear in AO rendering. Since AO occurs on the original faceted mesh, it is possible that the AO light makes faces visible even on objects with “smooth”on. This is due to the way AO rays are shot, and can be controlled with the *Bias* slider. Note that while it might even happen with QMC sampling methods, it is much morevisible with the *Constant Jittered* one and anyway, you have no *Bias* option for QMC.



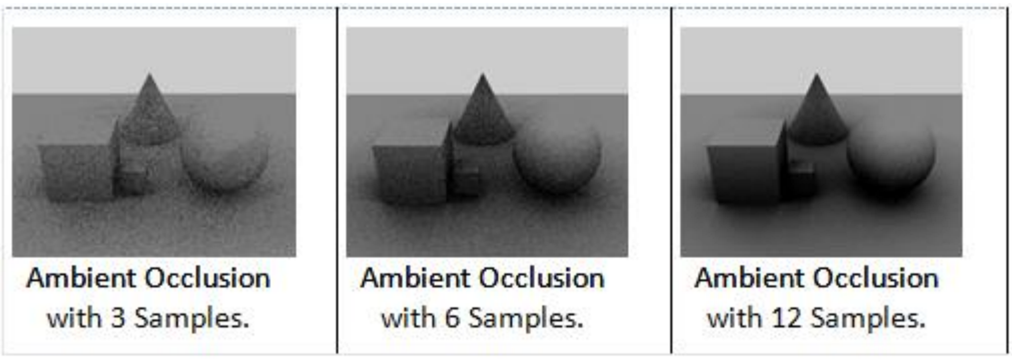
Title-Img 2.8 Bias

Source- blender.org

Linkhttps://docs.blender.org/manual/en/dev/render/blender_render/world/ambient_occlusion.html?highlight=world%20panel%20ambient%20color%20sliders%20highlighted

Samples

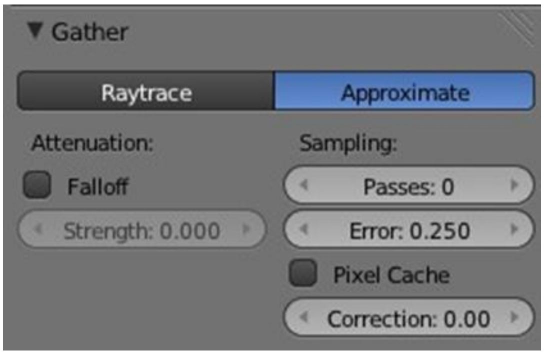
The number of rays used to detect if an object is occluded. Higher numbers of samples give smoother and more accurate results, at the expense of slower render times. The default value of 5 isusually good for previews. The actual number of rays shot out is the square of this number (i.e. *Samples* at 5 means 25 rays). Rays are shot at the hemisphere according to a random pattern (determined by the sample methods described above); this causes differences in the occlusion pattern of neighboring pixels unless the number of shot rays is big enough to produce good statistical data.



Title-Img 2.9 Ambient Occlusion samples

Source- blender.org
Link-[*https://docs.blender.org/manual/en/dev/render/blender_render/world/ambient_occlusion.html?highlight=world%20panel%20ambient%20color%20sliders%20highighted*](https://docs.blender.org/manual/en/dev/render/blender_render/world/ambient_occlusion.html?highlight=world%20panel%20ambient%20color%20sliders%20highighted)

Approximate



Title-Img 2.10 Ambient Occlusion panels, approximate method
Source- blender.org
Link-https://docs.blender.org/manual/en/dev/render/blender_render/world/ambient_occlusion.html?highlight=world%20panel%20ambient%20color%20sliders%20highlighted

The *Approximate* method gives a much smoother result for the same amount of render time, however, as its name states, it isonly an approximation of the *Raytrace* method, which implies it might produce some artifacts and it cannot use the sky's textureas the base color.

This method seems to tend to "over-occlude" the results. Youhave two complementary options to reduce this problem:

- **Passes**

  Set the number of pre-processing passes, between (0 to10) passes. Keeping the pre-processing passes high will increase render time however, will also clear some artifactsand over-occlusions.

- **Error**

  This is the tolerance factor for approximation error (i.e. themax allowed difference between approximated result and fully computed result). The lower, the slower the render, however, the more accurate the results... Ranges between (0.0 to 10.0), defaults to 0.250.

- **Pixel Cache**

  When enabled, it will keep values of computed pixels to interpolate it with its neighbours. This further speed up the render, generally without visible loss in quality...

- **Correction**

  A correction factor to reduce over-occlusion. Rangesbetween (0.0 to 1.0) correction.

Common Settings

- **Falloff**

When activated, the distance to the occluding objects will influence the “depth” of the shadow. This means that the further away the occluding geometry is, the lighter its “shadow” will be. This effect only occurs when theStrength factor is higher than 0.0. It mimics light dispersionin the atmosphere...

- **Strength**

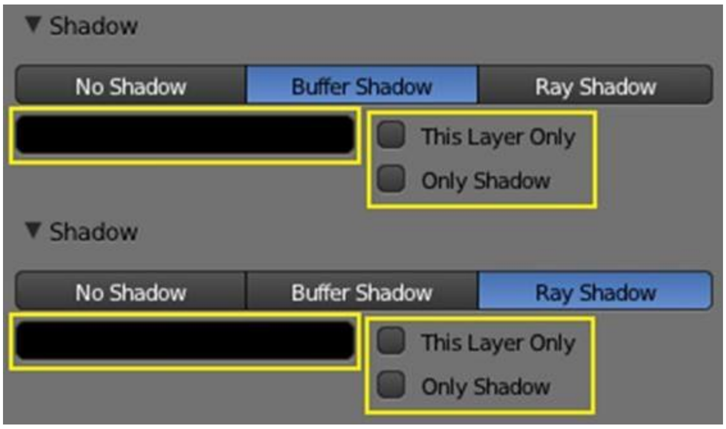
  Controls the attenuation of the shadows enabled with *Use Falloff*. Higher values give a shorter shadow, as it falls off more quickly (corresponding to a more foggy/dusty atmosphere). Ranges from (0.0 to 10.0), default is 0.0, which means no falloff.

- **Technical Details**

  Ambient occlusion is calculated by casting rays from each visible point, and by counting how many of them actually reach the sky, and how many, on the other hand, are obstructed by objects.

  The amount of light on the point is then proportional tothe number of rays which have “escaped” and have reached the sky. This is done by firing a hemisphere of shadow rays around. If a ray hits another face (it is occluded) then that ray is considered “shadow”, otherwise it is considered “light”. The ratio between “shadow” and “light” rays defines how bright a given pixel is.

Shadow Panel



Title-Img 2.11 Common shadowing options for lamps.
Source- blender.org
Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/shadows/shadow_panel.html?highlight=common%20shadowing%20options%20lamps

All lamps able to cast shadows. Share some options, describedbelow:

Shadow Method

- **No Shadow**

  The lamp casts no shadow.

- **Buffered Shadow**

  The Spot lamp is the only lamp able to cast buffered shadows.

- **Raytraced Shadows**

  Ray-traced Properties.

- **This Layer Only**

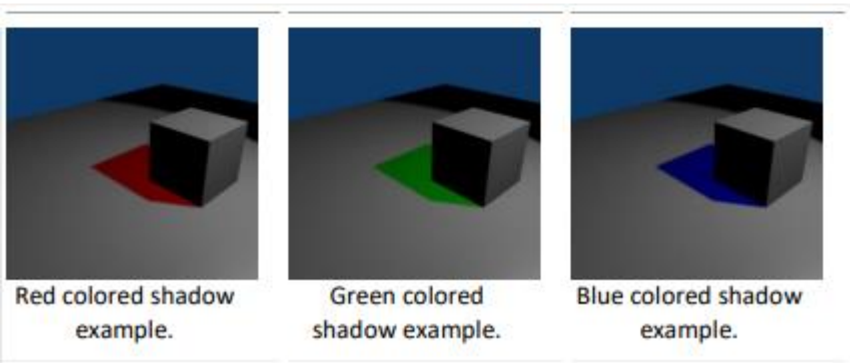
  When this option is enabled, only the objects on the same layer as the light source will cast shadows.

- **Only Shadow**

  The light source will not illuminate an object however, will generate the shadows that would normally appear. This feature is often used to control how and where shadows fall by having a light which illuminates however, has no shadow, combined with a second light which does not illuminate however, has *Only Shadow* enabled, allowingthe user to control shadow placement by moving the "Shadow Only" light around.

- **Shadow color**

  This color picker control allows you to choose the color of your cast shadows (black by default). The images below were all rendered with a white light and the shadow color was selected independently.



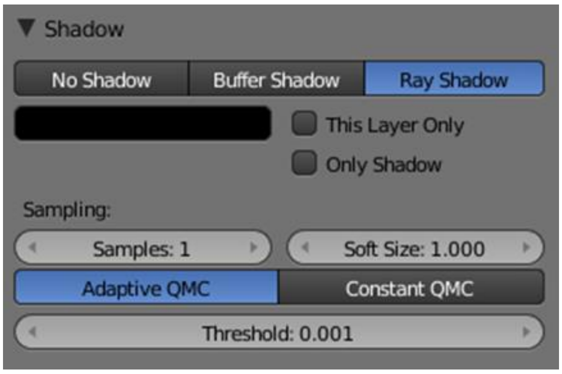
Title-Img 2.12 Shadow color

Source- blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/shadows/shadow_panel.html?highlight=common%20shadowing%20options%20lamps

Although you can select a pure white color for a shadow color, itappears to make a shadow disappear.

Raytraced Shadows



Title-Img 2.13 Ray shadowing options for lamps.
Source-blender.org
Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/shadows/raytraced_properties.html

Most lamp types (Lamp, Spot and Sun) share the same options for the ray-traced shadows generation, which are described below. Note that the Area lamp, even though using most of these options, have some specifics described in its own ray-traced shadows page.

Ray Shadow

The *Ray Shadow* button enables the light source to generate ray- traced shadows. When the *Ray Shadow* button is selected, another set of options is made available, those options being:

Shadow sample generator type

Method for generating shadow samples:

- **Adaptive QMC** is fastest,
- Constant QMC is less noisy however, slower. This allows you to choose which algorithm is to be used to generate the samples that will serve to compute the ray-traced shadows

  - **Constant QMC**

    The *Constant QMC* method is used to calculate shadow values in a very uniform, evenly distributed way. This method results in very good calculation of shadow value however, it is not as fast as using the *Adaptive QMC* method; however, *Constant QMC* is more accurate.

  - **Adaptive QMC**

    The *Adaptive QMC* method is used to calculate shadow values in a slightly less uniform and distributed way. This method results in good calculation of shadow valuehowever, not as good as *Constant QMC*. The advantage of using *Adaptive QMC* is that it is in general much quicker while being not much worse than *Constant QMC* in termsof overall results.

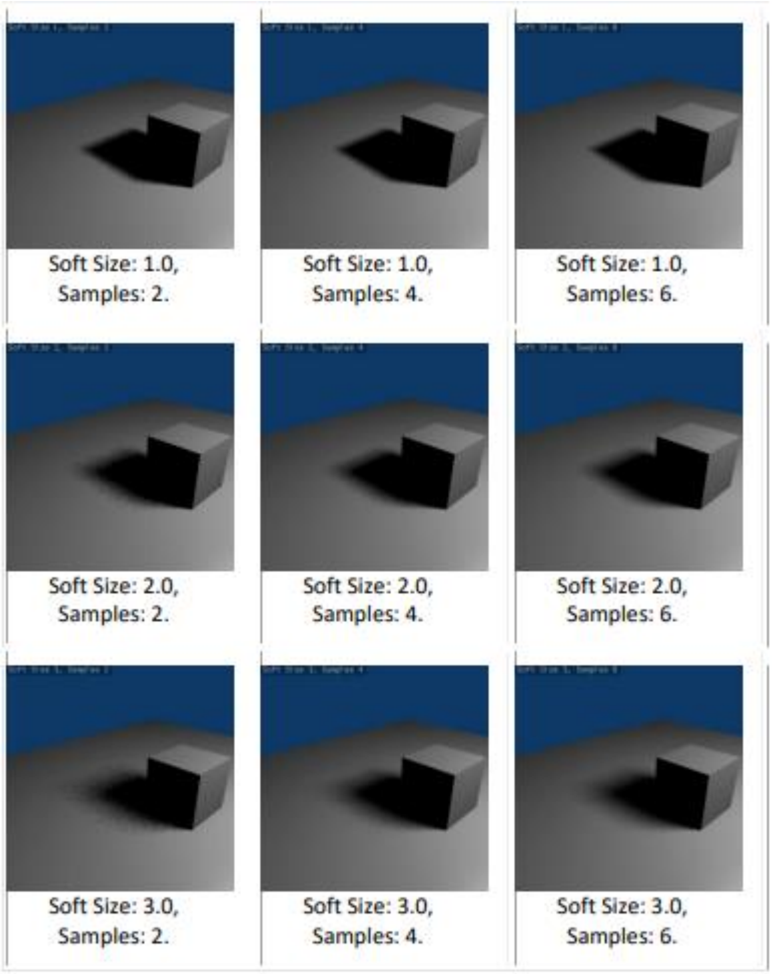
  - **Samples**

    Number of extra samples taken (samples x samples). This slider sets the maximum number of samples that both *Constant QMC* and *Adaptive QMC* will use to do their shadow calculations. The maximum value is 16: the real number of samples is actually the square of it, so setting a sample value of 3 really means $3^2 = 9$ samples will be taken.

- **Soft Size**

  Light size for ray shadow sampling. This slider determines the size of the fuzzy/diffuse/penumbra area around the edge of a shadow. *Soft Size* only determines the width of the soft shadow size, not how graded and smooth the shadow is. If you want a wide shadow which is also soft and finely graded, you must also set the number of samples in the *Samples* field higher than 1; otherwise this field has no visible effect and the shadows generated will not have a soft edge. The maximum value for *Soft Size* is 100.0.

Below is a **table of renders** with **different *Soft Size* and *Samples*** settings showing the effect of various values on the softness of shadow edges:

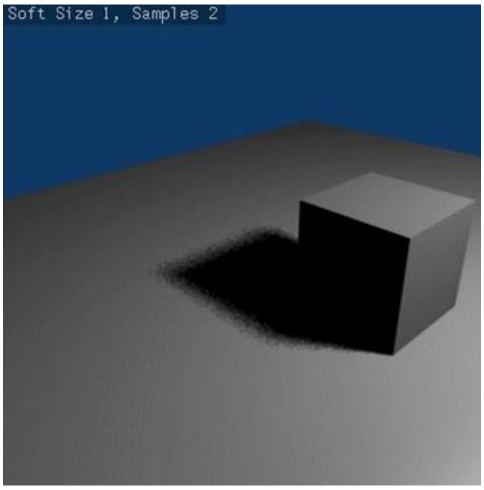


Title-Img 2.14 Different soft size and samples

Source-blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/shadows/raytraced_properties.html

Below is an animated version of the above table of imagesshowing the effects.



Title-Img 2.15 Animated version renders with different Soft Size and Samples settings showing the effect of various values on the softness of shadow edges.
Source-blender.org
Link-*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/shadows/raytraced_properties.html*

Threshold

Threshold is for **Adaptive Sampling.** This field is used with the ***Adaptive QMC*** shadow calculation method. The value is used to determine if the ***Adaptive QMC*** shadow sample calculation can be skipped based on a threshold of how shadowed an area is already.The maximum *Threshold* value is 1.0.

Quasi-Monte Carlo method

The **Monte Carlo method** is a method of taking a series of samples/readings of values (any kind of values, such as light values, color values, reflective states) in or around an area at random, so as to determine the correct actions to take in certain calculations which usually require multiple sample values to determine overall accuracy of those calculations. The Monte Carlo method tries to be as random as possible; this can often cause areas that are being sampled to have large irregular gaps in them (places that are not sampled/read). This in turn can cause problems for certain calculations (such as **shadow calculation**).

The solution to this was the Quasi-Monte Carlo method.

The Quasi-Monte Carlo method is also random, however, tries to make sure that the samples/readings it takes are also better distributed (leaving less irregular gaps in its sample areas) and more evenly spread across an area. This has the advantage of sometimes leading to more accurate calculations based onsamples/reading.

Volumetric Lighting

Volumetric lighting is a technique used in 3D computer graphics to add lighting effects to a rendered scene. It allows the viewer to see beams of light shining through the environment; seeing sunbeams streaming through an open window is an example of volumetric lighting, also known as **God rays**. The term seems to have been introduced from cinematography and is now widely applied to **3D modeling and rendering** especially in the field of **3D gaming**. In volumetric lighting, the light cone emitted by a light source is modeled as a transparent object and considered as a container of a "volume": as a result, light has the capability to give the effect of passing through an actual three dimensional medium (such as fog, dust, smoke, or steam) that is inside its volume, just like in the real world."

—According to Wikipedia, Volumetric Lighting.

A classic example is the search light with a visible halo/shaft of light being emitted from it as the search light sweeps around.

By default, Blender does not model this aspect of light. For example, when Blender lights something with a *Spot* light, you see the objects and area on the floor lit however, not the shaft/halo of light coming from the spotlight as it progresses to its target and would get scattered on the way.

The halo/shaft of light is caused in the real world by light being scattered by particles in the air, some of which get diverted into your eye and that you perceive as a halo/shaft of light. The scattering of light from a source can be simulated in Blender using various options, however, by default is not activated.

The only lamp able to create volumetric effects is the **Spot lamp** (even thought you might consider some of the "Sky & Atmosphere" effects of the *Sun* lamp as volumetric as well).

Unit summary

In this Unit, you have learnt

- Create depth using Shadows and lights
- Work on different types of shadows based on needs of your 3D Scene
- Work on Direct and Indirect Lighting
- Work on Shadows using ambient occlusion and shadow passes.

After learning this Unit, you can download the Open Source Software available on the internet for free of cost to practice the possibilities of creating 3D Objects.

Assignment

- Use the same Living Room scene created for Block 02, Unit – 01 Assignment to light with Blender
- Use this key word **“photo frame on wall”** on www.google.com to collect the reference image to build yourlighting reference

Assessment

1. Describe Ambient Occlusion
2. Write a note on Indirect Lighting
3. Define Volumetric Lighting
4. Write few lines about Raytracing
5. List the types of Shadow Settings available inBlender

Fill in the Blanks

1. Ray-traced shadows produce very precise______________with very low memory.
2. ___________shadows provide fast-rendered shadows.
3. Indirect Lighting adds light________of surrounding objects.
4. ____________simulates soft global illumination shadows.
5. ____________is also known as God rays.

Resources

While studying this Unit, you can browse the internet links for online video tutorials and several books and training DVDs available in theBlender Storeand on theBlenderCloud.

Links to download 3D Files for practice - Copyright Notice Attribution-Non Commercial – Share Alike CC BY-NC-SA

1. https://wiki.blender.org/index.php/Doc:2.4/Tutorials/Lighting/BSoD
2. https://cloud.blender.org/p/hdri
3. wiki.blender.org
4. ia600207.us.archive.org
5. archive.org

6. www.blender.org
7. docs.blender.org

Books to refer

8. Blender 2.5 Lighting and Rendering
9. https://www.lifewire.com/quick-tips-for-interesting-cg- lighting-2119

Unit-3 Using Lamps in Blender

Introduction

In this Unit, you will learn about Lighting using Lamps in Blender. AShading model is used to describe how surfaces respond to **light**.

Lighting refers to the simulation of light in computer graphics using Blender. This simulation can either be extremely accurate, as is the case in an application like Radiance which attempts to track the energy flow of light interacting with materials using Radiosity computational techniques. Alternatively, the simulation can simply be inspired by light physics, as is the case with non-photorealistic rendering. Between these two extremes, there are many different lighting approaches which can be employed to achieve almost on any desired visual result.

Outcomes

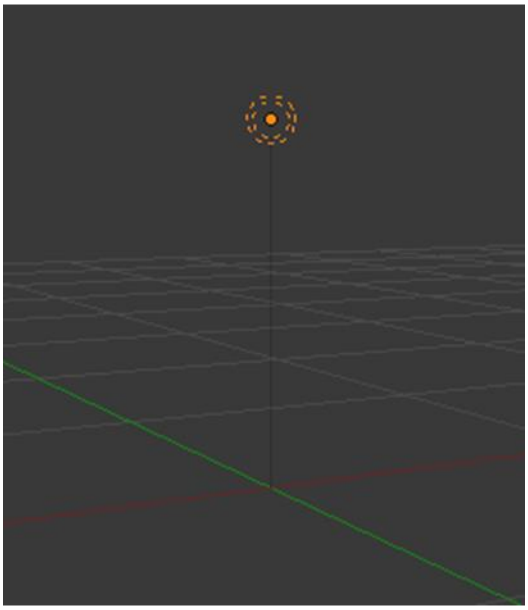
Upon completion of this unit, you will be able to:

- Design lighting with relevant Lamp type
- Differentiate the Lamp types with its Options
- Apply Lamp options for the available light setup andshadow parameters in Blender software

Terminology

Turbidity	:	Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generallyinvisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality.
Light Falloff	:	A candle across the room illuminates your book less well than a candle at your shoulder. The decline in illumination withdistance is called *falloff* or *attenuation*and in a physics
Volumetric Lighting	:	Volumetric lighting is a technique used in3D computer graphics to add lighting effects to a rendered scene.

Lamp Point



Title-Img 3. 1Point lamp

Source- docs.blender.org

Link-[*https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/p oint.html*](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/point.html)

The *Point* lamp is an **omni-directional point of light**, that is, a point radiating the same amount of light in all directions. It's visualized by a **plain, circled dot**. Being a point light source, the direction of the light hitting an object's surface is determined by the line joining the lamp and the point on the surface of the objectitself.

Light intensity/energy decays based on (among other variables) distance from the *Point* lamp to the object. In other words, surfaces that are further away are rendered darker.

Shadows

Title-Img 3. 2Without ray shadows.

Source- docs.blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/point.html

Title-Img 3. 3 Point lamp with ray shadows and Adaptive QMC samplegenerator enabled.

Source- docs.blender.org

Link-[https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/p oint.html](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/point.html)

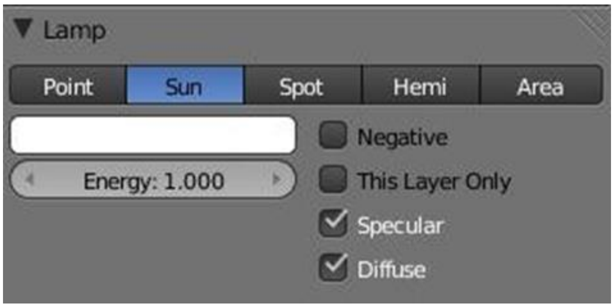
The *Point* light source can only cast ray-traced shadows. It shares with other lamp types the common shadow options described in Shadow Panel.

The ray-traced shadows settings of this lamp are shared with other lamps, and are described Raytraced Properties.

Lamp: Sun

A ***Sun* lamp** provides light of constant intensity emitted in a single direction. A *Sun* lamp can be very handy for a **uniform clear daylight** open-space illumination. In the 3D View, the *Sun* light is represented by an encircled **black dot with rays** emitting from it, plus a dashed line indicating the direction of the light.

This direction can be changed by rotating the *Sun* lamp, like any other object, but because the light is emitted in a constant direction, the location of a *Sun* lamp does not affect the rendered result (unless you use the "sky & atmosphere" option).



Title-Img 3. 4Sun lamp panel.

Atribution-

Source- docs.blender.org

***Link-**https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/s* [un/introduction.html](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/sun/introduction.html)

Lamp options

- **Energy and Color**

  These settings are common to most types of lamps, andare described in Light Properties.

- **Negative, This Layer Only, Specular, and Diffuse**

  These settings control what the lamp affects, as describedin What Light Affects.

The *Sun* lamp has **no light falloff** settings: it always uses a **constant attenuation** (i.e. no attenuation!).

Sky & Atmosphere

Title-Img 3. 5Sky & Atmosphere panel.

Source- docs.blender.org

Link-[https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/s un/introduction.html](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/sun/introduction.html)

Various settings for the appearance of the sun in the sky, and theatmosphere through which it shines, are available.

Shadow

Title-Img 3. 6Shadow panel.

Link- https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/s un/introduction.html

The ***Sun* light** source can only cast **ray-traced shadows**. It shares with other lamp types the same common shadowing options, described in Shadow Panel.

The ray-traced shadows settings of this lamp are shared with other lamps, and are described in Raytraced Properties.

Lamp: Sky & Atmosphere

Title-Img 3. 7Sky & Atmosphere panel.

Atribution-

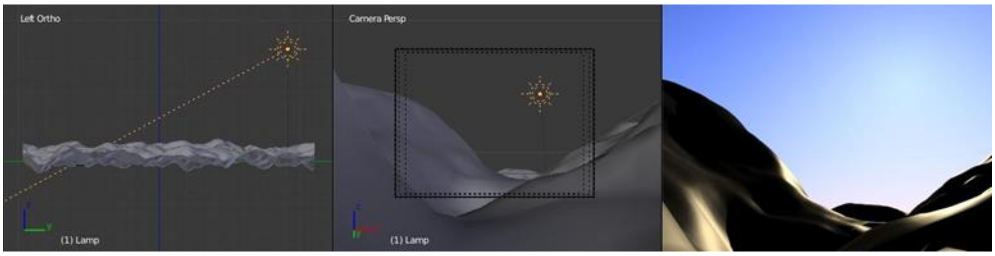
Source-

Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/s un/introduction.html

This panel allows you to enable an effect that **simulates various properties** of real sky and atmosphere: the scattering of sunlight as it crosses the kilometers of air overhead. For example, whenthe **Sun is high**, the **sky is blue** (and the horizon, somewhat whitish). When the **Sun is near the horizon**, the **sky is dark blue/purple**, and the horizon turns orange. The dispersion of the atmosphere is also more visible when it is a bit foggy: the farther away an object is, the more "faded" in light gray it is... Go out into the countryside on a nice hot day, and you will see it.

To enable this effect, you have to use a ***Sun* light source**. If, as usual, the *position* of the lamp has no importance, its *rotation* is crucial: it determines which hour it is. As a starting point, you should reset rotation of your *Sun* (with Alt-R, or typing 0 in each ofthe three *Rotation* Fields X, Y, Z in the *Transform* panel). This way, you will have a nice mid-day sun (in the tropics).

Now, there are two important angles for the *Sky/Atmosphere* effect: the "**incidence" angle** (between the light direction and the X-Y plane), which determines the "hour" of the day (as you might expect, the default rotation – straight down – is "mid-day", a light pointing straight up is "midnight", and so on...). And the rotation around the Z axis determines the position of the sun around the camera.



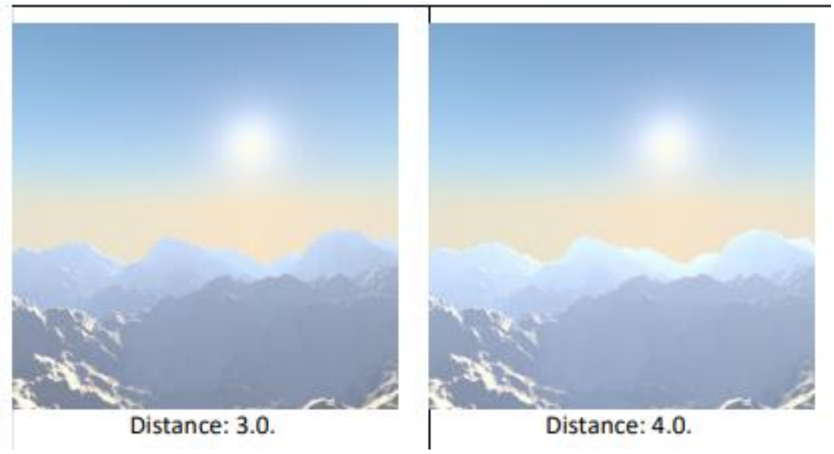
Title-Img 3. 8 The dashed "light line" of the Sun lamp crossing the camerafocal point.

Source- docs.blender.org\

Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/s un/sky_atmosphere.html

In fact, to have a good idea of where the sun is in your world, relative to the camera in your 3D View, you should always try to have the **dashed "light line**" of the lamp crossing the center of the camera (its "focal" point), as shown in Img 3. 8(The dashed "light line" of the *Sun lamp* crossing the camera focal point). This way, in camera view (Numpad0, center area in the example picture), you will see where the "virtual" sun created by this effect will be.

It is important to understand that **the *position* of the sun** has no importance for the effect: only its *orientation* is relevant. The position just might help you in your scene design.



Title-Img 3. 9 Variations in Distance parameter, all other settings to default.

Source- docs.blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/sun/sky_atmosphere.html

Hints and limitations

To always have the *Sun* pointing at the camera center, you can usea **Track To constraint** on the sun object, with the camera as target,and -Z as the "To" axis (use either X or Y as "Up" axis). This way, to modify height/position of the sun in the rendered picture, you just have to move it; orientation is automatically handled by the constraint. Of course, if your camera itself is moving, you should also add e.g. a **Copy Location constraint** to your *Sun* lamp, with the camera as target and the *Offset* option activated... This way, the sun light will not change as the camera moves around.

If you use the default *Add* mixing type, you should use a very dark-blue world color, to get correct "nights"...

This effect works quite well with a *Hemi* lamp, or some ambient occlusion, to fill in the *Sun* shadows.

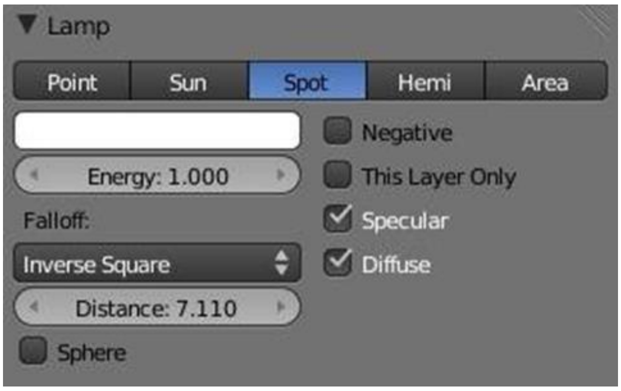
Atmosphere shading currently works incorrectly in reflections andrefractions and is only supported for solid shaded surfaces. This will be addressed in a later release.

Lamps: Spot

A *Spot* lamp emits a **cone-shaped beam of light** from the tip of thecone, in a given direction.

The Spot light is the most complex of the light objects and indeed, for a long time, among the most used thanks to the fact that it was the only one able to cast shadows. Nowadays, with a ray tracer integrated into Blender's internal render engine, all lamps can cast shadows (except *Hemi*). Even so, Spot lamps' shadow buffers are much faster to render than ray-traced shadows, especially when blurred/softened, and spot lamps also provide other functionality such as "volumetric" halos.

Lamp options



Title-Img 3. 9Common Lamp options of a Spot.
Source- docs.blender.org
Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/spot/introduction.html?highlight=common%20lamp%20options%20spot

- **Distance, Energy and Color**

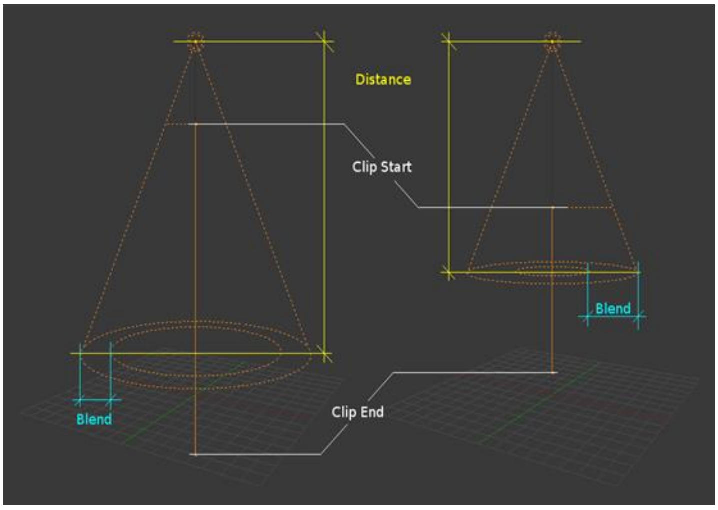
  These settings are common to most types of lamps, andare described in Light Properties.

- **This Layer Only, Negative, Diffuse and Specular**

  These settings control what the lamp affects, as describedin What Light Affects.

- **Light Falloff and Sphere**

  These settings control how the light of the *Spot* decayswith distance.

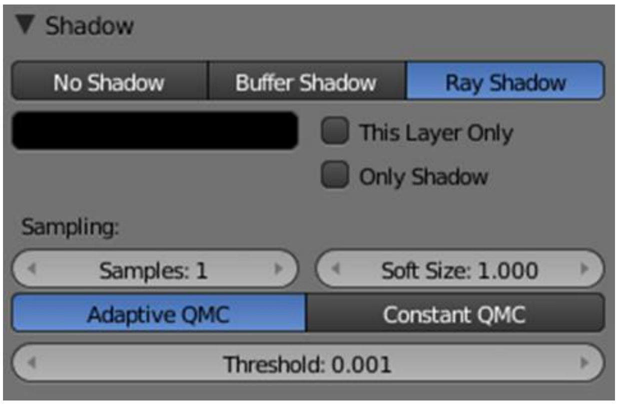


Title-Img 3. 10 Changing the Spot options also changes the appearance ofthe spotlight as displayed in the 3D View.

Source- docs.blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/spot/introduction.html?highlight=common%20lamp%20options%20spot

Shadows



Title-Img 3. 11Shadow panel set to Ray Shadow.

Source- docs.blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/spot/introduction.html?highlight=common%20lamp%20options%20spot

Spotlights can use either **ray-traced shadows or buffered shadows**. Either of the two can provide various extra options. Ray-traced shadows are generally **more accurate**, with extra capabilities such as transparent shadows, although they are quiteslower to render.

- **No Shadow**

  Choose this to turn shadows off for this spot lamp. This canbe useful to add some discreet directed light to a scene.

- **Buffer Shadow**

  Buffered Shadows are also known as depth map shadows. Shadows are created by calculating differences in the distance from the light to scene objects. Buffered shadows are more complex to set up and involve more faking, but the speed of rendering is a definite advantage. Nevertheless, it shares with other lamp types common shadow options described in Shadow Panel.

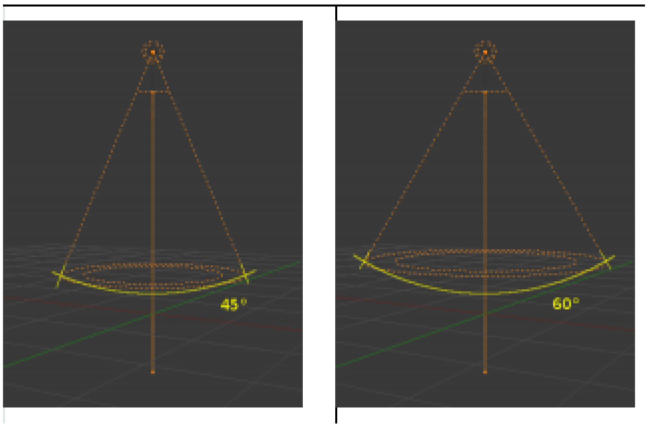
- **Ray Shadow**

  The ray-traced shadows settings of this lamp are shared with other lamps, and are described in Raytraced Properties.

Spot Shape

Size

The size of the outer cone of a *Spot*, which largely controls the circular area a *Spot* light covers. This slider in fact controls the angle at the top of the lighting cone, and can be between (1.0 to 180.0).



Title-Img 3. 12Changing the spot size option

Source- docs.blender.org

Link- *https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/spot/introduction.html?highlight=common%20lamp%20options%20spot*

Blend

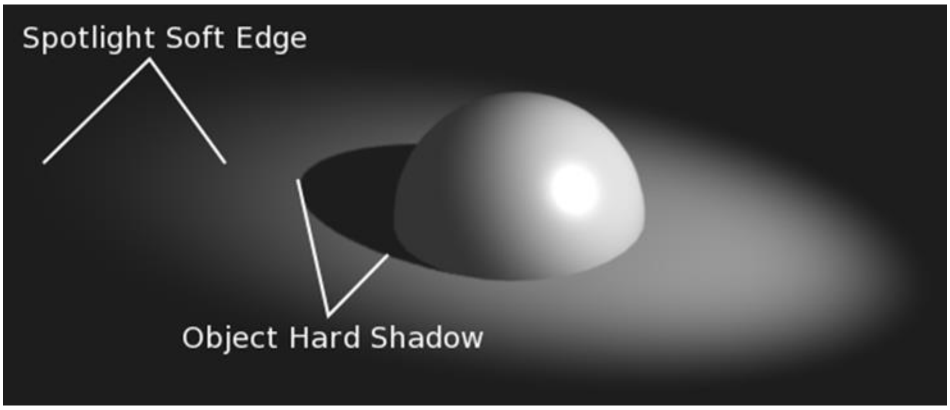
The *Blend* slider controls the inner cone of the *Spot*. The *Blend* value can be between (0.0 to 1.0). The value is proportional and represents that amount of space that the inner cone should occupy inside the outer cone ***Size***.

The inner cone boundary line indicates the point at which light from the *Spot* will start to blur/soften; before this point its lightwill mostly be full strength. The larger the value of *Blend* the more blurred/soft the edges of the spotlight will be, and the smaller the inner cone's circular area will be (as it starts to blur/soften earlier).

To make the *Spot* have a sharper falloff rate and therefore less blurred/soft edges, decrease the value of *Blend*. **Setting *Blend* to 0.0** results in very sharp spotlight edges, without any transition between light and shadow.

The falloff rate of the *Spot* lamp light is a ratio between the *Blend* and *Size* values; the larger the circular gap between the two, the more gradual the light fades between *Blend* and *Size*.

Blend* and *Size only control the *Spot* light cone's aperture and softness ("radial" falloff); they do not control the shadow's softness as shown below (Img 3.14)



Title-Img 3. 13 Render showing the soft edge spotlighted area and the sharp/hardobject shadow.

Link- https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/spot/introduction.html?highlight=common%20lamp%20options%20spot

Notice in the picture above Img 3. 14that the object's shadow is sharp as a result of the ray tracing, whereas the spotlight edges are soft. If you want other items to cast soft shadows within the ***Spot* area**, you will need to alter other shadow settings.

- **Square**

The *Square* button makes a *Spot* light cast a square lightarea, rather than the default circular one.

- **Show Cone**

  Draw a transparent cone in 3D View to visualize whichobjects are contained in it.

- **Halo**

  Adds a volumetric effect to the spot lamp.

Spot Buffered Shadows

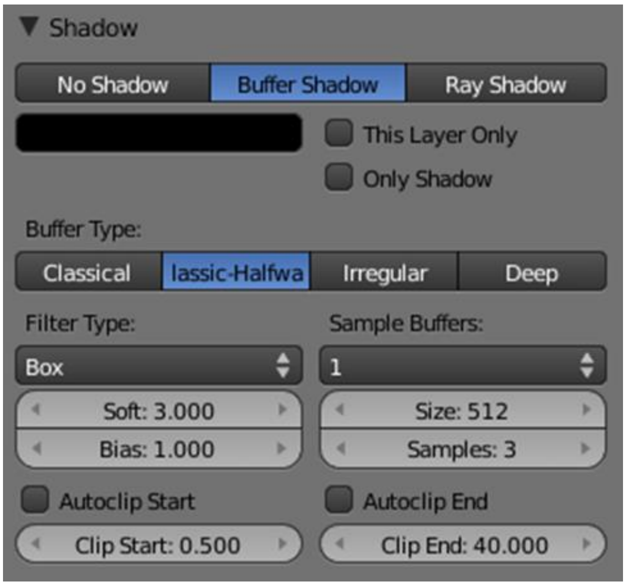
When the *Buffer Shadow* button is activated, the currently selected ***Spot* light** generates shadows, using a "shadow buffer" rather than using **raytracing,** and various extra options and buttons appear in the *Shadow* panel.

Buffer Type

There more than one way to generate buffered shadows. The shadow buffer generation type controls which generator to use.

There are four shadow generation types, those being:

1. Classical
2. Classic-Halfway
3. Irregular
4. Deep



Title-Img 3. 14Buffer Shadow set to Classic-Halfway.

Link- *https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/s* pot/buffered_shadow.html

Classical

A **Classical shadow generation** method, which is used to be the **Blender default** and unique method for generation of buffered shadows. It used an older way of generating buffered shadows, but it could have some problems with accuracy of the generated shadows and can be very sensitive to the resolution of the shadowbuffer Shadow **Buffer ‣ Size**, different *Bias* values, and all the self-shadowing issues that brings up.

The *Classical* method of generating shadows is obsolete and is really only still present to allow for backward compatibility with older versions of Blender. In most other cases, you will want to use *Classic-Halfway* instead.

Classic-Halfway

This shadow buffer type is an improved shadow buffering method and is the default option selected in Blender. It works by taking an averaged reading of the first and second nearest Z depth values allowing the *Bias* value to be lowered and yet not suffer as much from self-shadowing issues.

Not having to increase *Bias* values helps with shadow accuracy, because large *Bias* values can mean small faces can lose theirshadows, as well as preventing shadows being overly offset from the larger *Bias* value.

Classic-Halfway does not work very well when faces overlap, and biasing problems can happen.

Options

Here are now the options specific to these generation methods:

- **Size**

The *Size* number button can have a value from **(512 to 10240).***Size* represents the resolution used to create a shadow map. This shadow map is then used to determine where shadows lay withina scene.

As an example, if you have a *Size* with a value of 1024, you are indicating that the shadow data will be written to a buffer which will have a *square* resolution of **1024×1024 pixels/samples** from the selected spotlight.

The higher the value of *Size*, the **higher resolution** and accuracy of the resultant shadows, assuming all other properties of the light and scene are the same, although more memory and processing time would be used. The reverse is also true – if the *Size* value is lowered, the resultant shadows can be of lower quality, but would use less memory and take less processing time to calculate.

As well as the ***Size* value** affecting the quality of generated shadows, another property of *Spot* lamps that affects the quality of their buffered shadows is the angle of the spotlights lighted area (given in the *Spot Shape* Panel's *Size* field).

As the spot shape *Size* value is increased, the quality of the cast shadows degrades. This happens because when the *Spot* lighted area is made larger (by increasing spot shape *Size*), the shadow buffer area must be stretched and scaled to fit the size of the new lighted area.

The *Size* resolution is not altered to compensate for the change in size of the spotlight, so the quality of the shadows degrades. If youwant to keep the generated shadows the same quality, as you increase the spot shape *Size* value, you also need to increase the buffer *Size* value.

Filter Type

The ***Box*, *Tent*, and *Gauss* filter types** control what filtering algorithm to use to anti-alias the buffered shadows.

They are closely related to the *Samples* number button, as when this setting is set to 1, shadow filtering is disabled, so none of these buttons will have any effect whatsoever.

- **Box**

The buffered shadows will be anti-aliased using the "box" filtering method. This is the original filter used in Blender. It is relativelylow quality and is used for low resolution renders, as it produces very sharp anti-aliasing. When this filter is used, it only takes into account oversampling data which falls within a single pixel, and does not take into account surrounding pixel samples. It is often useful for images which have sharply angled elements and horizontal/vertical lines.

- **Tent**

The buffered shadows will be anti-aliased using the "tent" filtering method. It is a simple filter that gives sharp results, an excellent general-purpose filtering method. This filter also takes intoaccount the sample values of neighboring pixels when calculating its final filtering value.

- **Gauss**

The buffered shadows will be anti-aliased using the "Gaussian" filtering method. It produces a very soft/blurry anti-aliasing. As result, this filter is excellent with high resolution renders.

Samples

The *Samples* number button can have a value between **(1 and 16).** It controls the number of samples taken per pixel when calculatingshadow maps.

The higher this value, the more filtered, smoothed and anti-aliasedthe shadows cast by the current lamp will be, but the longer they will take to calculate and the more memory they will use. The **anti-aliasing method** used is determined by having one of the ***Box*,*Tent* or *Gauss* buttons activated.**

Having a *Samples* value of 1 is similar to turning off anti-aliasingfor buffered shadows.

Soft

The *Soft* number button can have a value between (1.0 to 100.0).It indicates how wide an area is sampled when doing anti-aliasing on buffered shadows. The larger the *Soft* value, the more graduated/soft the area that is anti-aliased/softened on the edge of generated shadows.

Sample Buffers

The *Sample Buffers* setting can be set to values (1, 4 or 9), and represents the number of shadow buffers that will be used when doing anti-aliasing on buffered shadows.

This option is used in special cases, like very small objects which move and need to generate really small shadows (such as strands).It appears that normally, pixel width shadows do not anti-alias properly, and that increasing *Buffer Size* does not help much.

So, this option allows you to have a sort of extra sample pass,done above the regular one (the one controlled by the *Box* / *Tent* /*Gauss, Samples* and *Soft* settings).

The default 1 value will disable this option.

Higher values will produce a smoother anti-aliasing – but be careful: using a *Sample Buffers* of 4 will require four times as muchmemory and process time, and so on, as Blender will have to compute that number of sample buffers.

Irregular

Title-Img 3. 15Buffer Shadow set to Irregular.

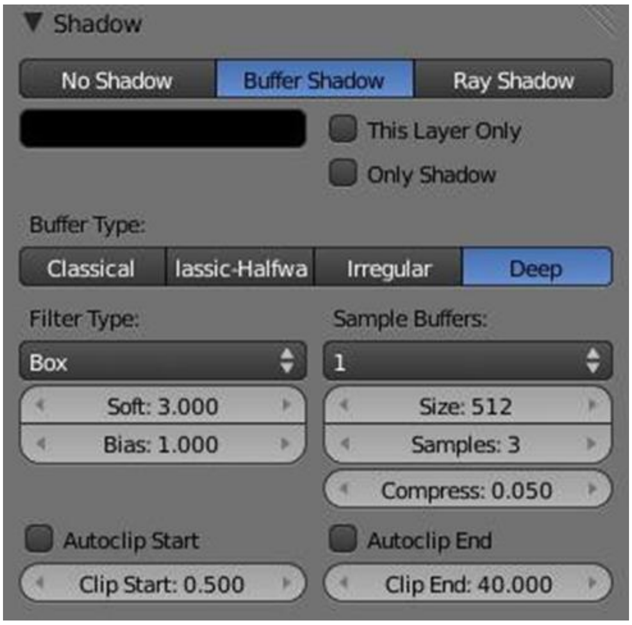
Source- docs.blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/spot/buffered_shadow.html

Irregular shadow method is used to generate **sharp/hard shadows**that are placed as accurately as raytraced shadows. This method offers **very good performance** because it can be done as a multi-threaded process.

This method supports transparent shadows. To do so, you will firstneed to setup the shadow setting for the object which will receive the transparent shadow **Material ‣ Shadow ‣ Cat Buffer Shadows and Buffer Bias.**

Deep Generation Method



Title-Img 3. 16Buffer Shadow set to Deep.

Source- docs.blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/spot/buffered_shadow.html

Deep Shadow buffer supports **transparency and better filtering,**at the cost of **more memory usage and processing time.**

- **Compress**

  Deep shadow map compression threshold.

Common options

The following settings are common to all buffered shadowgeneration method.

- **Bias**

  The *Bias* number button can have a value between **(0.001 to 5.0).***Bias* is used to add a slight offset distance between an object and the shadows cast by it. This is sometimes required because of inaccuracies in the calculation which determines whether an area of an object is in shadow or not.

  Making the *Bias* value smaller results in the distance between the object and its shadow being smaller. If the *Bias* value is too small, an object can get **artifacts**, which can appear as lines and interference patterns on objects. This problem is usually called "**self-shadowing**", and can usually be fixed by increasing the *Bias* value, which exists for that purpose!

  Other methods for correcting self-shadowing include increasing the size of the ***Shadow Buffer Size*** or using a different buffer shadow calculation method such as ***Classic-Halfway*** **or *Irregular*.**

  Self-shadowing interference tends to affect curvedsurfaces more than flat ones, meaning that if your scene has a lot of curved surfaces it may be necessary to increasethe *Bias* value or *Shadow Buffer Size* value.

  Having overly large *Bias* values not only places shadows further away from their casting objects, but can also cause objects that are very small to not cast any shadow at all. At that point altering *Bias*, *Shadow Buffer Size* or *Spot Size* values, among other things, may be required to fix theproblem.

- **Clip Start & Clip End**

  When a *Spot* light with buffered shadows is added to a scene, an extra line appears on the *Spot* 3D View representation.

  The start point of the line represents *Clip Start* 's value and the end of the line represents *Clip End* 's value. *Clip Start* can have a value between **(0.1 to 1000.0),** and *Clip End*, between **(1.0 to 5000.0).** Both values are represented in Blender Units.

  Clip Start indicates the point after which buffered shadows can be present within the *Spot* light area. Any shadow which could be present before this point is ignored and no shadow will be generated.

  Clip End indicates the point after which buffered shadows will not be generated within the *Spot*light area. Any shadow which could be present after this point is ignored and no shadow will be generated.

  The area between *Clip Start* and *Clip End* will be capable of having buffered shadows generated.

  Altering the *Clip Start* and *Clip End* values helps in controlling where shadows can be generated. Altering the range between *Clip Start* and *Clip End* can help speed up rendering, save memory and make the resultant shadows more accurate.

  When using a *Spot* lamp with buffered shadows, to maintain or increase quality of generated shadows, it is helpful to adjust the ***Clip Start* and *Clip End*** such that their values closely bound around the areas which they want to have shadows generated at. Minimizing the range between*Clip Start* and *Clip End*, minimizes the area shadows are computed in and therefore helps increase shadow quality in the more restricted area.

- **Autoclip Start & Autoclip End**

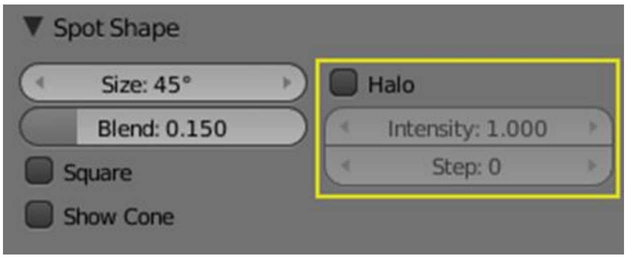
  As well as manually setting ***Clip Start* and *Clip End***fields to control when buffered shadows start and end, it is also possible to have Blender pick the best value independently for each *Clip Start* and *Clip End* field.

  Blender does this by looking at where the visible vertices are when viewed from the *Spot* lamp position.

Hints

Any object in Blender can act as a camera in the 3D View. Hence you can select the *Spot* light and switch to a view from its perspective by pressing **Ctrl-Numpad0.**

Spot Volumetric Effects



Title-Img 3. 17Spot lamps's Halo options.

Source- docs.blender.org

Link-[https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/s pot/halo.html](https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/spot/halo.html)

Spot lights also can produce "**volumetric" effects.**

- **Halo**

  The *Halo* button allows a ***Spot* lamp** to have a volumetric effect applied to it. This button must be active if the volumetric effect is to be visible. Note that if you are using buffered shadows.

- **Intensity**

  The *Intensity* slider controls how **intense/dense** the volumetric effect is that is generated from the light source. The lower the value of the *Intensity* slider, the less visible the volumetric effect is, while higher *Intensity* values give amuch more noticeable and dense volumetric effect.

- **Step**

  This field can have a value between **(0 to 12).** It is used to determine whether this Spot will cast volumetric shadows, and what quality those volumetric shadows will have. If Step is set to a value of 0, then no volumetric shadow will be generated. Unlike most other controls, asthe Step value increases, the quality of volumetric shadows decreases (but take less time to render), and vice versa.

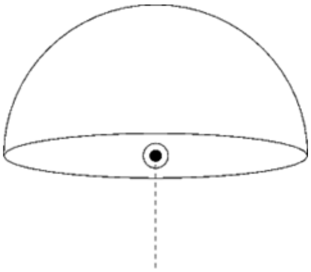
- **Tip**

  Step values

A value of **8 for *Halo Step*** is usually a good compromise between speed and accuracy.

Blender only simulates volumetric lighting in *Spot* lamps whenusing its internal renderer. This can lead to some strange resultsfor certain combinations of settings for the light's *Energy* and the halo's *Intensity*. For example, having a *Spot* light with null or very low light *Energy* settings but a very high halo *Intensity* setting can result in a dark/black halo, which would not happen in the real world. Just be aware of this possibility when using halos with the internal renderer.

Lamp: Hemi



Title-Img 3. 18Hemi light conceptual scheme.

Source- docs.blender.org

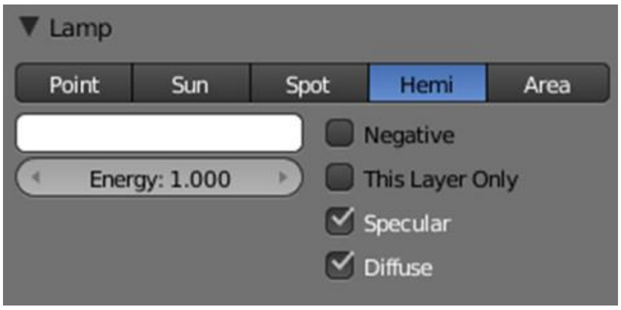
Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/hemi.html?highlight=hemi%20light%20conceptual%20scheme

The *Hemi* lamp provides light from the direction of a **180- hemisphere,** designed to simulate the light coming from a heavily clouded or otherwise uniform sky. In other words, it is a light which is shed, uniformly, by a glowing dome surrounding the scene.

Similar to the *Sun* lamp, the ***Hemi* 's location** is unimportant, whileits **orientation is key.**

The *Hemi* lamp is represented with **four arcs**, visualizing the orientation of the hemispherical dome, and a dashed line representing the direction in which the maximum energy is radiated, the inside of the hemisphere.

Options



Title-Img 3. 19Hemi lamp's panel.

Source- docs.blender.org

Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lamps/hemi.html?highlight=hemi%20light%20conceptual%20scheme

- **Energy and Color**

  These settings are common to most types of lamps.

- **Layer, Negative, Specular, and Diffuse**

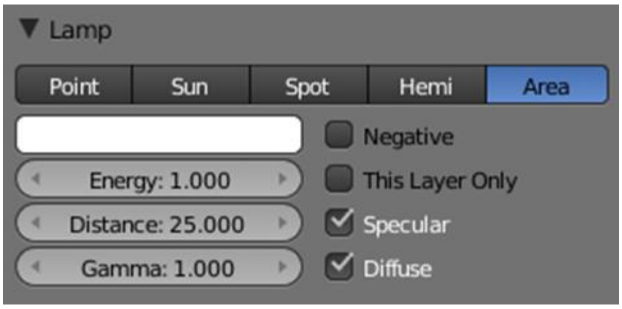
  These settings control what the lamp affects, as describedin What Light Affects.

  The *Hemi* lamp has **no light falloff** settings: it always uses aconstant attenuation (i.e. no attenuation).

Since this lamp is the only lamp which cannot cast any shadow,the *Shadow* panel is absent.

Lamp: Area

The *Area* lamp simulates light originating from a surface (or surface-like) emitter. For example, a TV screen, your supermarket's neon lamps, a window, or a cloudy sky are just afew types of area lamp. The area lamp produces shadows with soft borders by sampling a lamp along a grid the size of which is defined by the user. This is in direct contrast to point-like artificial lights which produce sharp borders.



Title-Img 3. 20Commons Options.

*Link-**http://blender-manual-***

i18n.readthedocs.io/ja/latest/render/blender_render/lighting/lamps/area.html

Lamp Options

- **Distance, Energy and Color**

  These settings are common to most types of lamps, andare described in *Light Properties*.

- **Gamma**

  Amount to gamma correct the brightness of illumination.Higher values give more contrast and shorter falloff.

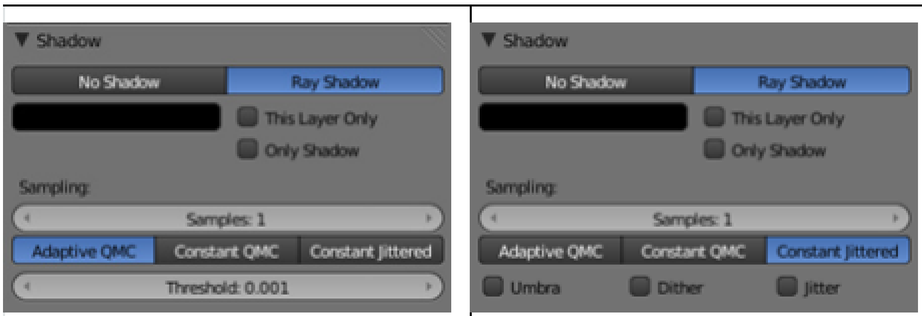
  The *Area* lamp does not have light falloff settings. It uses an "inverse quadratic" attenuation law. The only way to control its falloff is to use the *Distance* and/or *Gamma* settings.

- **This Layer Only, Negative, Specular and Diffuse**

  These settings control what the lamp affects.

Shadows

When an *Area* light source is selected, the *Shadow* panel has thefollowing default layout:



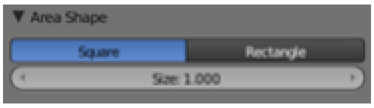
Adaptive QMC settings. Constant Jittered settings.

Title-Img 3. 21 The shadow panel when area light source is selected.

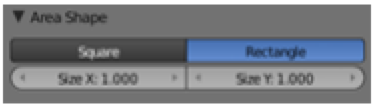
Link-*http://blender-manual- i18n.readthedocs.io/ja/latest/render/blender_render/lighting/lamps/area.html*

Area Shape

The shape of the area light can be set to ***Square* or *Rectangle***.



Square options.



Rectangle options.

Title-Img 3. 22Area shape

Link-http://blender-manual- i18n.readthedocs.io/ja/latest/render/blender_render/lighting/lamps/area.html

Square / Rectangular

Emit light from either a square or a rectangular area

- **Size / Size X / Size Y**

  Dimensions for the *Square* or *Rectangle*

Area Raytraced Shadows

Title-Img 3. 23Adaptive QMC settings.

Link-http://blender-manual- i18n.readthedocs.io/ja/latest/render/blender_render/lighting/lamps/area.html

The *Area* light source can only cast ray-traced shadows. The ray- traced shadows settings of this lamp are mostly shared with other lamps. However, there are some specifics with this lamp, which are detailed below:

Shadow Samples

Samples

This has the same role as with other lamps, but when using a ***Rectangle*** **Area lamp**, you have two samples settings: ***Samples X*** **and** ***Samples Y*,** for the two axes of the area plane. Note also that when using the ***Constant Jittered* sample generator method**, thisis more or less equivalent to the number of virtual lamps in the area. With QMC sample generator methods, it behaves similarly to with *Lamp* or *Spot* lamps.

Sample Generator Types

- **Adaptive QMC / Constant QMC**

  These common setting are described in Shadow Panel.

- **Constant Jittered**

  The *Area* lamp has a third sample generator method, *Constant Jittered*, which is more like simulating an array of lights. It has the same options as the old one: *Umbra*, *Dither* and *Jitter*.

Title-Img 3. 24Constant Jittered settings.

Link-http://blender-manual- i18n.readthedocs.io/ja/latest/render/blender_render/lighting/lamps/area.html

The following three parameters are only available when using the ***Constant Jittered* sample** generator method, and are intended to artificially boost the “soft” shadow effect, with possible loss in quality:

- **Umbra**

  Umbra, emphasizes the intensity of shadows in the area fully within the shadow rays. The light transition between fully shadowed areas and fully lit areas changes more quickly (i.e. a sharp shadow gradient). You need *Samples* values **equal to or greater than 2** to see any influence of this button.

- **Dither**

  Applies a sampling over the borders of the shadows, similar to the way anti-aliasing is applied by the *OSA* buttonon the borders of an object. It artificially softens the borders of shadows; when *Samples* is set very low, you can expect poor results, so *Dither* is better used with medium *Samples* values. It is not useful at all with high *Samples* values, as the borders will already appear soft.

- **Jitter**

  Jitter adds noise to break up the edges of solid shadow samples, offsetting them from each other in a pseudo- random way. Once again, this option is not very usefulwhen you use high *Samples* values where the drawback is that noise generates quite visible graininess.

Hints

You will note that changing the ***Size* parameter** of your area lamp does not affect the lighting intensity of your scene. On the other hand, rescaling the lamp using the S in the 3D View could dramatically increase or decrease the lighting intensity of the scene. This behavior has been coded this way so that you can fine tune all your light settings and then decide to scale up (or down) the whole scene without suffering from a drastic change in the lighting intensity. If you only want to change the dimensions of your ***Area* lamp**, without messing with its lighting intensity, you are strongly encouraged to use the *Size* button(s) instead.

If your computer is not very fast, when using the ***Constant Jittered*sample generator** method, you could find it useful to set a low *Samples* value (like 2) and activate ***Umbra, Dither,* and/or *Jitter***in order to simulate slightly softer shadows. However, these results will never be better than the same lighting with high *Samples*values.

Unit summary

In this Unit, you have learnt how to

- Create illumination using Lamps in Blender.
- Use lights allowing various shadow option types.
- Work on different setups created for diverse needs of your 3D Scene.
- Work on Dome type of lighting called Hemi and Area Lighting to create the desired effects on the objects using Lamps in Blender.

After learning this Unit, you can download the Open Source Software available on the internet for free of cost to practice the possibilities of creating 3D Objects.

Assignment

- Use the same **Living Room scene** created for Block 02, Unit – 01 Assignment **to light** with Blender, improvise the sameusing Lamps as required.
- Use these key words **“photo frame on wall”** on www.google.com to collect the reference image to build your lighting references.

Assessment

1. Explain Light Falloff
2. Write a note on Point Lamp
3. Write short note on the following
   a. Sun
   b. Sky & Atmosphere
4. Explain Buffer Shadow with Illustrations
5. Draw Soft Shadow Edge and Hard Shadow edge using “Sphere”as a reference point

Fill in the Blanks

1. ______________is an omni-directional source of light
2. Spot is a____________source of light.
3. ___________is a source simulating light, as windows, neon, TV screens.
4. Hemi simulates a very wide and far away light source, like the_________.
5. _____simulates a very far away and punctual light source, like the sun.

Resources

While studying this Unit, you can browse the following internet links for online video tutorials and several books and training DVDs available in the Blender Store and on the Blender Cloud.

Links to download 3D Files for practice - Copyright Notice

Attribution-Non Commercial-Share Alike CC BY-NC-SA

1. https://wiki.blender.org/index.php/Doc:2.4/Tutorials/Lighting/ BSoD
2. https://cloud.blender.org/p/hdri\
3. wiki.blender.org
4. ia600207.us.archive.org
5. archive.org
6. www.blender.org
7. docs.blender.org

Books to refer

8. Blender 2.5 Lighting and Rendering by Aaron W. Powell
9. Read Chapter 7 of the John Blain *"Complete Guide to BlenderGraphics"* - Lighting and Cameras (pages 131-136)

10. https://www.lifewire.com/quick-tips-for-interesting-cg-lighting-2119

Unit-4 Using Light Rigs

Introduction

In this Unit, you will learn about **Light Rigs** and how it is used. **A rig**is a standard setup and combination of objects; there can be **lighting rigs**, or **armature rigs**, etc. A rig provides a **basic setup** andallows you to start from a known point and go from there.

Different rigs are used for different purposes and emulate different conditions; the rig you start with depends on what you want to convey in your scene. Lighting can be very confusing, and the defaults do not give good results. Further, very small changes can have a dramatic effect on the mood and colors.

Outcomes

Upon completion of this unit you will be able to:

- Design One-point, Two-point and Three-point light rigs
- Utilize Camera Setup for Final rendering
- Recall all the lighting parameters to create one final LightRig
- Practice Lighting for different light setups Home, Factory,Office, Indoor, outdoor etc.,

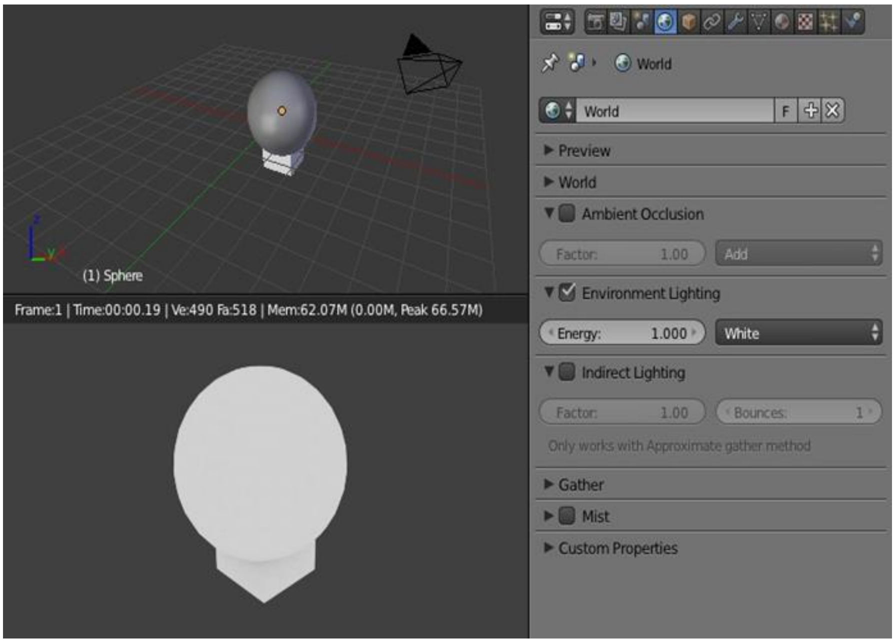
Terminology

Light Rigs	:	It is a collection of lights used to set up a simple light to effectively highlight and show off your modeled assets. This series of lessons will walk through the absolute basics of lighting for presentation. Showcasing your work is an essential part of being a Computer Graphic artist, and lighting is essential to showing off.
Lens	:	A lens is a transmissive optical device that focuses or disperses a light beam by means of refraction. A simple lens consists of a single piece of transparent material, while a compound lens consists of several simple lenses (elements), usually arranged along a common axis.
Depth of Field	:	In optics, particularly as it relates to film and photography, depth of field (DOF), also called focus range or effective focus range.

Lighting Rigs

In all the lighting rigs, the default camera is always positioned nearly **15 degrees** offdead-on, about **25 BU (Blender Units)** back and **9 BU to the side** ofthe subject, at eye level, and uses a long lens of 80 mm. Up close,a **35 mm lens** will distort the image. A long lens takes in more of the scene. A dead-on camera angle is too dramatic and frames toowide a scene to take in. So now you know; next time you go to a play, sit off-center and you will not miss the action happening on the sidelines and will have a greater appreciation for the depth of the set. Anyway, enough about camera angles; this is about **lighting**.

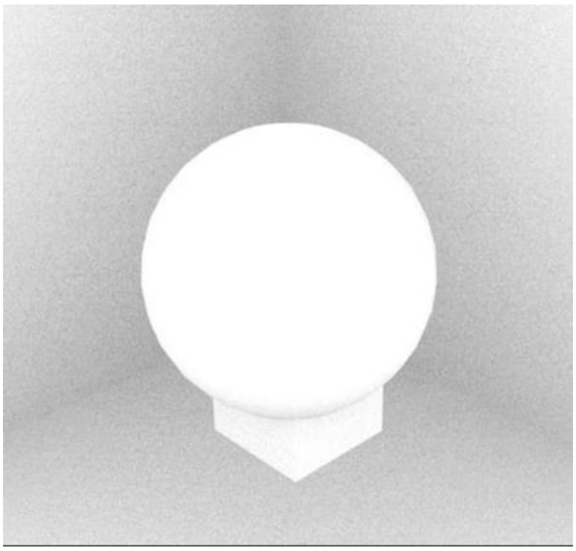
Environment or Ambient Light Only



Title-Img. 4. 1Environment (Ambient) lighting only.

Link-https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lightingrigs.html

In the *World* tab, there is a panel ***Environment Lighting***, where you enable environment or ambient lighting of your scene. **Ambient light** is the scattered light that comes from sunlight being reflected off every surface it hits, hitting your object, and traveling to camera.

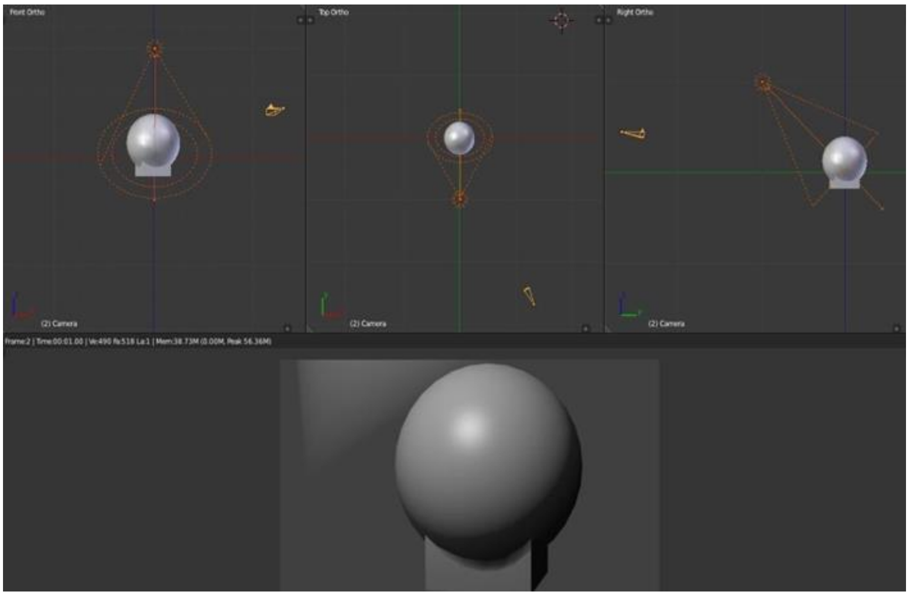


Title-Img. 4. 2Ambient occlusion.

Link- https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lighting_ rigs.html

Ambient light illuminates, in a perfectly balanced, Shadeless way, without casting shadows. You can vary the intensity of the ambient light across your scene via ambient occlusion. The ambient color is a **sunny white**.

Single Rig



Title-Img. 4. 3Standard Spot light rig.

Link- https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lighting_ rigs.html

The **sole, or key, spot light rig** provides a dramatic, showy, yet effective illumination of one object or a few objects close together. It is a **single *Spot* light**, usually with a hard edge. **Halos** are enabled in this render to remind you of a smoky nightclub scene. It is placed above and directly in front of the subject; in this case **10 BU in front** and **10 BU high**, just like a stage, it shinesdown at about a **40 degrees angle**. We use quadratic attenuation.

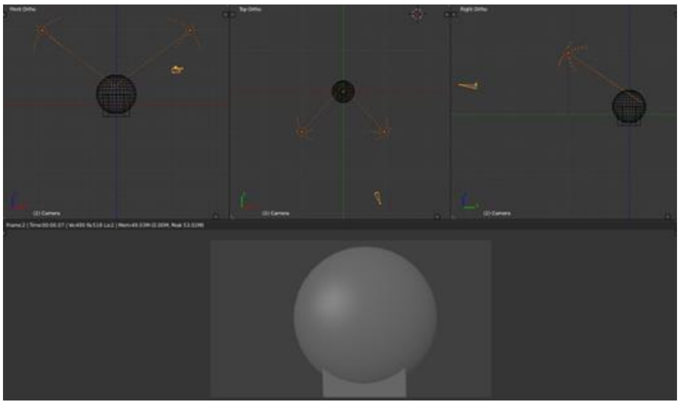
You can make the spot wider by increasing ***Size Spot Shape*** and softening the edge by increasing ***Blend Spot Shape***, and parent it to the main actor, so that the spot follows him as he moves around. Objects close to the main actor will naturally be more lit and your viewer will pay attention to them.

Moving this spot directly overhead and pointing down gives the interrogation effect. At the opposite end of the show-off emotional spectrum is one soft candlelight (***Point* lamp**, short falloff *Distance*, yellow light) placed really up close to the subject, dramatizing the fearful "lost in the darkness" effect.

Somewhere in the macabre spectrum is a hard spot on the floor shining upward. For fun, grab a flashlight, head into the bathroom and close the door. Turn out the light and hold the flashlight underyour chin, pointing up. Look in the mirror and turn it on. From this you can see that lighting, *even* with a single light, varying theintensity, location and direction, changes *everything* in a scene.

- Use this rig, with ***Environment Lighting*** (and props receiving and being lit by ambient light in their material settings) for scenes that feature one main actor or a product being spotlighted.
- Do not use this rig for big open spaces or to show all aspects of a model.

Two-Point Rig



Title-Img. 4. 4Standard two-point light rig.

Link- https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lighting_ rigs.html

The two-point lighting rig provides a **balanced illumination** of an object. Shown to the right are the views of the standard two-point lighting rig. It is called the **two-point** because there are **two pointsof light**. The standard two-point lighting rig provides a balanced illumination of untextured objects hanging out there in 3D space. This rig is used in real studios for lighting a product, especially a glossy one.

Both lights are almost the **same** but do **different things**. Bothemulate very wide, soft light by being ***Hemi*.** In real life, these lights bounce light off the inside of a **silver umbrella**.

Notice how we use low *Energy* to bring out the dimensionality of the sphere; I cannot stress that enough. Hard, bright lights actuallyflatten it and make you squint. Soft lights allow your eye to focus.

We disable specular for right *Hemi*, so we do not get that shiny forehead or nose.

The lamp on the left however, lets it be known that it is there by enabling specular; specular flare is that bright spot that is off center above midline on the sphere.

- Use this rig to give even illumination of a scene, where there is no main focus.

The *Hemi*'s will light up background objects and props, so *Environment Lighting* is not that important. At the opposite end of the lighting spectrum, two narrow *Spot* lights at higher power witha hard edge give a "This is the Police, come out with your hands up" kind of look, as if the subject is caught in the crossfire.

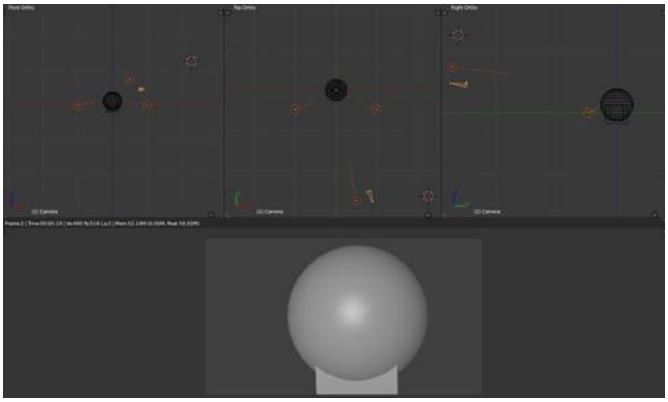
Three-Point Rig

The standard three-point lighting rig is the **most commonillumination** of objects and scenes bar none. If you want to show off your model, use this rig. As you can see, the untextured unmaterialized sphere seems to come out at you. There are multiple thesis on this rig, and you will use one of two:

1. **Studio:** Used in a real studio to film in front of a green screen or backdrop. Use this rig when you are rendering your CG objects to alpha into the scene so that the lighting on the actors *and* your CG objects is the same.

2. **Standard:** Used in real life to light actors on a set, and givessome backlighting to highlight the sides of actors, making them stand out more and giving them depth.

Studio Rig



Title-Img. 4. 5Studio three-point light rig.

Link- https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lighting_ rigs.html

Shown to the right are the **"Studio" top, front, and side** views of the standard three-point lighting rig. It changes the dynamics of the scene, by making a brighter "key" light give some highlights to the object, while two side "fill" lights soften the shadows created by the key light.

In the studio, use this rig to film a **talking head** (actor) in front of a green screen, or with multiple people, keeping the key light on themain actor. This rig is also used to light products from all angles, and the side fill lights light up the props.

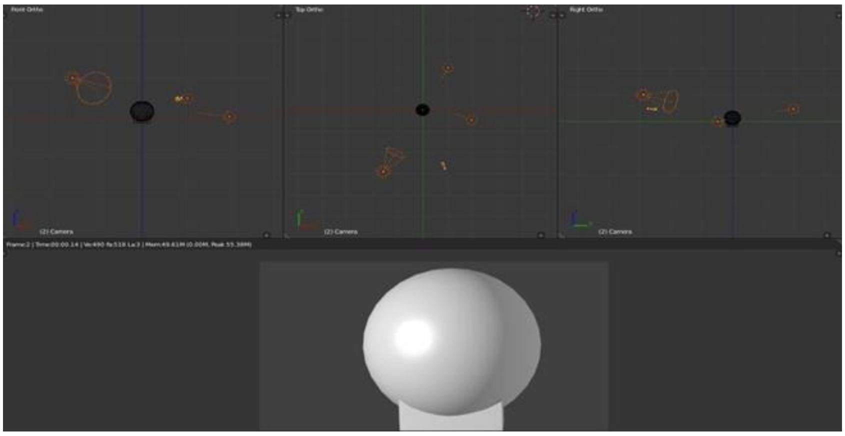
The key light is the ***Area* light** placed slightly above and to the left of the camera. It allows the specular to come out. It is about **30 BU**back from the subject, and travels with the camera. A little specular shine lets you know there is a light there, and that youare not looking at a ghost. In real life, it is a spot with baffles, or blinders, that limit the area of the light.

The two sidelights are reduced to only fill; each of them are *Hemi* lights placed **20 BU** to the side and 5 BU in front of the subject, at ground level. They do not cause a spot shine on the surface by disabling specular, and at ground level, light under the chin or any horizontal surfaces, countering the shadows caused by the key light.

- Use this rig to give **balanced soft lighting** that alsohighlights your main actor or object.

It combines the best of both the single rig and the two-point rig, providing balanced illumination and frontal highlights. For a wide scene, you may have to pull the sidelights back to be more positioned like the two-point rig.

Standard Rig



Title-Img. 4. 6Standard three-point light rig.

Link- *https://docs.blender.org/manual/en/dev/render/blenderrender/lighting/lightingrigs.html*

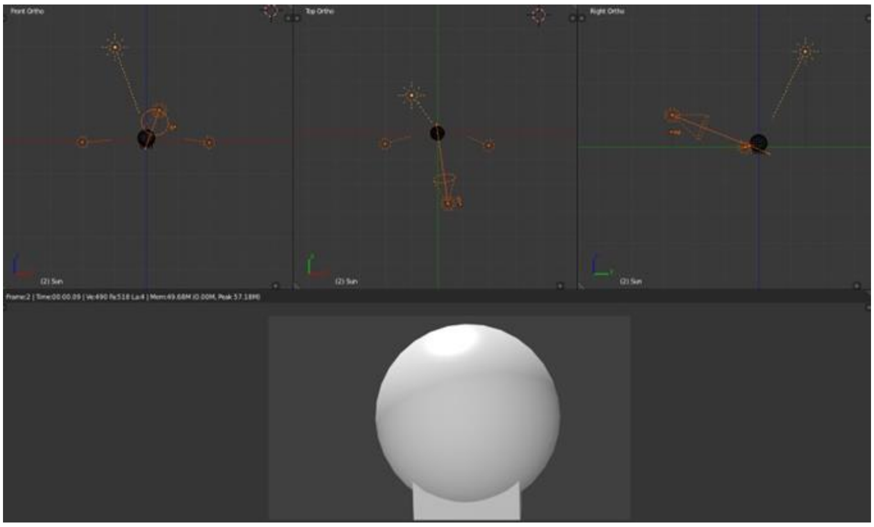
Without a curtain in back of your main subject, you have depth to work with. The left fill light has been moved behind the subject (soit is now called a **backlight**) and is just off-camera, while the right- side fill light remains the same. The **key light** gives you specular reflection so you can play with specularity and hardness in your object's material settings. The key light gives that "in-the-spotlight" feel, highlighting the subject, while the backlight gives a crisp edge to the subject against the background. This helps them stand out.

In this rig, the key light is a **fairly bright spot light**. Use a slighter tinge of yellow because the light is so bright; it is the only light for that side. The other sidelight has been moved in back and raisedto eye (camera) level. You need to cut the energy of the backlight in half, or when it is added to the remaining sidelight, it will lightup the side too much and call too much attention to itself. You canvary the angle and height of the backlight to **mimic sun lighting** upthe objects.

- Use this rig in normal 3D animations **to light the main actor**.
- Use this rig especially if you have transparent objects (like glass) so that there is plenty of light to shine through them to the camera.

The tricky part here is balancing the intensities of the lights so thatno one light competes with or overpowers the others, while making sure all three works together as a team.

Four-point Rig



Title-Img. 4. 7Four-point light rig.

Link- https://docs.blender.org/manual/en/dev/render/blender_render/lighting/lighting_ rigs.html

The **four-point lighting rig** provides a better simulation of outside lighting, by adding a ***Sun* lamp 30 BU** (Blender Unit) above, **10 to the side**, and **15 BU behind** the subject. This sunlight provides backlighting and fills the top of the subject; even producing an intentional glare on the top of their head, telling you there is a sunup there. Notice it is **colored yellow**, which balances out the **blue sidelights**.

Changing the key light to a *Spot*, select ***Inverse Square***, disable ***Specular***and pure white light combines with and softens the top sun flare while illuminating the face, resulting in a bright sunshine effect. Two lights above mean sharper shadows as well, so you might want to adjust the side fill lights. In this picture, they are still***Hemi*, disable *Specular***.

- Use this rig when the camera will be filming from behind the characters, looking over their shoulder or whatnot, because the sun provides the backlight there.
- Also use this rig when you have transparent objects, so there is light to come through the objects to the camera.

Another spot for the fill light is shining up onto the main actor's face, illuminating the underside of his chin and neck. This gets rid of a sometimes-ugly shadow under the chin, which if not corrected, can make the actor look fat or like they have a double chin; otherwise distracting. It evens out the lighting of the face.

Troubleshooting

If you run into a problem with your render, where there are really bright areas, or really dark ones, or strange shadows, or lines on your objects, here are some good steps to debugging what is wrong:

- First, try **deactivating all materials** (create a default, gray one, and enter its name in the ***Mat* field, *Layer* panel, the *Render Layer* tab** to get back all your normalmaterials, just erase this text field!). See if you get those problems with just grayness objects. If you donot have the problem anymore, that should tell you that you have got a materials-interacting-with-light problem. Check the material settings, especially ambient, reflection and all those little buttons and sliders in the ***Material* tab**. You can set some lights to affect only certain materials, so if there is an issue with only a few objects being really bright, start with those.
- Then **start "killing" lights** (e.g. moving them to an unused layer); regress all the way back to one light, make sure it is smooth, then add them in one by one.As they add together, reduce power in the tested ones so they merge cleanly, or consider not adding it at all, or, especially, reduce the energy of the lamp you just introduced.
- You can also **set lights to only light** objects on a layer, so again, if some of the gray spheres have weirdness, check for that as well. Again, you may have done some of this accidentally, so sometimes deleting the light andre-adding it with defaults helps you reset to a known-good situation.
- **Negative lights can be very tricky**, and make your model blotchy, so pay special attention to your use of those special lights. Shadow-only lights can throw off the look of the scene as well. Overly textured lights can make your scene have random weird colors. Do not go too far off a slight tinge of blue or yellow or shades of white, or your material may show blue in the ***Material* tab** but render green, and you will be very confused.

Look at your Environment Settings *World* tab: ***Horizon*, *Zenith*, and** Environment Lighting**.**

Camera

A *Camera* is an object that provides a means of **rendering images from Blender**. It defines which portion of a scene is visible in the rendered image. By default, a scene contains **one camera.** However, a scene can contain more than one camera, but onlyone of them will be used at a time.

Add a New Camera

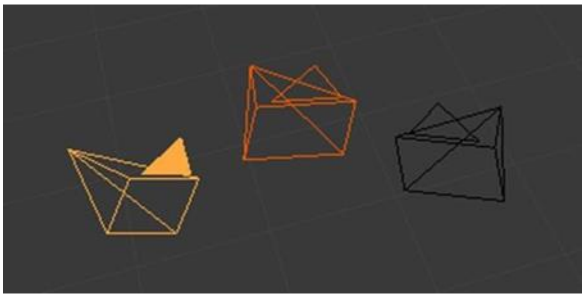
In *Object* mode simply press Shift-A and in the pop-up menu choose ***Add* ‣ *Camera*.**

The default scene in Blender includes a camera, so you'll probably only need to add a new one if you have deleted the default one, orneed to animate a cut between two cameras.

Changing the Active Camera

Reference

- Mode: Object Mode
- Hotkey: Ctrl-Numpad0



Title-Img.4.8Active camera (left one).

Link- https://docs.blender.org/manual/en/dev/render/blender_render/camera/introduction.html

The ***Active* Camera** is the camera that is currently being used forrendering and camera view **Numpad0**.

- **Step 1:** Select the camera you would like to makeactive
- **Step 2:** Press Ctrl-Numpad0
- **Step 3:** Switch the view to camera view.

In order to render, each scene **must** have an active camera.

The active camera can also be set in the ***Scene* tab** of the *Properties Editor*.

The camera with the solid triangle on top is the active camera.

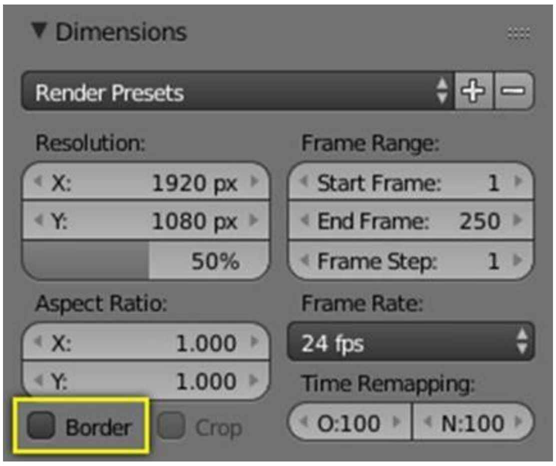
Warning

The active camera, as well as the layers, can be specific to a givenview, or global (locked) to the whole scene.

Render Border

Reference

- Mode: All modes
- Menu: View ‣ Render Border
- Hotkey: Ctrl-B



Title-Img. 4. 9Render Border toggle.

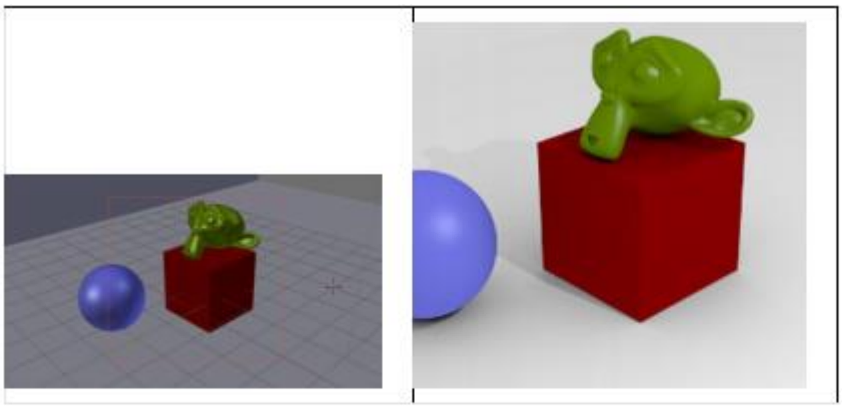
Link- https://docs.blender.org/manual/en/dev/render/blender_render/camera/introduction.html

While in camera view, you can define a sub region to render by drawing out a **rectangle** within the camera's frame. Your renders will now be limited to the part of scene visible within the render border. This can be very useful for reducing render times for quick previews on an area of interest.

The border can be disabled by disabling the ***Border* option** in the ***Dimensions* panel** in the ***Render* tab** or by activating the option again.

Note

When Render Border is activated, **Sampled Motion Blur** willbecome available to view in the 3D View.



Title-Img. 4. 10 Render border and associated render

Link- *[https://docs.blender.org/manual/en/dev/render/blender_render/camera/introduc](https://docs.blender.org/manual/en/dev/render/blender_render/camera/introduction.html) [tion.html](https://docs.blender.org/manual/en/dev/render/blender_render/camera/introduction.html)*

Object Data

Cameras **are invisible** in renders, so they do not have any material or texture settings. However, they do have ***Object* and *Editing* setting panels** available which are displayed when a camera is the selected (active!) object.

Camera Lens

Title-Img. 4. 10Camera Lens panel.

Link- *https://docs.blender.org/manual/en/dev/render/blender_render/camera/objectdata.html*

The camera lens options control the way 3D objects arerepresented in a 2D image.

Lens Type

There are three different lens types:

1. Perspective
2. Orthographic
3. Panoramic

Perspective

This matches how you view things in the real-world. Objects in thedistance will appear smaller than objects in the foreground, and parallel lines (such as the rails on a railroad) will appear to converge as they get farther away.

Title-Img. 4. 11 Render of a train track scene with a Perspective camera.

Link- https://docs.blender.org/manual/en/dev/render/blender_render/camera/object_ data.html

Settings which adjust this projection include:

- **Focal length**
- **Shift**
- **Sensor size**

Focal length

The focal length setting controls the **amount of zoom**, i.e. the amount of the scene which is visible all at once. Longer focallengths result in a **smaller FOV** (more zoom), while short focal lengths allow you to see more of the scene at once **(larger FOV, less zoom)**.

Title-Img. 4. 12 Render of the same scene as above, but with a focal lengthof 210mm instead of 35mm.

Link- *https://docs.blender.org/manual/en/dev/render/blender_render/camera/object_data.html*

Lens Unit

The focal length can be set either in terms of millimeters orthe actual Field of View as an angle.

Orthographic

With *Orthographic* perspective objects **always appear at their actual size**, regardless of distance. This means that parallel lines appear parallel, and do not converge like they do with ***Perspective***.

Title-Img. 4. 13 Render from the same camera angle as the previousexamples, but with orthographic perspective.

Link- *https://docs.blender.org/manual/en/dev/render/blender_render/camera/object_data.html*

Orthographic Scale

This controls the apparent size of objects in the camera.

Note that this is effectively the only setting which applies to orthographic perspective. Since parallel lines do not converge in orthographic mode (no vanishing points), the lens shift settings are equivalent to translating the camera in the 3D View.

Panoramic

Panoramic cameras are only supported in **the Cycles renderengine**.

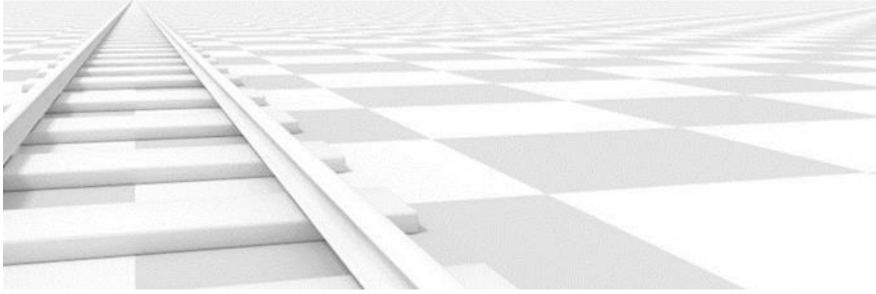
Shift

The *Shift* setting allows for the adjustment of ***vanishing points***. *Vanishing points* refer to the positions to which parallel lines converge. In this example, the most obvious vanishing point is at the end of the railroad.

To see how this works, take the following examples:

Title- Img. 4. 14 Render of a train track scene with a horizontal lens shift of0.330.

Link- *https://docs.blender.org/manual/en/dev/render/blender_render/camera/object_ data.html*



Title-Img. 4. 15 Render of a train track scene with a rotation of the camera object instead of a lens shift.

Link- https://docs.blender.org/manual/en/dev/render/blender_render/camera/object_ data.html

Notice how the horizontal lines remain perfectly horizontal when using the lens shift, but do get skewed when rotating the camera object.

Using lens shift is equivalent to rendering an image with a larger FOV and cropping it off-center.

- **Clipping**

  Set the clipping limits with the *Start* and *End* values.

Only objects within the limits are rendered.

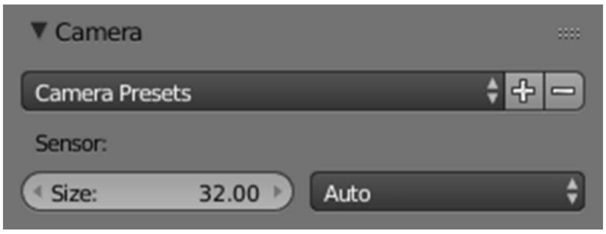
For **OpenGL display**, setting clipping distances to limited values is important to ensure sufficient rasterization precision. Ray tracing renders do not suffer from this issue so much, and as such more extreme values can safely be set.

When ***Limits* in the *Display* panel** is enabled, the clip bounds will be visible as **two yellow connected dots** on the camera line of sight.

Camera Preset

Options

Camera Presets



Title-Img.4. 16Camera Presets panel.

Link- https://docs.blender.org/manual/en/dev/render/blender_render/camera/object data.html

Sensor size

This setting is an alternative way to control the focal- length, it is useful to match the camera in Blender to a physical camera & lens combination, e.g. for motion tracking.

Depth of Field

Title-Img. 4. 17Camera Depth of Field Panel.

Link- https://docs.blender.org/manual/en/dev/render/blender_render/camera/object_ data.html

Real world cameras transmit light through a lens that bends andfocuses it onto the sensor. Because of this, objects that are a certain distance away are in focus, but objects in front and behind that are blurred.

The area in focus is called the *focal point* and can be set using either an exact value, or by using the distance between the camera and a chosen object:

- **Focus Object**

  Choose an object which will determine the focal point. Linking an object will deactivate the distance parameter. Typically, this is used to give precise control over the position of the focal point, and also allows it to be animated or constrained to another object.

- **Distance**

  Sets the distance to the focal point, when no *Focus Object*is specified. If *Limits* are enabled, a yellow cross is shownon the camera line of sight at this distance.

- **Hint**

  Hover the mouse over the *Distance* property and press E touse a special *Depth Picker*. Then click on a point in the 3D View to sample the distance from that point to the camera.

- **High Quality**

  In order for the viewport to offer an accurate representation of depth of field, like a render, you must enable High Quality. Without it, you may notice a difference in shading.

- **Viewport F-stop**

Controls the real-time focal blur effect used during sequencer or OpenGL rendering and, when enabled,camera views in the 3D View. The amount of blur depends on this setting, along with Focal Length and Sensor Size. Smaller Viewport F-stop values result in more blur.

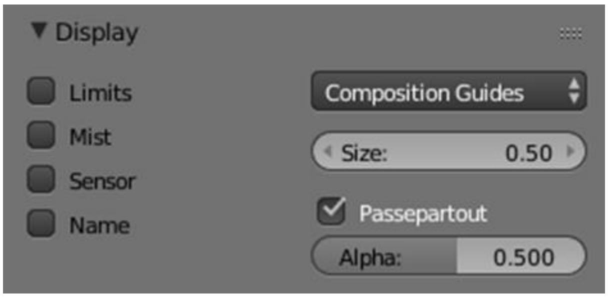
- **Blades**

Add a number of polygonal *blades* to the blur effect, in order to achieve a ***bokeh effect*** in the viewport. To enable this feature, the blades must be set to **at least 3 (3 sides, triangle)**

Title-Img. 4. 18The viewport bokeh effect with the blades set to 3.

Link- *https://docs.blender.org/manual/en/dev/render/blender_render/camera/object_data.html*

Display



Title-Img. 4. 19Camera Display Panel.

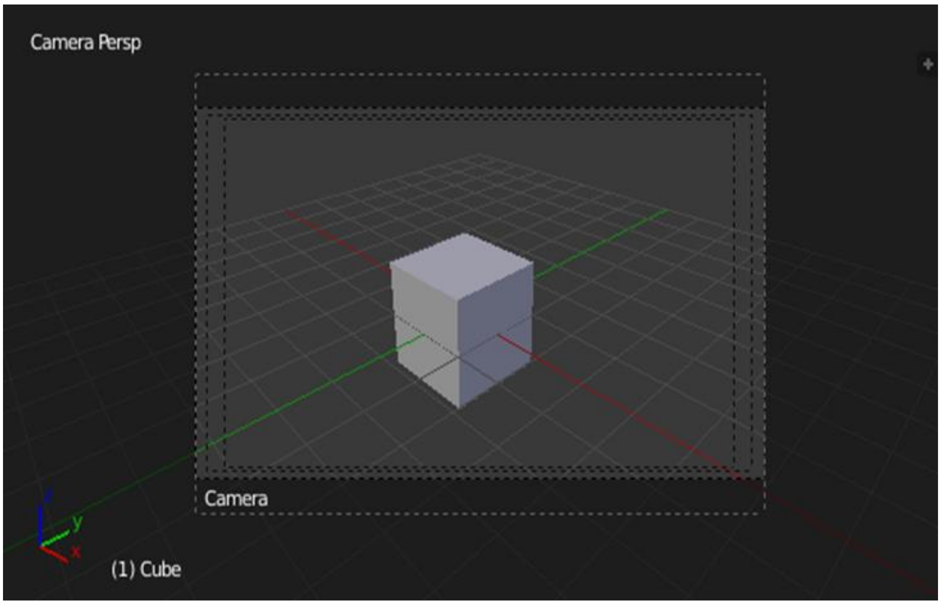
Link- https://docs.blender.org/manual/en/dev/render/blender_render/camera/object_ data.html

- **Limits**

Shows a line which indicates *Start* and *End Clipping* values.

- **Mist**

Toggles viewing of the mist limits on and off. The limits are shown as two connected white dots on the camera line of sight. The mist limits and other options are set in the *World*panel, in the Mist section.



Title-Img. 4. 20Camera view displaying safe areas, sensor and name.

Link- https://docs.blender.org/manual/en/dev/render/blender_render/camera/object_ data.html

- **Sensor**

  Displays a dotted frame in camera view.

- **Name**

  Toggle name display on and off in camera view.

- **Size**

  Refers to the size of the camera icon in the 3D View. This setting has no effect on the render output of a camera, andis only a cosmetic setting. The camera icon can also be scaled using the standard Scale S transform key.

- **Passé partout, Alpha**

  This mode darkens the area outside of the camera's field ofview, based on the *Alpha* setting.

- **Composition Guides**

  Composition Guides are available from the menu, whichcan help when framing a shot. There are eight types of guides available:

- **Center**

  Adds lines dividing the frame in half vertically and horizontally.

- **Center Diagonal**

  Adds lines connecting opposite corners.

- **Thirds**

  Adds lines dividing the frame in thirds vertically and horizontally.

- **Golden**

  Divides the width and height into Golden proportions (About 0.618 of the size from all sides of the frame).

- **Golden Triangle A**

  Draws a diagonal line from the lower-left to upper-right corners, then adds perpendicular lines that pass through the top left and bottom right corners.

- **Golden Triangle B**

  Same as A, but with the opposite corners.

- **Harmonious Triangle A**

  Draws a diagonal line from the lower-left to upper-right corners, then lines from the top left and bottom right corners to 0.618 the lengths of the opposite side.

- **Harmonious Triangle B**

  Same as A, but with the opposite corners.

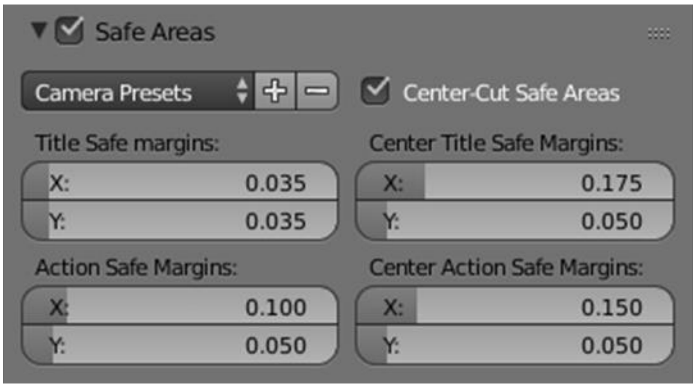
Safe Areas

Safe areas are guides used to **position elements** to ensure that themost important parts of the content can be seen across all screens.

Different screens have varying amounts of over scan (specially**older TV** sets). That means that not all content will be visible to all viewers, since parts of the image surrounding the edges are not shown. To work around this problem TV producers defined, two areas where content is guaranteed to be shown: action safe and title safe.

Modern LCD/plasma screens with purely digital signals have no over scan, yet safe areas are still considered best practice and maybe legally required for broadcast.

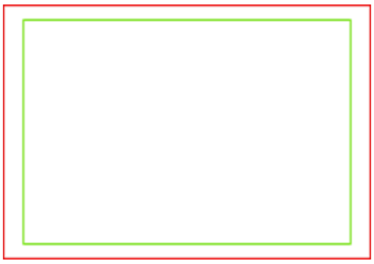
In Blender, safe areas can be set from the Camera and Sequencer views.



Title-Img. 4. 21The Safe areas panel found in the camera properties, and the viewmode of the sequencer.

Link- *https://docs.blender.org/manual/en/dev/render/blender_render/camera/object_ data.html*

Main Safe Areas



Title- Img. 4. 22Red line: Action safe. Green line: Title safe.

Link- https://docs.blender.org/manual/en/dev/render/blender_render/camera/object_ data.html

Title Safe

Title safe is also known as *Graphics Safe*. Place all important information (graphics or text) inside this area to ensure it can be seen by the majority of viewers.

Action Safe

Make sure any significant action or characters in the shot areinside this area. This zone also doubles as a sort of "margin" for the screen which can be used to keep elements from piling up against the edges.

Tip

Legal Standards

Each country sets a legal standard for broadcasting. These include, among other things, specific values for safe areas. Blender defaults for safe areas follow the EBU (European Union) standard. Make sure you are using the correct values when working for broadcast to avoid any trouble.

Center-Cuts

Title- Img. 4. 23Cyan line: action center safe. Blue line: title center safe.

Link- https://docs.blender.org/manual/en/dev/render/blender_render/camera/object_ data.html

Center-cuts are a **second set of safe areas** to ensure content is seen correctly on screens with a different aspect ratio. Old TV sets receiving **16:9 or 21:9** video will cut off the sides. Position content inside the center-cut areas to make sure the most important elements of your composition can still be visible in these screens.

Blender defaults show a **4:3 (square) ratio inside 16:9 (wide- screen).**

Unit summary

In this Unit, you have learnt how to

- Use Lighting Rig to produce photorealistic results with itsphysically plausible shading and lighting system.
- Work with lights realistically, with shape and falloff.
- Produce final quality results, resulting in faster setup andmore accurate results.

After learning this Unit, you can download the Open Source Software available on the internet for free of cost to practice thepossibilities of creating 3D Objects.

Assignment

- Use the same **Living Room scene** created for Block 02, Unit – 01 Assignment to light with Blender, improvise the same using Lamps as rigs and render using camera with required DOF – Depth of Field
- Use this key word **"photo frame on wall"** on www.google.com to collect the reference image to build your lighting reference.

Assessment

1. Describe the use of Light Rigs
2. Explain One-point light rig with appropriate example
3. Explain Two-point light rig with appropriate example
4. Explain Studio light rig with appropriate example
5. Describe Depth of Filed

Objective type Questions

1. You can make the spot wider by increasing spot ______________
2. Studio Light rig is similar to____________Light Rig
3. You cannot set lights to only light objects on a layer (True / False)

4. Hard, bright lights actually flatten it and make you squint. Softlights allow your eye to focus (True / False)

5. Ambient light illuminates, in a perfectly balanced, Shadeless way,without casting shadows (True / False)

Resources

While studying this Unit, you can browse the following internet

links for online video tutorials and several books and trainingDVDs available in the

Blender Store and on the Blender Cloud.

Links to download 3D Files for practice - Copyright Notice

Attribution-NonCommercial-ShareAlike CC BY-NC-SA

1. https://wiki.blender.org/index.php/Doc:2.4/Tutorials/Lig hting/BSoD
2. https://cloud.blender.org/p/hdri
3. wiki.blender.org
4. ia600207.us.archive.org
5. archive.org
6. www.blender.org
7. docs.blender.org

Books to refer

8. Blender 2.5 Lighting and Rendering by Aaron W. Powell
9. Read Chapter 7 of the John Blain *"Complete Guide to Blender Graphics"* - Lighting and Cameras (pages 131-136)
10. https://www.lifewire.com/quick-tips-for-interesting-cg- lighting-2119

DMA-201

3D Animation

Block – V: 3D Dynamics (Practical)

Unit-1 Introduction Dynamics

Introduction

All real world physical phenomena are the branches of **Physics.** The software **Blender** offers a variety for different physics. For example you can use Blender to simulate to **Smoke, Rain, Dust, Cloth, Water, Jelly Etc.,**

Particle Systems can be used to simulate many things: hair, grass, smoke, flocks. Hair is a subset of the particle system, and can be used for **strand-like objects**, such as hair, fur, grass, quills, etc.

Soft Bodies are useful for everything that tends to bend, deform,in reaction to forces like gravity or wind, or when colliding with other objects. It can be used for skin, rubber, and even clothes, even though there is separate Cloth Simulation specific for **cloth- like objects**. **Rigid Bodies** can simulate dynamic objects that are fairly rigid.

Fluids, which include liquids and gases, can be simulated, includingSmoke. Force Fields can modify the behavior of simulations.

In this Unit, you will learn the physical simulation to 3D objectsand practice real world physical simulation.

Outcomes

Upon completion of this unit you will be able to:

- Apply physical simulation to 3D Objects in your scene
- Demonstrate the utility of Force Fields
- Use Multiple field to create the required effects
- Practice real world physical simulation

Terminology

Baking	:	Baking, in general, is the act of pre-computing something, in order to speed up some otherprocess later down the line.
Cache	:	A collection of items of the same type stored in a hidden or inaccessible place
Gravity	:	Gravity is a global setting that is applied the same to all physics systems in a scene, which can be found in the scene tab. This value is generally fine left at its default value, at -9.810in the Z-Axis, which is the force of gravity in the

real world. Lowering this value would simulate a lower or higher force of gravity

Baking Physics Simulations

Baking refers to the **act of storing or caching** the results of a calculation.

It is generally recommended to bake your physics simulations before rendering. Aside from no longer needing to go through the time-consuming process of simulating again, baking can help **prevent potential glitches** and ensure that the outcome of the simulation remains exactly the same every time.

Compression

Compression level for cache files. Some physics caches can be **verylarge** (such as **smoke**). Blender can compress these caches in orderto save space.

- *None*

  Do not compress the cache.

- *Light*

  Compression optimizes speed ofcompressing/decompressing operations over file size.

- *Heavy*

  Compression will result in smaller cache file more than*Light*, however, requires more CPU time to compress/decompress.

External

Read and write the cache to disk using a **user-specified file path**.

- *Index Number*

  This number specifies which cache should be used when the specified cache directory contains multiple caches. 0 refers to the top-most cache, 1 to the second from the top,2to the third, and so on.

- *Use Lib Path*

  Share the disk cache when the physics object is linked into another blend-file.

  When this option is enabled, linked versions of the object will reference the same disk cache. When disabled, linked versions of the object will use independent caches.

- *Start*

  Frame on which to start the simulation.

- *End*

  Frame on which to stop the simulation.

- *Cache Step*

Interval for storing simulation data.

- *Bake*

  Start baking. Blender will become unresponsive during most baking operations. The cursor will display as a number representing the bakes' progress.

- *Free Bake*

  Mark the baked cache as temporary. The data will stillexist, However, will be removed with the next object modification and frame change. This button is only available when the physics system has been baked.

- *Calculate to Frame*

  Bake only up to the current frame. Limited by *End* frame set in the cache settings.

- *Current Cache to Bake*

  Store any temporarily cached simulation data as a bake. Note that playing the animation will try to simulate any visible physics simulations. Depending on the physics type, this data may be temporarily cached. Normally such temporary caches are cleared when an object or setting is modified, However, converting it to a bake will "save" it.

- *Bake All Dynamics*

  Bake all physics systems in the scene, even those of different types. This is useful for baking complex setups involving interactions between different physics types.

- *Free All Bakes*

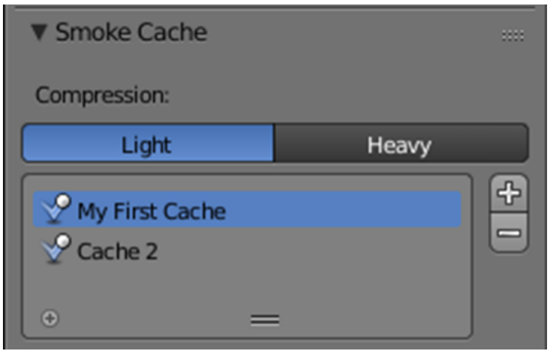
  Free bakes of all physics systems in the scene, even thoseof different types.

- *Update All to Frame*

  Bake all physics systems in the scene to the current frame.

Multiple Caches

Blender allows for storing and managing multiple caches at oncefor the same physics object.



Title-Img. 1. 1Two different caches stored simultaneously.
Attribution-Source-Link-
https://docs.blender.org/manual/en/dev/physics/baking.html?highlight=two%20different%20caches%20stored%20simultaneously

Caches can be added and removed with the **Plus** and **Minus** buttons. Renaming a cache can be done by either **double clicking** or **pressing Ctrl-LMB** on the desired cache.

Force Fields

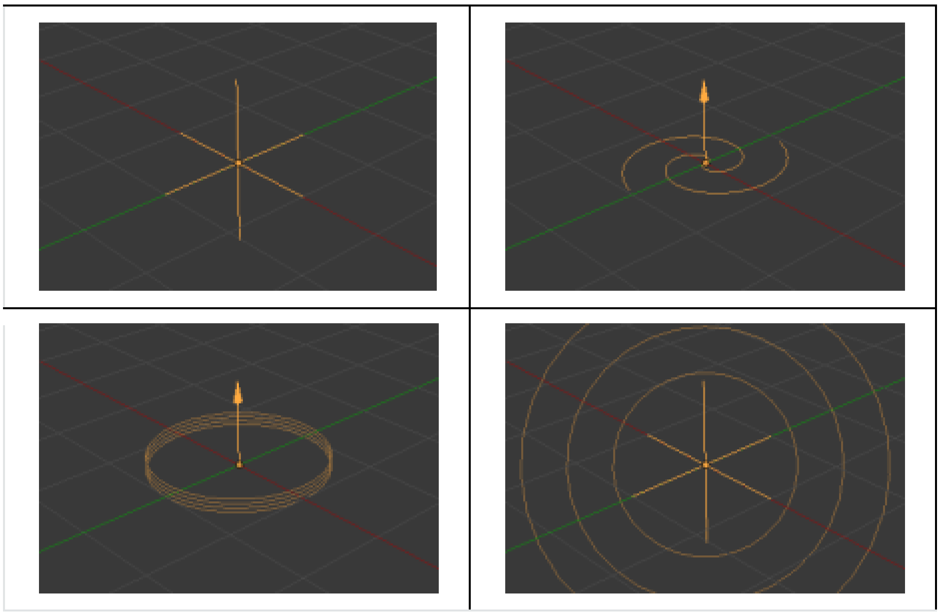
Force Fields offer a way to add **extra movement** to dynamic systems. **Particles, Soft Bodies, Rigid Bodies and Cloth objects** canall be affected by forces fields. Force Fields automatically affect everything. To remove a simulation or particle system from their influence, simply turn down the influence of that type of Force Field in its Field Weights panel.

- All types of objects and particles can generate fields, However, only curve object can bear ***Curve Guides*** fields.
- Force Fields can also be generated from particles.
- The objects need to share at least one common layer to have effect.

You may limit the effect on particles to a group of objects.

Creating a Force Field

Force field types



Title-Img. 1. 2Creating a Force Field.
Attribution-Source- Link-
https://docs.blender.org/manual/en/dev/physics/force_fields/introduction.h tml#creating-a-force-field

Reference

- **Mode:** Object Mode
- **Panel:** Physics ‣ Fields

To create a single Force Field,

- Step 1: Select **Add ‣ Force Field** and
- Step 2: Select the desired force field.

This method creates an Empty with the force field attached.To create a field from an existing object,

- Select the object and change to the ***Physics* tab**.
- Select the field type in the *Fields* menu.

The fields have many options in common; these common optionsare explained for the ***Spherical* field**.

Common Field Settings

Most Fields have the same settings, even though they act very differently. Settings unique to a field type are described below. **Curve Guide and Texture Fields** have very different options.

- *Shape*

  The field is either a *Point*, with omni-directional influence, or a *Plane*, constant in the XY-plane, changes only in Zdirection.

- *Strength:*

  The strength of the field effect can be positive or negative to change the direction that the force operates in. A force field's strength is scaled with the force object's scale, allowing you to scale up and down scene, keeping the same effects.

- *Flow*

  Convert effector force into air flow velocity.

- *Noise*

  Adds noise to the strength of the force.

- *Seed*

  Changes the seed of the random noise.

- *Effect Point*

  You can toggle the field's effect on particle *Location* and *Rotation*

- *Collision Absorption*

  Force gets absorbed by collision objects.

Falloff

Here you can specify the shape of the force field (if the ***Fall-off* Power is greater than 0).**

- **Sphere**

  Falloff is uniform in all directions, as in a sphere.

- Tube

  Fall off results in a tube-shaped force field. The Field's *Radial falloff* can be adjusted, as well as the *Minimum* and *Maximum* distances of the field.

- Cone

  Fall off results in a cone shaped force field. Additional options are the same as those of *Tube* options.

- Z Direction

  Fall-off can be set to apply only in the direction of the positive Z Axis, negative Z Axis, or both.

- Power (Power)

  How the power of the force field changes with the distancefrom the force field. If r is the distance from the center of the object, the force changes with 1/ r^{power}. A *Fall-off* of 2 changes the force field with 1/ r^2, which is the falloff of gravitational pull.

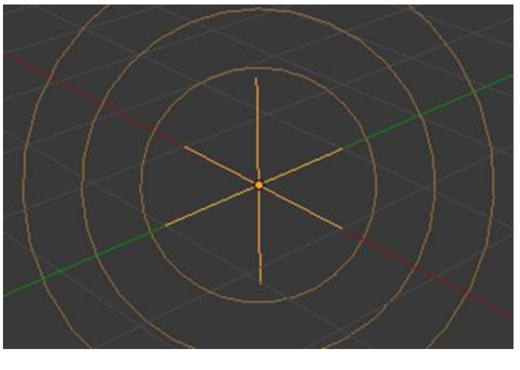
- Max Distance

  This makes the force field to take effect within a specified maximum radius (shown by an additional circle around the object).

- Min Distance

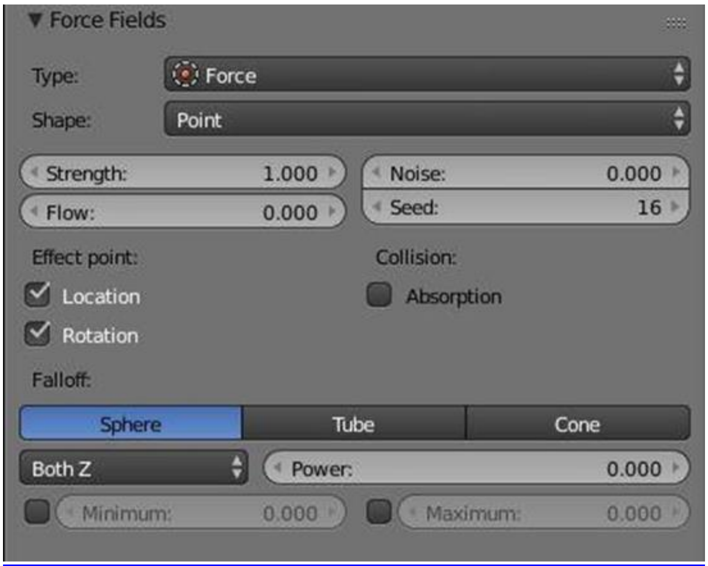
  The distance from the object center, up to where the force field is effective with full strength. If you have a *Fall-off* of 0this parameter does nothing, because the field is effective with full strength up to *Max Distance* (or the infinity).

Force



Title-Img. 1. 3Force field.
Attribution-Source-Link-
[https://docs.blender.org/manual/en/dev/physics/force_fields/introduction.h](https://docs.blender.org/manual/en/dev/physics/force_fields/introduction.html#creating-a-force-field) [tml#creating-a-force-field](https://docs.blender.org/manual/en/dev/physics/force_fields/introduction.html#creating-a-force-field)

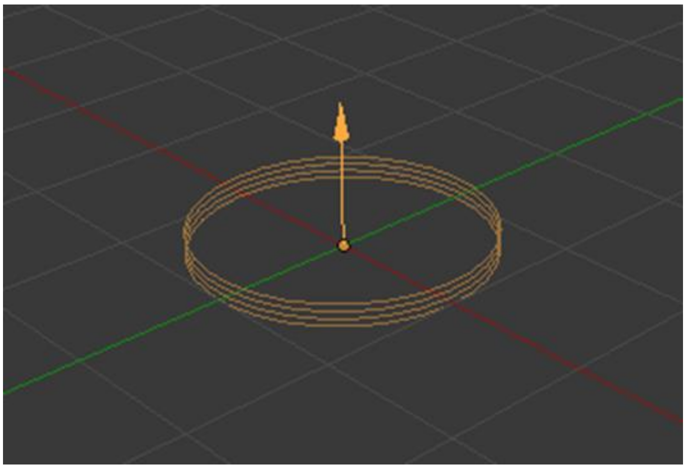
The *Force* field is the **simplest of the fields**. It gives a constantforce towards (positive strength) or away from (negative strength) the object's center. Newtonian particles are attracted to a field with negative strength, and are blown away from a field withpositive strength.



Title-Img. 1. 4UI for a Force field.
Attribution-Source- Link-
https://docs.blender.org/manual/en/dev/physics/force_fields/types/force.html

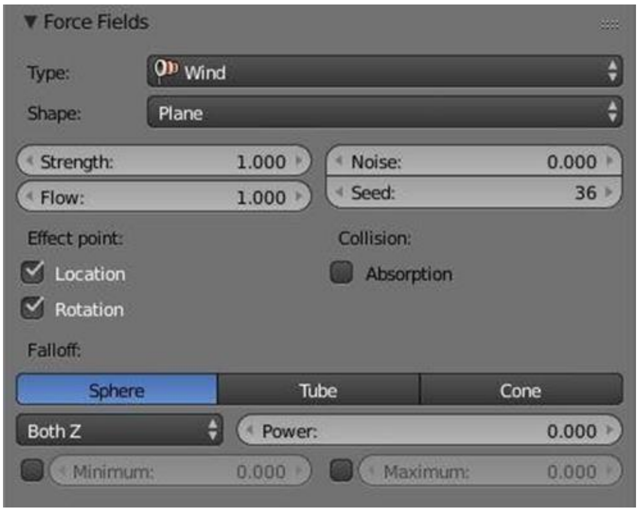
For Boids Particles, a field with positive strength can be used as a ***Goal,*** a field with negative strength can be used as ***Predator*.** Whether *Boids* seek or fly goals/predators depends on the *Physics* settings of the Boids.

Wind



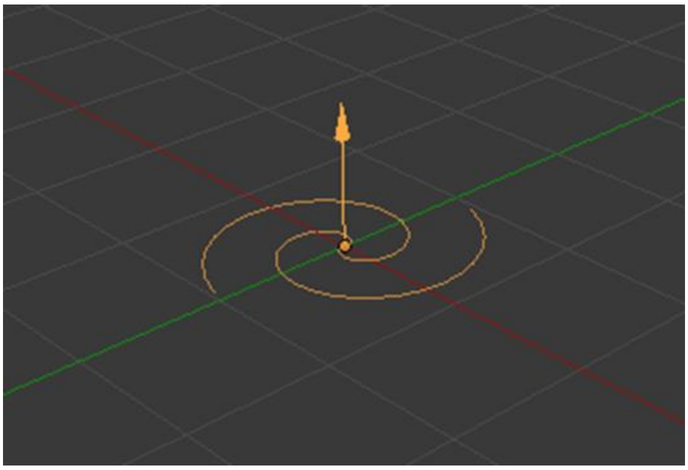
Title-Img. 1. 5Wind force field.
Attribution-Source- Link-
https://docs.blender.org/manual/en/dev/physics/force_fields/types/wind.html

The *Wind* force field gives a constant force in a single direction, along the force object's local Z axis. The strength of the force is visualized by the spacing of the circles shown.



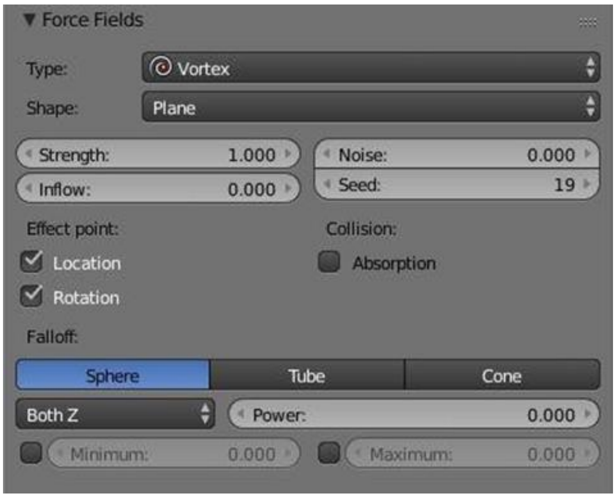
Title-Img. 1. 6UI for a Wind force field.
Attribution-Source-
Link- ***https://docs.blender.org/manual/en/dev/physics/force_fields/types/wind.html***

Vortex



Title-Img. 1. 7Vortex force field.
Attribution-Source-Link-
https://docs.blender.org/manual/en/dev/physics/force_fields/types/wind.ht ml

The *Vortex* force field gives a **spiraling force** that twists the direction of points around the force object's local Z axis. This can be useful for making a **swirling sink**, or **tornado**, or **kinks** in particle hair.



Title-Img. 1. 8UI for a Vortex force field.
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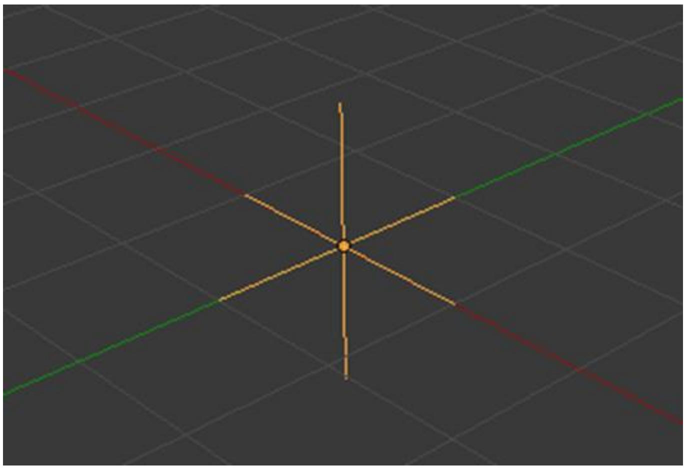
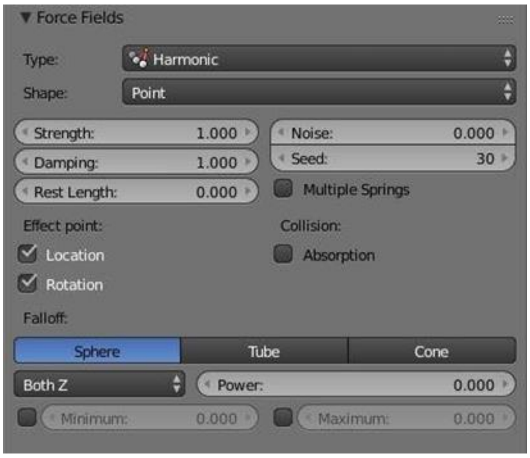
Source-
Link- **https://docs.blender.org/manual/en/dev/physics/force_fields/types/vortex.html**

Magnetic



Title-Img. 1. 9Magnetic force field.
Attribution-Source-Link-
https://docs.blender.org/manual/en/dev/physics/force_fields/types/magneti c.html

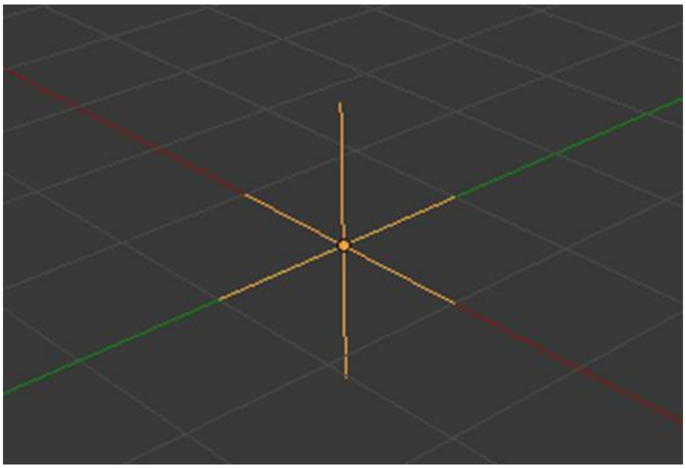
This field depends on the **speed of the particles**. It simulates theforce of magnetism on magnetized objects.



Title-Img. 1. 10UI for a Magnetic force field.

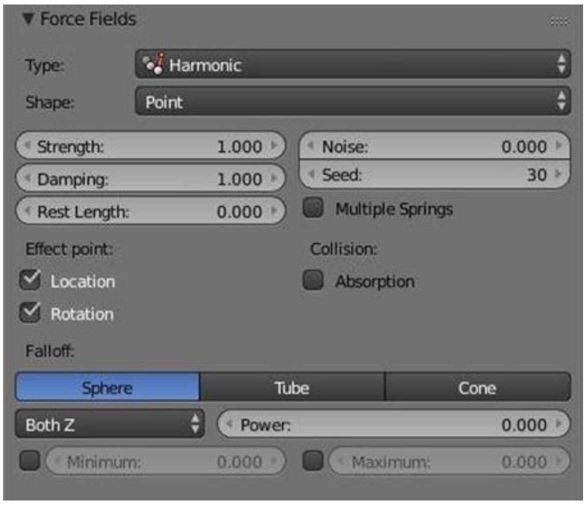
Attribution-***Source-***
Link- **https://docs.blender.org/manual/en/dev/physics/force_fields/types/magnetic.html**

Harmonic



Title-Img. 1. 11Harmonic force field.
Attribution-Source-
Link-https://docs.blender.org/manual/en/dev/physics/force_fields/types/harmon ic.html

In a *Harmonic* force field, the source of the force field is **the zero point** of a harmonic oscillator (spring, pendulum). If you set the ***Damping*** **parameter to 1**, the movement is stopped in the moment the object is reached. This force field is really special if you assign it to particles.



Title-Img. 1. 12UI for a Harmonic force field.
Attribution-Source-***Link-*** ***https://docs.blender.org/manual/en/dev/physics/force_fields/types/harmon ic.html***

Options:

- **Rest Length**

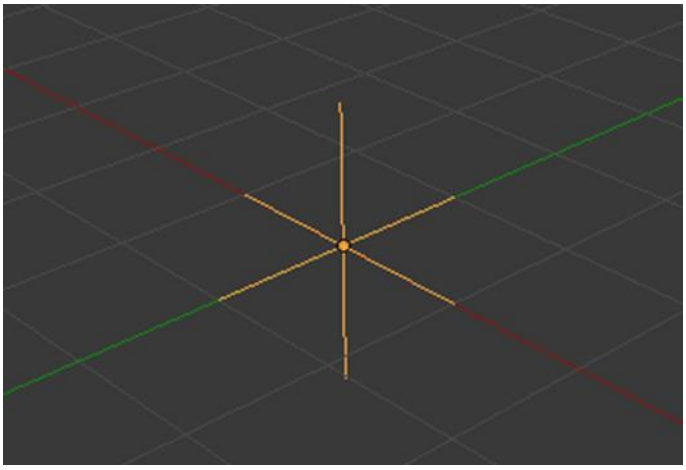
  Controls the rest length of the harmonic force.

- Multiple Springs

  This causes every point to be affected by multiple springs. Normally every particle of the field system influences everyparticle of the target system. Not with *Harmonic* ! Here every target particle is assigned to a field particle. So particles will move to the place of other particles, thusforming shapes.

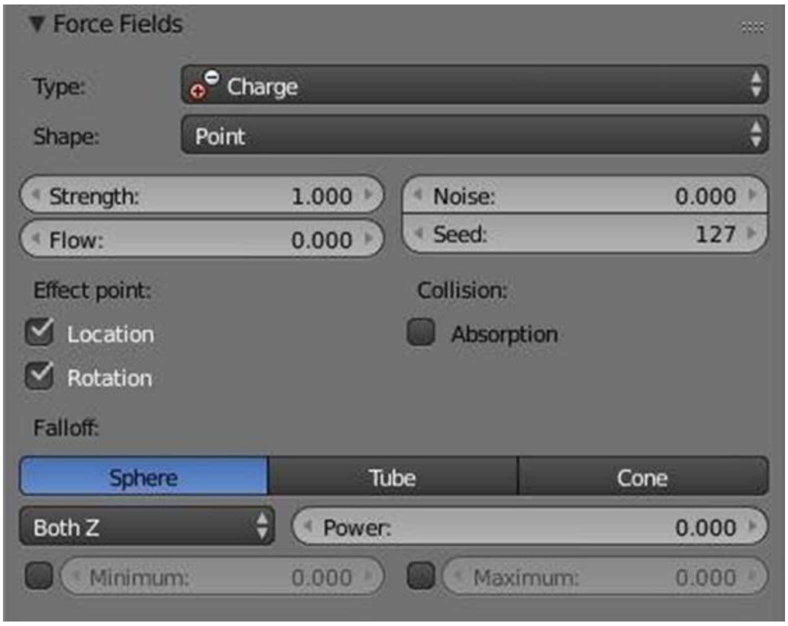
Tutorial: https://en.wikibooks.org/wiki/Blender_3D:_Noob_to_Pro/Particles_for ming_Shapes

Charge



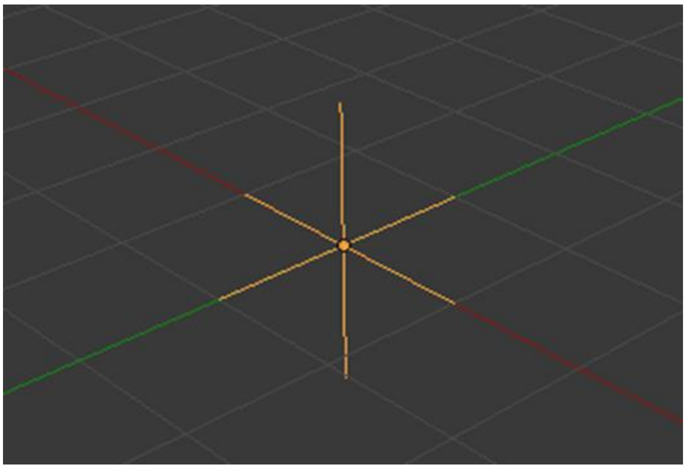
Title-Img. 1. 13Charge force field.
Attribution-Source-Link-https://docs.blender.org/manual/en/dev/physics/force_fields/types/charge. html

A *Charge* force field is similar to **spherical field** except it changesbehavior (attract/repulse) based on the effected particles charge field (negative/positive), like real particles with a charge. This means this field has only effect on particles that have also a ***Charge* field** (else, they have no "charge", and hence areunaffected)!



Title-Img. 1. 14UI for a Charge force field.
Attribution-Source-Link-[https://docs.blender.org/manual/en/dev/physics/force_fields/types/charge. html](https://docs.blender.org/manual/en/dev/physics/force_fields/types/charge.html)

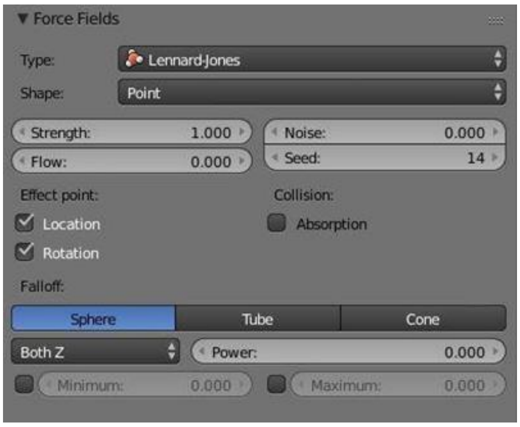
Lennard Jones



Title-Img. 1. 15Lennard Jones force field.
Attribution-***Source-Link-https://docs.blender.org/manual/en/dev/physics/force_fields/types/lennard_jones.html***

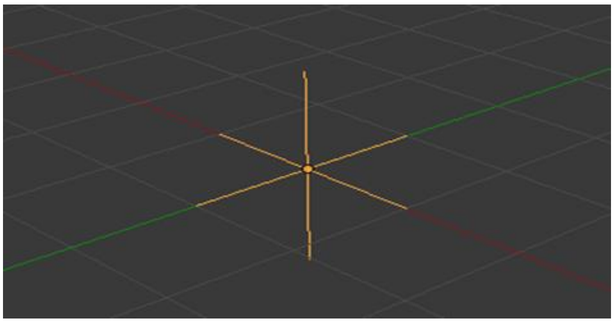
The *Lennard Jones* force field is a **very short range force** with a behavior determined by the sizes of the effector and effectedparticle. At a distance smaller than the combined sizes the field is very repulsive and after that distance it is attractive. It tries to keep the particles at an equilibrium distance from each other. Particles need to be at a close proximity to each other to be effected by this field at all.

Particles can have for example both a **charge and a Lennard-Jones potential**, which is probably something for the nuclear physicists amongst us.



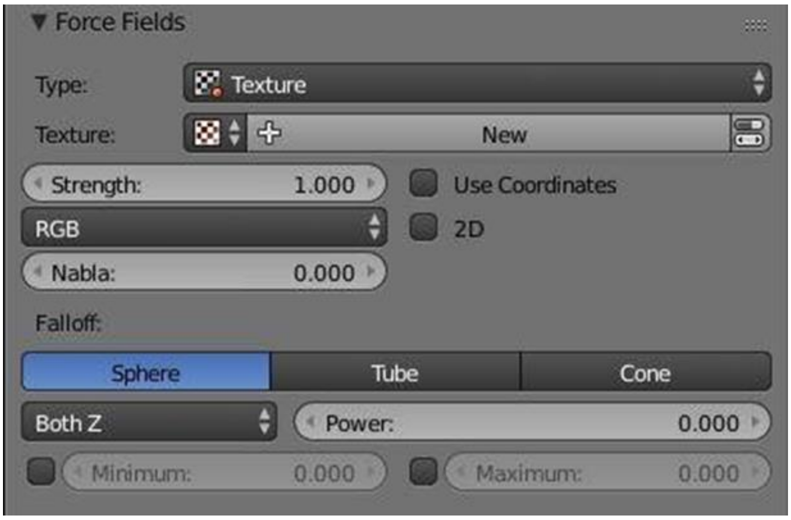
Title-Img. 1. 16UI for a Lennard Jones force field.
Attribution-Source-
Link-https://docs.blender.org/manual/en/dev/physics/force_fields/types/lennard_jones.html

Texture



Title-Img. 1. 17Texture force field.
Attribution-Source-
Link- [https://docs.blender.org/manual/en/dev/physics/force_fields/types/texture.](https://docs.blender.org/manual/en/dev/physics/force_fields/types/texture.html) html

You can use a ***Texture* force field** to create an **arbitrarily complicated** force field, which force in the three directions is colorcoded. **Red** is coding for the X-axis, **green** for the Y-axis and **blue** for the Z-axis (like the color of the coordinate axes in the 3D View). A value of **0.5** means no force, a value **larger than 0.5** acceleration in negative axis direction (like -Z), a value **smaller than 0.5** acceleration in positive axis direction (like +Z).



Title-Img. 1. 18UI for a Texture force field.
Attribution-Source-
***Link-*[*https://docs.blender.org/manual/en/dev/physics/force_fields/types/texture. html*](https://docs.blender.org/manual/en/dev/physics/force_fields/types/texture.html)**

Options

Texture mode

This sets the way a force vector is derived from the texture.

- RGB

Uses the color components directly as the force vector components in the color encoded directions. You need an RGB texture for this, e.g. an image or a color band. So, a *Blend* texture without a color band would not suffice.

- Gradient

Calculates the force vector as the 3D-gradient of the intensity(grayscale) of the texture. The gradient vector always points to thedirection of increasing brightness.

- Curl

Calculates the force vector from the curl of the 3D-RGB texture (rotation of RGB vectors). This also works only with a color texture. It can be used for example to create a nice-looking turbulence force with a color clouds texture with Perlin noise.

- Nabla

It is the offset used to calculate the partial derivatives needed for *Gradient* and *Curl* texture modes.

- Use Object Coordinates

Uses the emitter object coordinates (and rotation & scale) as the texture space the particles use. Allows for moving force fields that have their coordinates bound to the location coordinates of an object.

- Root Texture Coordinates

This is useful for hair as it uses the texture force calculated for theparticle root position for all parts of the hair strand.

- 2D

The *2D* button disregards the particles z-coordinate and only usesparticles x & y as the texture coordinates.

Remember that only procedural texture is truly 3D.

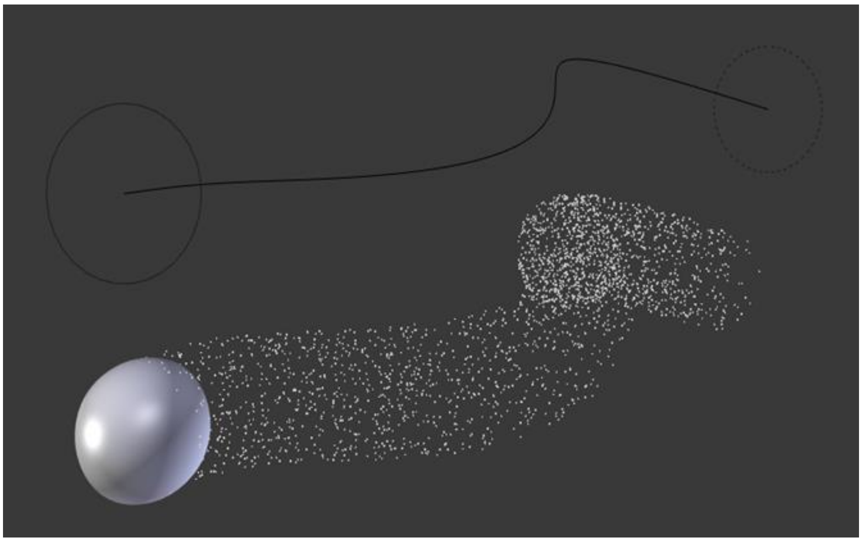
Examples

A single colored texture (0.5, 0.0, 0.5) creates a force in thedirection of the positive Y-axis, e.g. hair is orientated to the Y-axis.

A blend texture with color band can be used to create a force “plane”. E.g. on the left side (0.5, 0.5, 0.5), on the right side (1.0, 0.5, 0.5) you have a force plane perpendicular to XY (i.e. parallel toZ). If you use an object for the coordinates, you can use the object to push particles around.

An animated wood texture can be used to create a wave likemotion.

Curve Guide



Title-Img. 1. 19Curve Guide force field.
Attribution-Source-
Link-[https://docs.blender.org/manual/en/dev/physics/force_fields/types/curve_g uide.html](https://docs.blender.org/manual/en/dev/physics/force_fields/types/curve_guide.html)

The *Curve Guide* is used to force particles to follow a certain path defined by a Curve Object. A typical scenario would be to move a red blood cell inside a vein, or to animate the particle flow in a motor. You can use *Curve Guide* s also to shape certain hair strands.

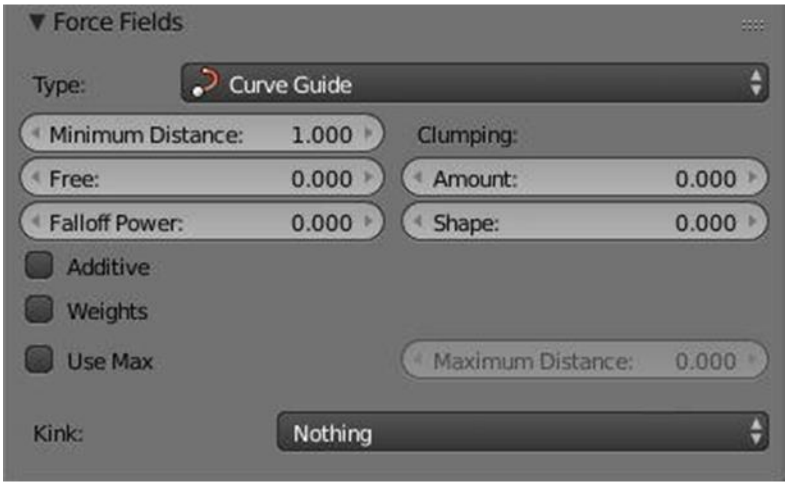
You can also use the Particle Edit Mode to define a path.

Since you can animate curves as Soft Body or any other usual way, you may build very complex animations while keeping great control and keeping the simulation time to a minimum.

The option *Curve Follow* does not work for particles. Instead you must set ***Angular Velocity*** (*Particle system* tab) to *Spin* and leave the rotation constant (i.e. do not turn on *Dynamic*).

Curve Guideaffects all particles on the same layer, independently from their distance to the curve. If you have several guides in a layer, their fields add up to each other (the way you may have learned it in your physics course). However, you can limit theirinfluence radius by changing their *Minimum Distance*.

Options



Title-Img. 1. 20UI for a Curve Guide force field.
Attribution-
Source-
Link-[https://docs.blender.org/manual/en/dev/physics/force_fields/types/curve_g uide.html](https://docs.blender.org/manual/en/dev/physics/force_fields/types/curve_guide.html)

- Minimum Distance

  It means the distance from the curve, up to where theforce field is effective with full strength. If you have a *Fall- off* of 0 this parameter does nothing, because the field is effective with full strength up to *Max Distance* (or the infinity). *Min Distance* is shown with a circle at the endpoints of the curve in the 3D View.

- Free

  Fraction of particle life time, which is not used for thecurve.

Fall-off

This setting governs the strength of the guide between ***Min Distance*** and ***Max Distance***. A *Fall-off* of 1 means a linear progression.

A particle follows a ***Curve Guide*** during its lifetime, the velocity depends on its lifetime and the length of the path.

- Additive

  If you use *Additive*, the speed of the particles is alsoevaluated depending on the *Fall-off*.

- Weights

  Use Curve weights to influence the particle influence alongthe curve.

- Maximum Distance / Use Max

  This maximum distance value influence radius which isshown by an additional circle around the curve object.

The other settings govern the form of the force field along the curve.

- Clumping Amount

  The particles come together at the end of the curve (1) or they drift apart (-1).

- Shape

  Defines the form in which the particles come together.+0.99: the particles meet at the end of the curve. 0: linear progression along the curve. -0.99: the particles meet atthe beginning of the curve.

- Kink

  Changes the shape that the particles can take:

- Curl

  The radius of the influence depends on the distance of the curve to the emitter.

- Radial

  A three dimensional, standing wave.

- Wave

  A two dimensional, standing wave.

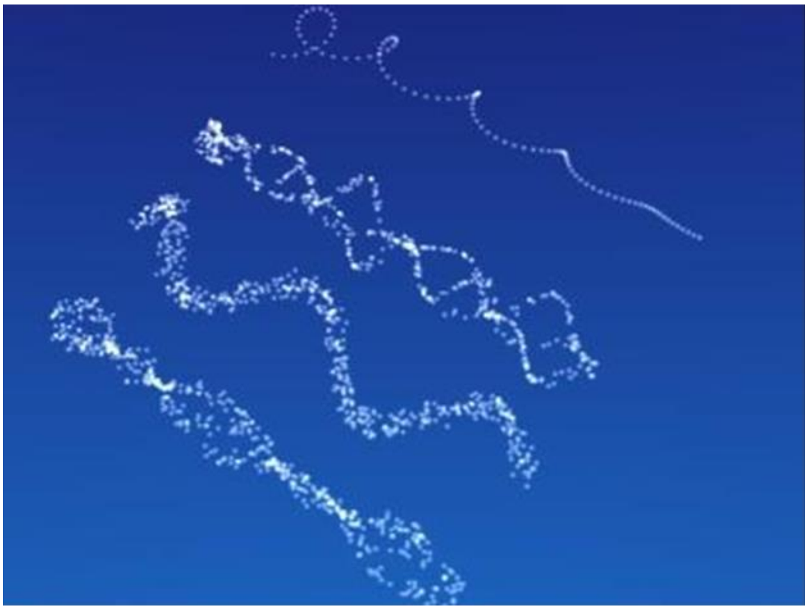
- Braid

  Pattern that follows along the curve.

- Roll

  A one dimensional, standing wave.

It is not so easy to describe the resulting shapes, so have a look atthe example below.



Title-Img. 1. 21 Kink options of a curve guide. From left to right:Radial, Wave, Braid, and Roll.
Attribution-Source-
***Link-*[*https://docs.blender.org/manual/en/dev/physics/force_fields/types/curveguide.html*](https://docs.blender.org/manual/en/dev/physics/force_fields/types/curveguide.html)**

- Frequency

The frequency of the offset.

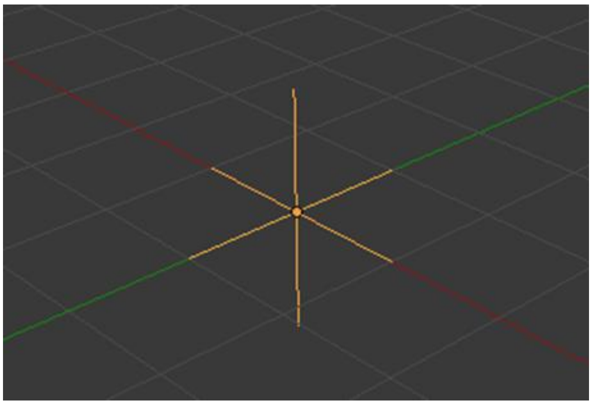
- Shape

Adjust the offset to the beginning/end.

- Amplitude

The Amplitude of the offset.

Boid

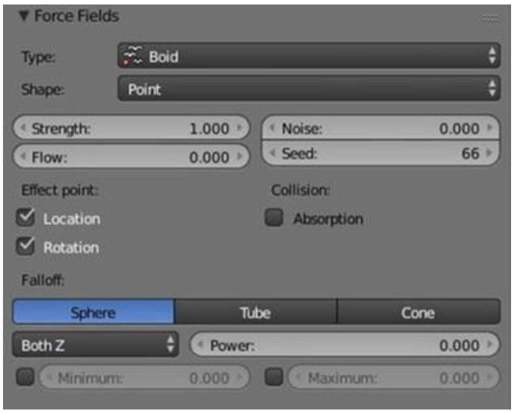


Title-Img. 1. 22Boid force field.

Attribution-Source-
Link- [https://docs.blender.org/manual/en/dev/physics/force_fields/types/boid.ht ml](https://docs.blender.org/manual/en/dev/physics/force_fields/types/boid.html)

Boid probably comes from **theoretical works**. *Boids* is an **artificial life program**, developed by

Craig Reynolds (1986), which simulates the flocking behavior of birds. His paper on this topic was published in 1987 in the proceedings of the ACM SIGGRAPH conference. The name refers to a "**bird-like object**", However, its pronunciation evokes that of "bird" in a stereotypical New York accent. As with most artificial life simulations, **Boids** is an example of **emergent behavior**; that is, the complexity of Boids arises from the interaction of individual agents (the Boids, in this case) adhering to a set of simple rules.



Title-Img. 1. 23UI for a Boid force field.
Attribution-
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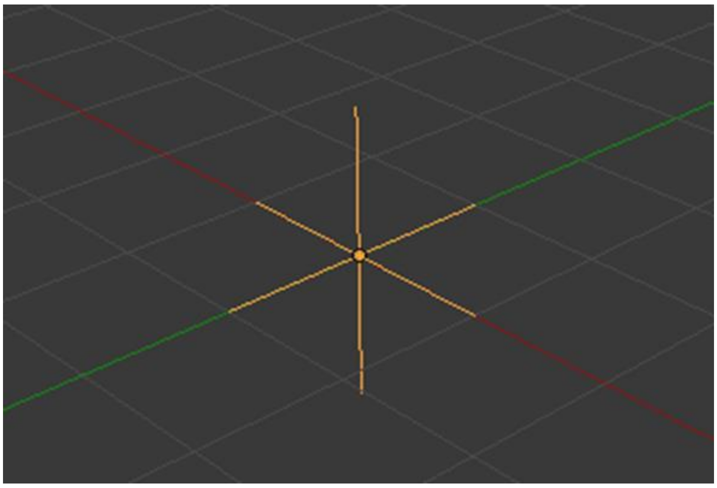
Link- [**https://docs.blender.org/manual/en/dev/physics/force_fields/types/boid.ht ml**](https://docs.blender.org/manual/en/dev/physics/force_fields/types/boid.html)

The rules applied in the simplest Boids world are as follows:

- **Separation:** steer to avoid crowding local flock mates
- **Alignment:** steer towards the average heading of localflock mates
- **Cohesion:** steer to move toward the average position(center of mass) of local flock mates

More complex rules can be added, such as obstacle avoidance andgoal seeking.

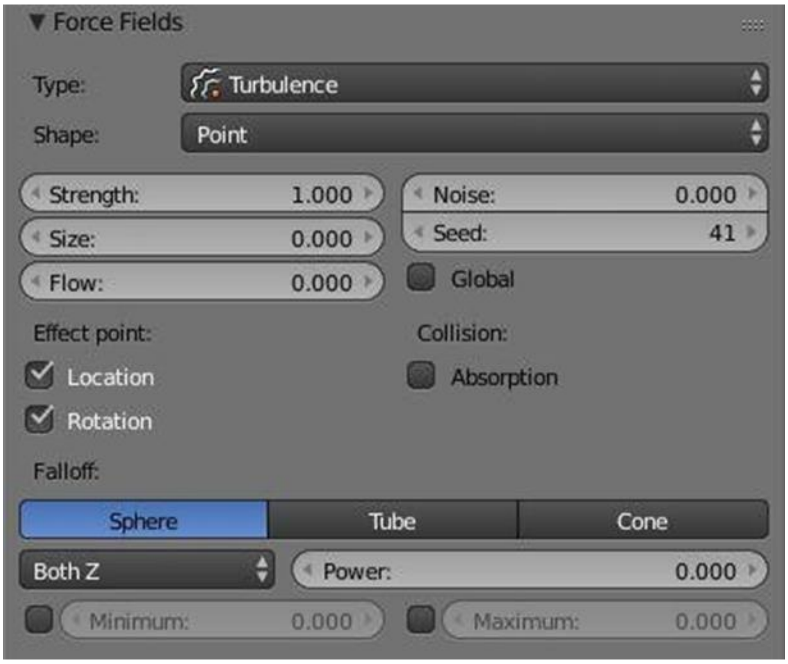
Turbulence



Title-Img. 1. 24Turbulence force field.

Attribution-
Source-
Link- **https://docs.blender.org/manual/en/dev/physics/force_fields/types/turbule nce.html**

A *Turbulence* force field creates a **random & chaotic 3D noise** effect, similar to jets of water or geysers under the ocean.



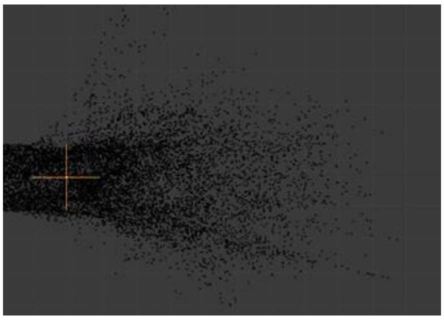
Title-Img. 1. 25UI for a Turbulence force field.
Attribution-
Source-
Link **https://docs.blender.org/manual/en/dev/physics/force_fields/types/turbule nce.html**

- Size

  Indicates the scale of the noise.

- Global

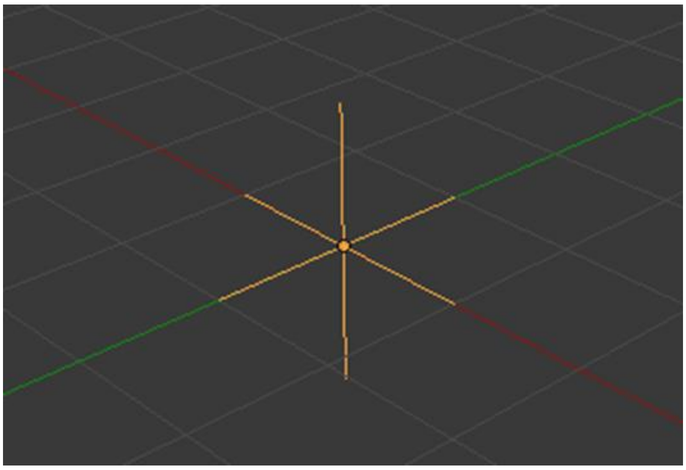
  Makes the size and strength of the noise relative to theworld, instead of the object it is attached to.



Title-Img. 1. 26 Turbulence force field affecting a particle system.

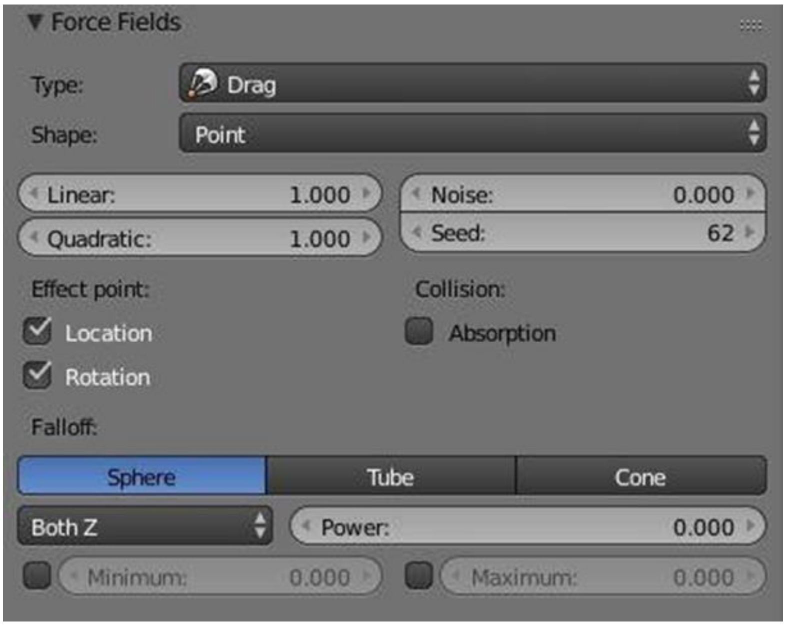
Attribution-Source-
Link-https://docs.blender.org/manual/en/dev/physics/force_fields/types/turbulence.html

Drag



Title-Img. 1. 27Drag force field.
Attribution-Source-
Link-https://docs.blender.org/manual/en/dev/physics/force_fields/types/drag.ht ml

A *Drag* force field resists **particle motion** by slowing it down.



Title-Img. 1. 28UI for a Drag force field.
Attribution-Source-
Link- https://docs.blender.org/manual/en/dev/physics/force_fields/types/drag.ht ml

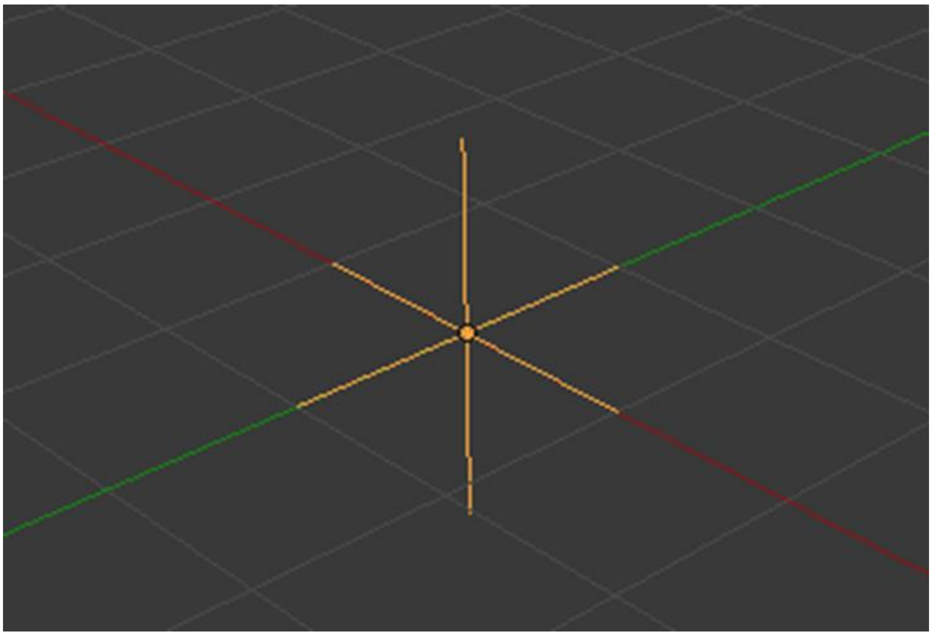
- Linear

Drag component proportional to velocity.

- Quadratic

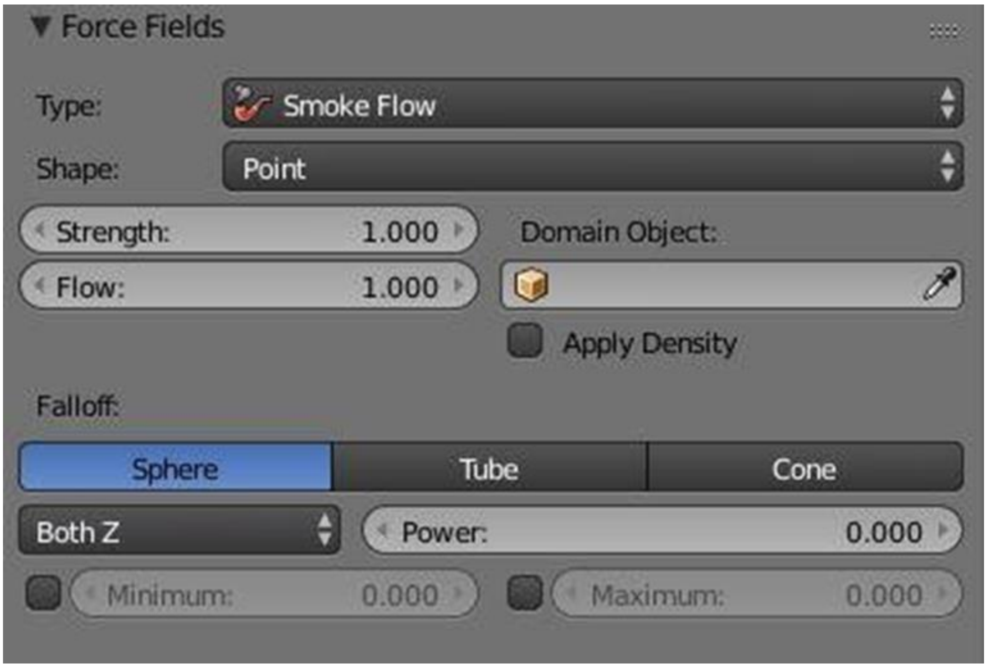
Drag component proportional to the square of the velocity.

Smoke Flow



Title-Img. 1. 29Smoke Flow force field.
Attribution-
Source-
Link-https://docs.blender.org/manual/en/dev/physics/force_fields/types/smoke_ flow.html

A *Smoke Flow* force field directs the **smoke within a smoke** simulation.



Title-Img. 1. 30UI for a Smoke Flow force field.
Attribution-
Source-
Link-https://docs.blender.org/manual/en/dev/physics/force_fields/types/smoke_flow.html

Unit summary

In this Unit, you have learnt what is Physical Simulation and Gravity and how to

- Use the real-world simulation effects in your 3D Projects likeDust, Smoke, Rain, Fire, Water etc.
- Use the force fields in your 3D simulation project.
- Apply Gravity in 3D Simulation using Rigid Body and Soft Body.

After learning this Unit, you can download the Open Source Software available on the internet for free of cost to practice the possibilities of creating 3D Interface.

Assignment

- Learners are expected to experiment the force fields options / setups and parameters available in the panel and to experiment the way the physical simulation works for different force fields from the links.

Assessment

- Describe Force Fields with examples.
- Define Magnetic Force Field.
- Explain Harmonic Force Field with examples.
- Define Charge Filed.
- Explain the Process of using curve as a guide in Force Field.
- Define Boid Field?
- List down the effects Turbulence filed can create.

Fill in the Blanks

1. Default value of Gravity in Blender is_____________.
2. Baking refers to the act of______________the results of acalculation
3. Force Fields can also be generated from_________.
4. Field with positive strength can be used as a____________.
5. A field with negative strength can be used as___________.

Resources

While studying this Unit, you can browse the following internet links for online video tutorials and several books and training DVDsavailable in the Blender Store and on the Blender Cloud.

- wiki.blender.org
- ia600207.us.archive.org
- archive.org
- www.blender.org
- docs.blender.org

Links to download 3D Files for practice

1. https://en.wikibooks.org/wiki/Blender_3D:_Noob_to_Pro/P articles_forming_Shapes
2. https://cloud.blender.org/training

Unit-2 Introduction to Rigid Body, Soft Body and Constraints

Introduction

In this Unit, you will be introduced to a **Rigid Body** which is an idealization of a **Solid Body** in which deformation is neglected. In other words, the distance between any two given points of a Rigid Body remains constant in time regardless of external forces exerted on it and Soft-body dynamics that it is a field of computer graphics that focuses on visually realistic physical simulations of the motion and properties of deformable objects (or soft bodies).

You will also learn the different types of constraints available in **Blender** to control both **Rigid and Soft Body**.

Outcomes

Upon completion of this unit you will be able to:

- Create Passive Body and Active Body
- Demonstrate the utility of Rigid Body
- Use Multiple constraints
- Practice Soft Body animation
- Use constraints to control dynamic animation
- Reuse simulation as cache

Terminology

Active	:	Object is directly controlled by simulation results. One can select Active type with *Add Active* Button in the *Physics* tab of the *Tool Shelf*.
Passive	:	Enables/disables Rigid Body simulation for object.
Dynamic	:	Enables/disables Rigid Body simulation for object.
Animated	:	Allows the Rigid Body additionally to becontrolled by the animation system.
Mass	:	Specifies how heavy the object is and "weights" irrespective of gravity. There is predefined mass preset available with the *Calculate Mass* Button in the *Physics* tab of the *Tool Shelf*..

Rigid Body

The Rigid Body simulation can be used to **simulate the motion of solid objects**. It affects the **position** and **orientation** of objects anddoes **not deform** them.

Unlike the other simulations in Blender, the Rigid Body simulation works closer with the animation system. This means that rigidbodies can be used like **regular objects** and be part of **parent-child relationships**, **animation constraints and drivers**.

Title-Img. 2. 1Create Rigid Body.

Attribution-

Source-

Link-https://docs.blender.org/manual/en/dev/physics/rigid_body/properties.html

Right now, only mesh objects can participate in the Rigid Bodysimulation.

To create Rigid Bodies,

- **Step 1:** Either click on ***Rigid Body*** **Button** in the *Physics* tabof the Properties editor
- **Step 2:** Or use *Add Active*/*Add Passive* buttons in the *Physics* tab of the *Tool Shelf*.

There are **two types of Rigid Body**:

1. Active 2. Passive

Active **bodies** are dynamically simulated, **Passive bodies** remain static. Both types can be driven by the animation system when using the ***Animated*** **option**.

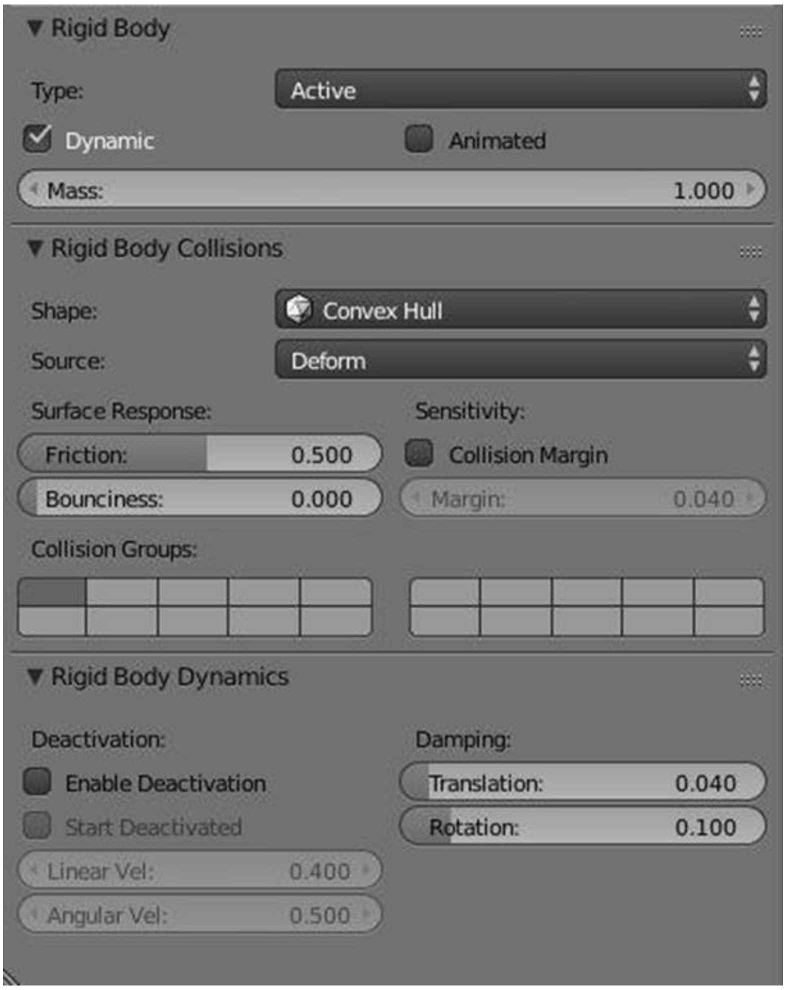
During the simulation, the Rigid Body system will **override** the position and orientation of dynamic Rigid Body objects. Note however, that the location and rotation of the objects is not changed, so the Rigid Body simulation acts similar to a **constraint**.

To apply the Rigid Body transformations, you can use the ***Apply Transformation*** **Button** in the *Physics* tab of the *Tool Shelf*.

The scale of the Rigid Body object also influences the simulation, however, is always controlled by the animation system.

Rigid Body physics on the object can be ***removed*** with the ***Rigid Body* Button** in the *Physics* tab or *Remove* Button in the *Physics* tab of the *Tool Shelf*.

Properties of Rigid Body



Title-Img. 2. 2 Default Rigid Body panel.

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Link- https://docs.blender.org/manual/en/dev/physics/rigid_body/properties.html

These are

- Type

Role of the Rigid Body in the simulation. **Active objects** can be simulated **dynamically,** whereas **Passive object** remain **static**.

- Active

Object is directly controlled by simulation results. The possibility to select this type also available with ***Add Active* Button** in the *Physics* tab of the *Tool Shelf*.

- Passive

Object is directly controlled by animation system. Thus,this type is not available for Rigid Body Dynamics. The possibility to select this type also available withAdd Passive Button in the Physics tab of the Tool Shelf.

- Dynamic

Enables/disables Rigid Body simulation for object.

- Animated

Allows the Rigid Body additionally to be controlled by the animation system.

- Mass

Specifies how heavy the object is and “weights”irrespective of gravity. There is predefined mass preset available with the ***Calculate Mass* Button** in the *Physics* tabof the *Tool Shelf*.

- Calculate Mass

Automatically calculate mass values for Rigid Body Objects based on volume. There are many useful presets available from the menu, patching real-world objects.

- Note

Also, you can have *Custom* mass material type, which is achieved by setting a custom density value (kg/m^3).

Rigid Body Collisions

Rigid Body Collisions panel.

Collision shapes

The *Shape* option determines the collision shape of the object. Thefollowing Collision Shapes are available:

Primitive shapes

these are best in terms of memory/performance however, do not necessarily reflect the actual shape of the object. They are calculated based on the object’s bounding box. The center of gravity is always in the middle for now.

- **Box**

Box-like shapes (i.e. cubes), including planes (i.e. ground planes). The size per axis is calculated from the bounding box.

- Sphere

Sphere-like shapes. The radius is the largest axis of the bounding box.

- Capsule

This points up the Z-Axis.

- Cylinder

This points up the Z-Axis. The height is taken from the z- axis, while the radius is the larger of the x/y-axes.

- Cone

This points up the Z-Axis. The height is taken from the z- axis, while the radius is the larger of the x/y-axes.

Mesh based shapes

These are calculated based on the geometry of the object so they are a better representation of the object. The center of gravity for these shapes is the object origin.

- Convex Hull

A mesh-like surface encompassing (i.e. shrink-wrap over)all vertices (best results with fewer vertices). Convex approximation of the object, has good performance and stability.

- Mesh

Mesh consisting of triangles only, allowing for more detailed interactions than convex hulls. Allows to simulate concave objects, however, is rather slow and unstable.

The changing collision shape is available also with ***Change Shape*** **Button** in the *Physics* tab of the *Tool Shelf*.

Mesh source

Users can now specify the mesh *Source* for *Mesh* bases collisionshapes:

- Base

The base mesh of the object.

- Deform

Includes any deformations added to the mesh (shape keys,deform modifiers).

Deforming

Rigid Body deforms during simulation.

- Final

Includes all modifiers.

General settings

- Surface Response

Friction

Resistance of object to movement. Specifies how muchvelocity is lost when objects collide with each other.

Bounciness

Tendency of object to bounce after colliding with another (0 to 1) (rigid to perfectly elastic). Specifies how much objects can bounce after collisions.

- Collision Groups

Allows Rigid Body collisions allocate on different groups (maximum 20).

Collision Margin

Margin

Threshold of distance near surface where collisions are stillconsidered (best results when non-zero).

The collision margin is used to improve performance and stability of rigid bodies. Depending on the shape, it behaves differently: some shapes embed it, while others have a visible gap around them.

The margin **is *embedded*** for these shapes:

- Sphere

- Box
- Capsule
- Cylinder
- Convex Hull: Only allows for uniform scale when embedded.

The margin **is *not embedded*** for these shapes:

- Cone
- Active Triangle Mesh
- Passive Triangle Mesh: Can be set to 0 most of the time.

Rigid Body Dynamics

Used to control the physics of the rigid body simulation. Rigid BodyDynamics panel.

This panel is available only for ***Active* type** of rigid bodies.

Deactivation

- Enable Deactivation

Enable deactivation of resting rigid bodies. Allows object tobe deactivated during the simulation (improves performance and stability, however, can cause glitches).

- Start Deactivated

Starts objects deactivated. They are activated on collision with other objects.

- Linear Velocity

Specifies the linear deactivation velocity below which the Rigid Body is deactivated and simulation stops simulating object.

- Angular Velocity

Specifies the angular deactivation velocity below which theRigid Body is deactivated and simulation stops simulating object.

Damping

A reduction in the amplitude of an oscillation as a result of energy being drained from the system to overcome frictional or other resistive forces

- Translation

Amount of linear velocity that is lost over time.

- Rotation

Amount of angular velocity that is lost over time.

Rigid Body World

Rigid Body objects and constraints are only taken into account by the simulation if they are in the groups specified in *Group* field of the *Rigid Body World* panel in the *Scene* tab.

- Rigid Body World

Enable/disable evaluation of the Rigid Body simulation based on the Rigid Body objects participating in the specified group of Rigid Body World.

- **Remove Rigid Body World**

Remove Rigid Body simulation from the current scene.

- Group

Containing Rigid Body objects participating in this simulation.

- Constraints

Containing Rigid Body object constraints participating inthe simulation.

Simulation quality and timing settings:

- Speed

Can be used to speed up/slow down the simulation.

- Split Impulse

Enable/disable reducing extra velocity that can build up when objects collide (lowers simulation stability a little so use only when necessary). Limits the force with which objects are separated on collision, generally produces nicerresults, however, makes the simulation less stable (especially when stacking many objects).

- Steps Per Second

Number of simulation steps made per second (higher values are more accurate however, slower). This only influences the accuracy and not the speed of the simulation.

- Solver Iterations

Amount of constraint solver iterations made per simulationstep (higher values are more accurate however, slower). Increasing this makes constraints and object stacking more stable.

Rigid Body Cache

The *Rigid Body Cache* panel specifies the frame range in which thesimulation is active. Can be used to bake the simulation.

- Start/End

First and last frame of the simulation.

- Bake

Calculates the simulation and protects the cache. You needto be in *Object Mode* to bake.

- Free Bake

Active after the baking of simulation. Clears the baked cache.

- Calculate to Frame

Bake physics to current frame.

- Current Cache to Bake

Bake from Cache.

- Bake All Dynamics

Bake all physics.

- Free All Bakes

Free all baked caches of all objects in the current scene.

- Update All to Frame

Update cache to current frame.

If you haven't saved the blend-file, the cache is created in memory, so save your file first or the cache may be lost.

Rigid Body Field Weights

As other physics dynamics systems, Rigid Body simulation are also influenced by external force effectors.

Rigid Body Constraints

Constraints (also known as Joints) for rigid bodies **connect two Rigid Bodies**.

The physics constraints available in the non-game modes are meant to be attached to an Empty object. The constraint then hasfields which can be pointed at the two physics-enabled objectwhich will be bound by the constraint. The *Empty* object providesa location and axis for the constraint distinct from the two constrained objects. The location of the entity hosting the physics constraint marks a location and set of axes on each of the two constrained objects. These two anchor points are calculated at thebeginning of the animation and their position and orientation remain fixed in the *local* coordinate system of the object for the duration of the animation. The objects can move far from the constraint object; however, the constraint anchor moves with the object. If this feature seems limiting, consider using multiple objects with a non-physics *Child-of* constraint and animate the relative location of the child.

Connect

The quickest way to constrain two objects is to select both and click the ***Connect*** **Button** in the *Physics* tab of the *Tool Shelf*. This creates a new *Empty* object (named “Constraint”) with a physics constraint already attached and pointing at the two selected objects.

Physics Tab

Also, you can create *Rigid Body Constraint* on of the two constrained objects with ***Rigid Body Constraint*** **Button** of the *Physics* tab in the Properties editor. This constraint is dependent on the object location and rotation on which it was created. This way, there are no *Empty* object created for the constraint. Therole of the *Empty* object is put on this object. The constrained object can be then set as *Passive* type for better driving the constrain.

Additional parameters appear in the *Rigid Body Constraint* panel of the *Physics* tab in the Properties editor for the selected *Empty* object or the one of the two constrained objects with the created constraint.

Common Options

Rigid Body Constraint panel.

- Enabled

  Specifies whether the constraint is active during the simulation.

- Disable Collisions

Allows constrained objects to pass through one another.

- Object 1

First object to be constrained.

- Object 2

Second object to be constrained.

- Breakable

Allows constraint to break during simulation. Disabled forthe *Motor* constraint.

- Threshold

Impulse strength that needs to be reached beforeconstraint breaks.

- Override Iterations

Allows to make constraints stronger (more iterations) or weaker (less iterations) than specified in the Rigid Body world.

- Iterations

Number of constraint solver iterations made per simulationstep for this constraint.

- Limits

By using limits, you can constrain objects even more by specifying a translation/rotation range on/around respectively axis (see below for each one individually). To lock one axis, set both limits to 0

Soft Body

A Soft Body in general, is a simulation of a **soft or rigid deformableobject**. In Blender, this system is best for simple **cloth objects and closed meshes**. There is dedicated Cloth Simulation physics that use a different solver, and is better for cloth.

This simulation is done by applying forces to the vertices or control points of the object. There are exterior forces like gravityor force fields and interior forces that hold the vertices together. This way you can simulate the shapes that an object would take onin reality if it had volume, was filled with something, and was acted on by real forces.

Soft Bodies can interact with other objects **through*Collision*.** They can interact with themselves through ***Self Collision***.

The result of the Soft Body simulation can be converted to a **static object**. You can also ***bake edit*** the simulation, i.e. edit intermediate results and run the simulation from there.

Typical scenarios for using Soft Bodies

Title-Img. 2. 3 A wind cone. The cone is a Soft Body, as the suspension.

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https://docs.blender.org/manual/en/dev/physics/soft_body/introduction.html?highlight=wind%20cone%20cone%20soft%20body%20suspension

Soft Bodies are well suited for:

- Elastic objects with or without collision.
- Flags, fabric reacting to forces.
- Certain modeling tasks, like a cushion or a table cloth overan object.
- Blender has another simulation system for clothing. However, you can sometimes use Soft Bodies for certain parts of clothing, like wide sleeves.
- Hair (as long as you minimize collision).
- Animation of swinging ropes, chains and the like.

Creating Soft Body

Soft Body simulation works for all objects that have vertices or control points:

- Meshes.

- Curves.
- Surfaces.
- Lattices.

To activate the Soft Body simulation for an object:

- **Step 1:** In the Properties editor, go to the *Physics* tab (itis all the way on the right, and looks like a bouncing ball).
- **Step 2:** Activate the *Soft Body* button.
- **Step 3:** You start a Soft Body simulation with Alt-A.
- **Step 4:** You pause the simulation with Spacebar, continue with Alt-A.
- **Step 5:** You stop the simulation with Esc.

Simulation Quality

The settings in the *Soft Body Solver* panel determine the accuracy of the simulation.

- Min Step

Minimum simulation steps per frame. Increase this value, if the Soft Body misses fast moving collision objects.

- Max Step

Maximum simulation steps per frame. Normally the number of simulation steps is set dynamically (with the *Error Limit*) however, you have probably a good reason to change it.

- Auto-Step

Use Velocities for automatic step sizes.

- **Error Limit**

Rules the overall quality of the solution delivered, default value is 0.1. The most critical setting that says how precise the solver should check for collisions. Start with a valuethat is 1/2 the average edge length. If there are visible errors, jitter, or over-exaggerated responses, decrease the value. The solver keeps track of how “bad” it is doing and the Error Limit causes the solver to do some “adaptive step sizing”.

- Fuzzy

Simulation is faster, however, less accurate.

- Choke

Calms down (reduces the exit velocity of) a vertex or edge once it penetrates a collision mesh.

Diagnostics

- **Print Performance to Console**

Prints on the console how the solver is doing.

- Estimate Matrix

Estimate matrix. Split to COM, ROT, SCALE

Cache and Bake

Soft Bodies and other physic simulations use a **unified system** for caching and baking.

The results of the simulation are automatically cached to disk when the animation is played, so that the next time it runs, it can play again quickly by reading in the results from the disk. If you ***Bake* the simulation,** the cache is protected and you will be asked when you are trying to change a setting that will make a recalculating necessary.

Caching

- As animation is played, each physics system writes each frame to disk, between the simulation start and end frames. These files are stored in folders with prefix blend cache, next to the blend-file.
- The cache is cleared automatically on changes. However, not on all changes, so it may be necessary to free it manually, e.g. if you change a force field. Note that for the cache to fill up, one must start playback before or on the frame that the simulation starts.
- If you are not allowed to write to the required sub- directory caching will not take place.
- The cache can be freed per physics system with a Button in the panels, or with the Ctrl-B shortcut key to free it for all selected objects.
- You may run into trouble if your blend-file path is very long and your operating system has a limit on the path length that is supported.

Baking

- The system is protected against changes after baking.

- The *Bake* result is cleared also with Ctrl-B for all selected objects or click on *Free Bake* for the current Soft Body system.
- If the mesh changes the simulation is not calculated anew.
- For render farms, it is best to bake all the physics systems, and then copy the blend cache to the render farm as well.

Interaction in real time

To work with a **Soft Body simulation**, you will find it handy to use the **Timeline editor**. You can change between frames and thesimulation will always be shown in the actual state. The option ***Continue Physics*** in the *Playback* menu of the ***Timeline* editor** lets you interact in real time with the simulation, e.g. by moving collision objects or shake a Soft Body object. If the objects have an even vertex distribution then the Soft Bodieswork especially well. You need enough vertices for good collisions.You change the deformation (the stiffness) if you add more vertices in a certain region.

The calculation of collisions may take a long time. If something is not visible, why calculate it?

To speed up the collision calculation it is often useful **to collide with an additional, simpler, invisible, somewhat larger object.**

Use Soft Bodies only where it makes sense. If you try to cover a body mesh with a tight piece of cloth and animate solely with Soft Body, you will have no success. Self-collision of Soft Body hair may be activated, however, that is a path that you must wander alone. We will deal with Collisions in detail later.

Try and use a ***Lattice* or a *Curve Guide* Soft Body** instead of the object itself. This may be magnitudes faster.

Simple Example

Here are some simple examples showing the power of Soft Body physics.

Bouncing Cube

The Process

Title-Img. 2. 4 The timeline.

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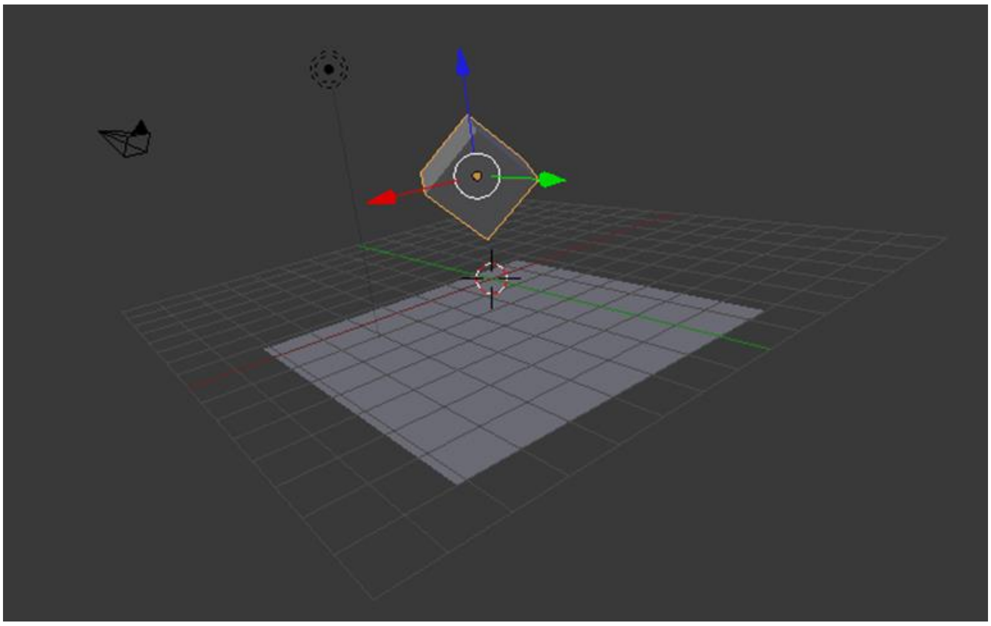
Link-https://docs.blender.org/manual/en/dev/physics/soft_body/examples.html?hig hlight=bouncing%20cube

- Step 1: First, change your start and end frames to 1 and 150.
- Step 2: Then, add a plane, and scale it five times.
- Step 3: Next, go to the physics tab, and add a collision. Thedefault settings are fine for this example.
- Step 4: Now add a cube, or use the default cube.
- Step 5: Tab into edit mode and subdivide it three times.
- Step 6: Add a bevel modifier to it to smoothen the edges.
- Step 7: Add a little more, press r twice, and move yourcursor a bit.

When finished, your scene should look like this:



Title-Img. 2. 5 The scene, ready for Soft Body physics.

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https://docs.blender.org/manual/en/dev/physics/soft_body/examples.html? highlight=bouncing%20cube

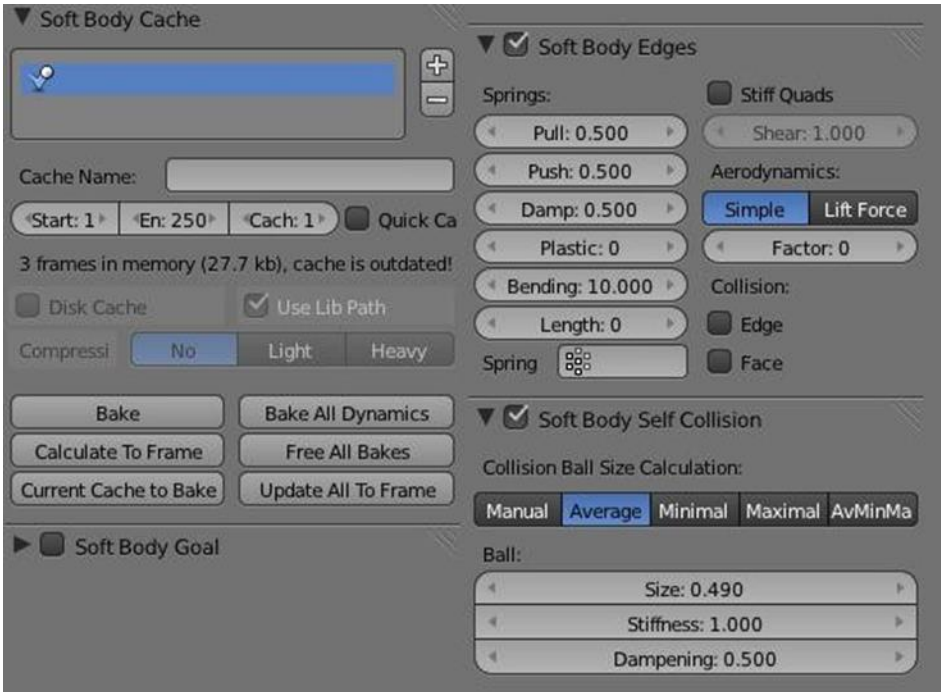
Everything is ready to add the Soft Body physics.

- **Step 1:** Go to Properties ‣ Physics and choose *Soft Body*.
- **Step 2:** Uncheck the Soft Body goal, and check Soft Body self-collision.
- **Step 3:** Also, under Soft Body edges, increase the bending to 10.
- **Step 4:** Playing the animation with Alt-A will now give a slow animation of a bouncing

cube.

- **Step 5:** To speed things up, we need to bake the Soft Body physics.
- **Step 6:** Under *Soft Body Cache*, change the start and end values to your start and end frames. In this case 1 and 150.
- **Step 7:** Now, to test if everything is working, you can take acache step of 5 or 10, however, for the final animation it is better to reduce it to 1, to cache everything.

When finished, your physics panel should look like this:



Title-Img. 2. 6 The physics settings.

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Link-https://docs.blender.org/manual/en/dev/physics/soft_body/examples.html?highlight=bouncing%20cube

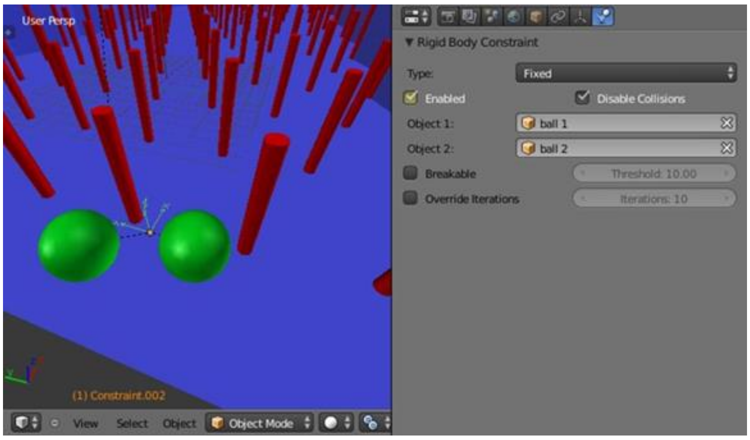
You can now bake the simulation, give the cube materials andtextures and render the animation.

The Result

The rendered bouncing cube:

Rigid Body Constraint Types

Fixed Constraint



Title-Img. 2. 7 Options available to a Fixed constraint.

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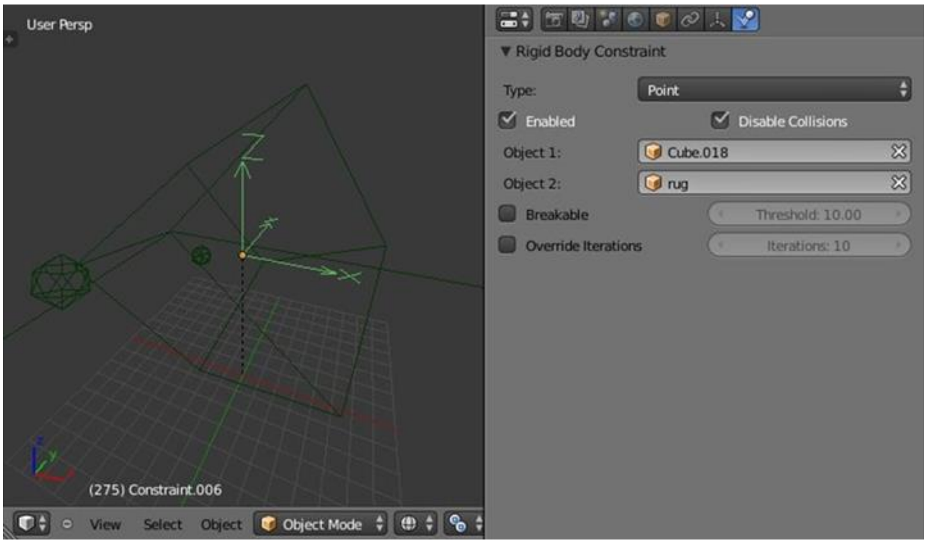
https://docs.blender.org/manual/en/dev/physics/rigid_body/constraints/types/fixed.html?highlight=options%20available%20fixed%20constraint

This constraint causes the **two objects to move as one**. Since the physics system does have a tiny bit of slop in it, the objects do not move as rigidly as they would if they were part of the same mesh.

Point Constraint



Title-Img. 2. 8 Options available to a Point constraint.

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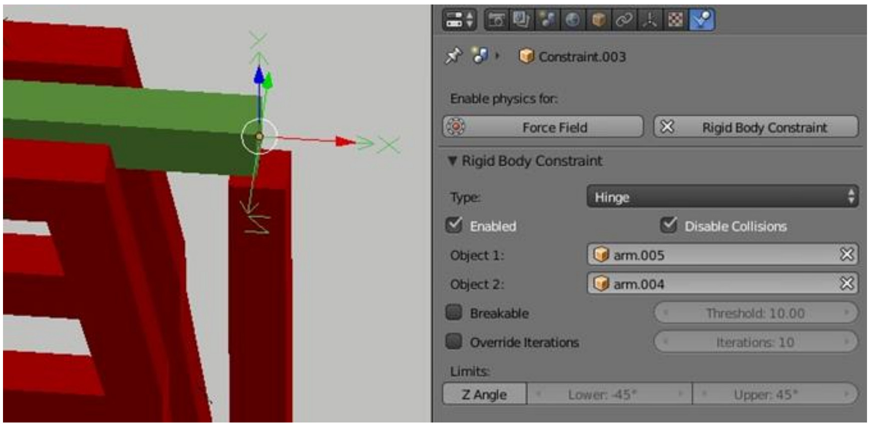
Link-https://docs.blender.org/manual/en/dev/physics/rigid_body/constraints/types/point.html

The objects are linked by a point bearing allowing any kind of rotation around the location of the constraint object, however, no relative translation is permitted. The physics engine will do its best to make sure that the two points designated by the constraint object on the two constrained objects are coincident

Hinge



Title- Img. 2. 9 Options available to a Hinge constraint.

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Link-https://docs.blender.org/manual/en/dev/physics/rigid_body/constraints/types/hinge.html

The Hinge permits **1 degree of freedom between two objects**. Translation is completely constrained. Rotation is permitted about the **Z axis** of the object hosting the Physics constraint (usually an Empty, distinct from the two objects that are being linked). Adjusting the position and rotation of the object hosting the constraint allows you to control the anchor and axis of the hinge.

The Hinge is the only **1-axis** rotational constraint that uses the **Z axis** instead of the **X axis**. If something is wrong with your hinge, check your other constraints to see if this might be the problem.

Options - Limits

- **Z Angle**

Enables/disables limit rotation around Z axis.

- Lower

Lower limit of Z axis rotation.

- Upper

Upper limit of Z axis rotation.

Slider Constraint

The Slider constraint allows relative translation along the **X axis** of the constraint object, however, permits no relative rotation, or relative translation along other axes.

Options - Limits

- **X Axis**

Enables/disables limit translation around X axis.

- Lower

Lower limit of X axis translation.

- Upper

Upper limit of X axis translation

Piston Constraint

A piston permits translation along the X axis of the constraint object. It also allows rotation around the X axis of the constraint object. It is like a combination of the freedoms of a slider with the freedoms of a hinge (neither of which is very free alone).

Options - Limits

- **X Axis**

Enables/disables limit translation around X axis.

- Lower

Lower limit of X axis translation.

- Upper

Upper limit of X axis translation.

- X Angle

Enables/disables limit rotation around X axis.

- Lower

Lower limit of X axis rotation.

- Upper

Upper limit of X axis rotation

Generic Constraint

The generic constraint has a lot of available parameters.

The **X, Y, and Z axis** constraints can be used to limit the amount of translation between the objects. Clamping the min/max to zero has the same effect as the Point constraint.

Clamping the relative rotation to **zero** keeps the objects in alignment. Combining an absolute rotation and translation clamp would behave much like the **Fixed constraint**.

Using a **non-zero spread** on any parameter allows it to rattle around in that range throughout the course of the simulation.

Options - Limits

- **X Axis/Y Axis/Z axis**

Enables/disables limit translation on X, Y or Z axisrespectively.

- Lower

Lower limit of translation for X, Y or Z axis respectively.

- Upper

Upper limit of translation for X, Y or Z axis respectively.

- X Angle/Y Angle/Z Angle

Enables/disables limit rotation around X, Y or Z axisrespectively.

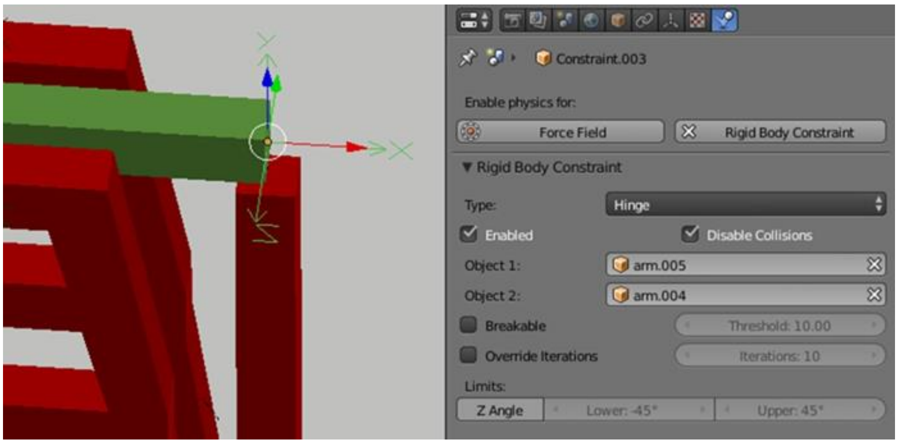
- Lower

Lower limit of rotation for X, Y or Z axis respectively.

- Upper

Upper limit of rotation for X, Y or Z axis respectively.

Generic Spring Constraint



Title-Img. 2. 10 Options available to a Generic Spring constraint.

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https://docs.blender.org/manual/en/dev/physics/rigid_body/constraints/types/generic_spring.html

The generic spring constraint adds some spring parameters for the**X/Y/Z axes** to all the options available on the Generic constraint. Using the spring alone allows the objects to bounce around as if attached with a spring anchored at the constraint object. This is usually a little too much freedom, so most applications will benefitfrom enabling translation or rotation constraints.

If the damping on the springs is **set to 1,** then the spring forces areprevented from realigning the anchor points, leading to strange behavior. If your springs are acting weird, check the damping.

Options - Limits

- **X Axis/Y Axis/Z axis**

Enables/disables limit translation on X, Y or Z axisrespectively.

- Lower

Lower limit of translation for X, Y or Z axis respectively.

- Upper

Upper limit of translation for X, Y or Z axis respectively.

- X Angle/Y Angle/Z Angle

Enables/disables limit rotation around X, Y or Z axisrespectively.

- Lower

Lower limit of rotation for X, Y or Z axis respectively.

- Upper

Upper limit of rotation for X, Y or Z axis respectively.

Options - Springs

- **X/Y/Z**

Enables/disables springs on X, Y or Z axis respectively.

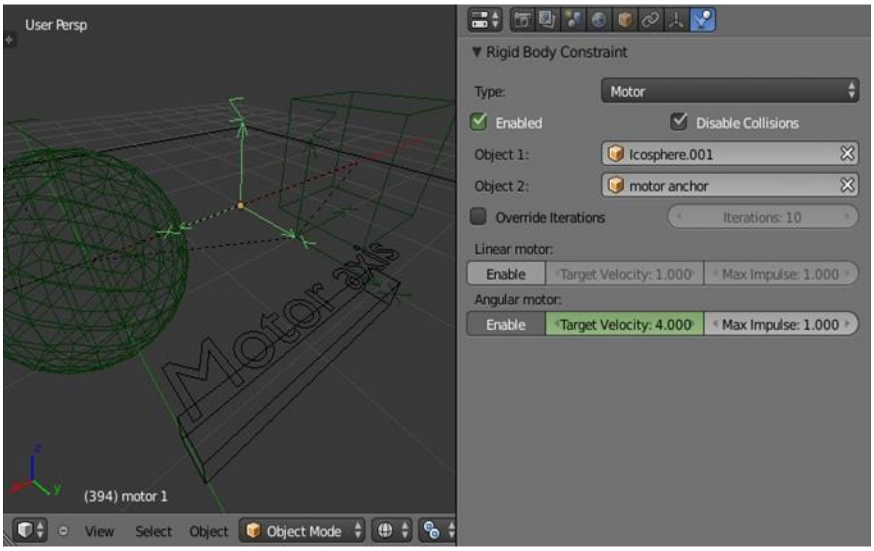
- Stiffness

Spring Stiffness on X, Y or Z axis respectively. Specifies how“bendy” the spring is.

- Damping

Spring Damping on X, Y or Z axis respectively. Amount ofdamping the spring has.

Motor Constraint



Title-Img. 2. 2Options available to a Motor constraint.

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Link-https://docs.blender.org/manual/en/dev/physics/rigid_body/constraints/types/motor.html

The motor constraint causes translation and/or rotation between two entities. It can drive **two objects apart or together**. It can drive simple rotation, or rotation and translation (although it will not be constrained like a screw since the translation can be blocked by other physics without preventing rotation).

The rotation axis is the **X axis** of the object hosting the constraint. This is in contrast with the Hinge which uses the **Z axis**. Since the Motor is vulnerable to confusing perturbations without a matching

Hinge constraint, special care must be taken to align the axes. Without proper alignment, the motor will appear to have no effect(because the Hinge is preventing the motion of the motor).

Options - Linear motor/Angular motor

- **Enable**

  Enable linear or angular motor respectively.

- Target Velocity

  Target linear or angular motor velocity respectively.

- Max Impulse

  Maximum linear or angular motor impulse respectively.

Animation

The most common trick is to **key frame animate** the location or rotation of an *Active* physics object as well as the *animated* checkbox. When the curve on the *animated* property switches to disabled, the physics engine takes over using the object's last known location, rotation and velocities.

Animating the strengths of various other parameters (a Motor's Target Velocity, a Hinge's limits, etc.) can be used to accomplish a wide variety of interesting results.

Enabling a constraint during the **physics simulation** often has dramatic results as the physics engine tries to bring into alignmenttwo objects which are often dramatically out of alignment. It is very common for the affected objects to build up enough **kinetic energy** to bounce themselves out of camera (and into orbit, although the physics engine is not yet capable of simulating aplanet's gravity well, so scratch that). Rigid Body dynamics can be **baking to normal keyframes** with *Bake to **Keyframes*** **Button** in the *Physics* tab of the *Tool Shelf*.

Simulation Stability

The simplest way of improving simulation stability is to **increase the steps per second**. However, care must be taken since making too many steps can cause problems and make the simulation even less stable (if you need **more than 1000 steps**, you should look at other ways to improve stability).

Increasing the number of solver iterations helps making constraints stronger and also improves object stacking stability.

It is best to **avoid small objects**, as they are currently unstable. Ideally, objects should be at **least 20 cm in diameter**. If it is still necessary, setting the **collision margin to 0**, while generally not recommended, can help making small object behave more naturally. When objects are small and/or move very fast, they can pass through each other. Besides what is mentioned above it's also good to **avoid using mesh shapes** in this case. Mesh shapes consist of individual triangles and therefore do not really have any thickness, so objects can pass through more easily. You can give them some thickness by **increasing the collision margin.**

Combining Rigid Bodies with Other Simulations

Since the Rigid Body simulation is part of the animation system, itcan influence other simulations just like the animation system can.

In order for this to work, the Rigid Body object needs to have a **Collision Modifier.** Simply click on ***Collision*** in the *Physics* tab.

Scaling Rigid Bodies

Rigid Body objects can be scaled, also during the simulation. Thiswork well in most cases, however, can sometimes cause problems.

If dynamic scaling is not needed, Rigid Body objects should havethe scale applied by using the ***Apply Scale*** **Command Ctrl-A.**

Unit summary

In this Unit, you have learnt what is Rigid Body and Soft Body and how to

- Use the Constraints to control the dynamic motion of the Activeand Passive bodies in real time.
- Create different type of dynamic animation using the Active,Passive bodies to match the real-world physics.

After learning this Unit, you can download the Open Source Software available on the internet for free of cost to practice thepossibilities of creating 3D Interface.

Assignment

- Create a **Simple bouncing ball** using one – Soft Body and one – Rigid Body.
- Use the key words **"bouncing ball"** on www.google.com tocollect the reference video to build your scene.

Assessment

1. Describe Active and Passive Rigid Bodies
2. List the Parameters of Rigid Body Collision
3. Explain the Primitive Shapes with examples
4. Explain Hinge Constraint
5. Explain Soft Body.
6. Define Motor Constraint

Fill in the Blanks

1. There are two types of Rigid Body:_________and __________
2. The________option determines the collision shape of the object
3. The quickest way to constrain two objects is to select both and click the ____________Button
4. Constraint is dependent on the object _____________
5. __________allows to make constraints stronger.

Resources

While studying this Unit, you can browse the internet links for online video tutorials and several books and training DVDs available in the Blender Store and on the Blender Cloud.

- wiki.blender.org
- ia600207.us.archive.org
- archive.org
- www.blender.org
- docs.blender.org

Unit-3 Welcome to Cloth Simulations

Introduction

In this Unit, you will be introduced with **Cloth Simulations** and to describe which objects will be part of the Simulation and whichare not**.** Once you have done this, you can define what the objects are made of. You can also specify what Cloth is made of, and what a solid or collision object is. This is where you define Cloth and collision objects, assign properties, and execute the Simulation. Other controls included is creating constraints, interactively dragging the cloth, and erasing parts of the Simulation.

Outcomes

Upon completion of this unit you will be able to:

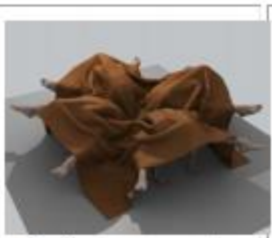
- Demonstrate the utility of Cloth Simulation
- Use Cloth Simulation to create flags and banners
- Practice Cloth Simulation to make clothing to your 3DAssets
- Use Cloth as extra effects in your 3D Scene

Terminology

Mass	:	The mass of the Cloth material.
Bending	:	It is the Wrinkle coefficient, higher the valuecreates more large folds on the cloth.
Damping	:	Damping of Cloth velocity. Higher values givea smoother result (less jiggling)
Velocity	:	Damps the velocity to help the Cloth reachthe final resting position faster.

Cloth Simulations

Cloth Simulation is one of the **hardest aspects** of Computer Graphics (CG), because it is a deceptively simple real-world item that is taken for granted, yet actually has very complex internal and environmental interactions. After years of development, **Blender** has a very **robust Cloth simulator** that is used to make **clothing, flags, banners,** and so on. Cloth interacts with and is affected by other moving objects, the wind and other forces, as well as a general aerodynamic model, all of which is under your control.

 Cloth Example.	 Cloth on carved wooden men (made by motorsep).	 Cloth Example.

Title-Img. 3. 3Options available to a Motor constraint.

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Link-https://docs.blender.org/manual/en/dev/physics/cloth/introduction.html

A piece of Cloth is any **Mesh, open or enclosed**, that has been designated as cloth. The *Cloth* panels are located in the *Physics* taband consist of **three panels of options**. Cloth is either an open or closed Mesh and is mass-less, in that all Cloth is **assumed to have** the same density, or mass per square unit.

Cloth is commonly modeled as a **Mesh grid primitive, or a cube**, but can also be, for example, **a teddy bear**. However, Blender's **Soft body system** provides better Simulation of closed meshes; Cloth is a **specialized Simulation of fabrics**.

Once the object is designated as Cloth, a **Cloth Modifier** will be added to the object's Modifier Stack **automatically**. As a Modifier, then, it can interact with other Modifiers, such as ***Armature*** and ***Smooth***. In these cases, the ultimate shape of the Mesh is computed in accordance with the order of the Modifier stack. For example, you should smooth the Cloth *after* the Modifiercomputes the shape of the cloth.

So, you edit the **Cloth settings** in two places:

1. Use the Physics buttons to edit the properties of the Cloth
2. Use the Modifier Stack to edit the Modifier propertiesrelated to display and interaction with other Modifiers.

You can *apply* the **Cloth Modifier** to freeze, or lock in, the shape ofthe Mesh at that frame, which removes the Modifier. For example,you can drape a **flat Cloth over a table**, let the Simulation run, andthen apply the Modifier. In this sense, you are using the simulator to save yourself a lot of modeling time.

Results of the Simulation are saved in a cache, so that the shape ofthe Mesh, once calculated for a frame in an animation, does not must be recomputed again. If changes to the Simulation are made, you have **full control over** clearing the cache and re-running the Simulation. Running the Simulation for the first time is **fully automatic** and **no baking** or separate **step interrupts** the workflow.

Computation of the shape of the Cloth at every frame is automaticand done in the background; thus, you can continue working whilethe Simulation is computed. However, it is **CPU-intensive** and depending on the power of your PC and the complexity of the Simulation, the amount of CPU needed to compute the Mesh varies, as does the lag you might notice.

Cloth Workflow

A general process for working with Cloth is to:

- Model the Cloth object as a general starting shape.
- Designate the object as a "cloth" in the *Physics* tab of theProperties editor.
- Model other deflection objects that will interact with the cloth. Ensure the Deflection Modifier is last on the Modifierstack, after any other Mesh Deforming Modifiers.
- Light the Cloth and assign materials and textures, UV- unwrapping if desired.
- If desired, give the object particles, such as steam coming off the surface.
- Run the Simulation and adjust Options to obtain satisfactory results. The Timeline editors' VCR controls are great for this step.
- Optionally age the Mesh to some point in the Simulation toobtain a new default starting shape.
- Make minor edits to the Mesh on a frame-by-frame basisto correct minor tears.

Cloth Settings

Cloth

- Presets

Contains a number of preset Cloth examples.

- Quality

Set the number of Simulation steps per frame. Highervalues result in better quality, but is slower.

- Speed

Adjust how fast time flows in the Cloth Simulation.

Material

- Mass

The mass of the Cloth material.

- **Structural**

Overall stiffness of the cloth.

- Bending

Wrinkle coefficient. Higher creates more large folds.

Damping

- Spring

Damping of Cloth velocity. Higher values give a smootherresult (less jiggling).

- Air

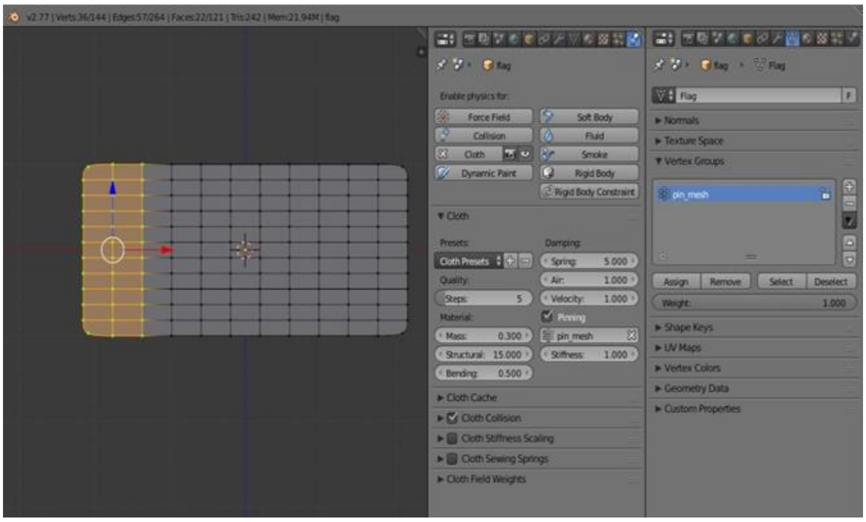
Air normally has some thickness which slows falling thingsdown.

- Velocity

Damps the velocity to help the Cloth reach the final restingposition faster.

Pinning

The first thing you need when pinning Cloth is a Vertex Group. There are several ways of doing this including using the Weight Paint tool to paint the areas you want to pin. The weight of each vertex in the group controls how strongly it is pinned.



Title-Img. 3. 1Cloth Pinning.

Attribution-Source-***Link***-
https://docs.blender.org/manual/en/dev/phys
ics/cloth/settings/cloth_settings. html

Once you have a vertex group set, things are pretty straightforward; all you must do is press the *Pinning of Cloth* button in the *Cloth* panel and select which vertex group you want to use, and the stiffness you want it at.

- Stiffness

Target position stiffness. You can leave the stiffness as it is;the default value of 1 is fine.

Cloth Pinning to an Armature

Clothing can be **simulated and pinned** to an armature. For example, a character could have a baggy tunic pinned to the character's waist with a belt.

- The typical workflow for pinning:
- Set the armature to its bind pose.
- Model clothing that encloses but does not penetrate the character's Mesh.
- Parent the clothing objects to the armature. The armature will now have several children meshes bound to it.
- Create a new vertex group on each Cloth object for its pinned vertices
- Add vertexes to be pinned to this vertex group and give these vertices non-zero weights (you probably want weight = 1). For example, the belt area of the tunic would be inthe vertex group and have weight one.
- Designate the clothing objects as "cloth" in the Physics tab of the Properties editor. Make sure the *Cloth* Modifier is below the *Armature* Modifier in the Modifier stack.
- Press the *Pinning of Cloth* button in the *Cloth* panel and select the vertex group.
- Designate the character's Mesh as "collision" object in the Physics tab of the Properties editor.
- The clothing is now ready. Non-pinned vertices will be under control of the Cloth Modifier. Pinned vertices will be under control of the Armature Modifier.

Dynamic Mesh

Normally Cloth uses the state of the object in the first frame to compute the natural rest shape of the cloth, and keeps that constant throughout the Simulation. This is reasonable for fully realistic scenes, but does not quite work for clothing on **cartoon style characters** that use a lot of squash and stretch.

When ***Dynamic Mesh***is enabled, the rest shape is recalculatedevery frame, allowing unpinned Cloth to squash and stretch following the character with the help of an Armature Modifier, but otherwise move freely under control of the physics Simulation.

Dynamic Mesh is incompatible with using a shape key to specify the rest shape.

Cloth Sewing Springs

Another method of restraining Cloth similar to pinning is **Sewing Springs**. Sewing Springs are **virtual springs** that pull vertices in onepart of a Cloth Mesh toward vertices in another part of the Cloth Mesh. This is different from pinning which binds vertices of the Cloth Mesh in place or to another object. A clasp on a cloak could be created with a Sewing Spring. The spring could pull two cornersof a cloak about a character's neck. This could result in a more **realistic Simulation** than pinning the cloak to the character's neck since the cloak would be free to slide about the character's neck and shoulders.

Sewing Springs are created by **adding extra edges to a Cloth Mesh**that are not included in any faces. They should connect vertices in the Mesh that should be pulled together. For example, the cornersof a cloak.

To activate the springs, enable the *Cloth Sewing Springs* panel.

Options

- Sewing Force

  Maximum force that can be applied by Sewing Springs.Zero means unbounded, but it is not recommended to leave the field at zero in most cases, as it can cause instability due to extreme forces in the initial frames wherethe ends of the Sewing Springs are far apart.

The *Cloth Sewing Springs* panel also contains **controls forshrinking** the actual Cloth faces.

Shrinking Group

Vertex group that is used to vary the intensity of the shrinkingeffect over the cloth.

- Min

  Fraction of the size to shrink the Cloth by around vertices with weight 0 (or those not in vertex group.) The value 0.01means shrink by 1% etc.

- Max

Fraction of the size to shrink the Cloth by around vertices with weight 1.

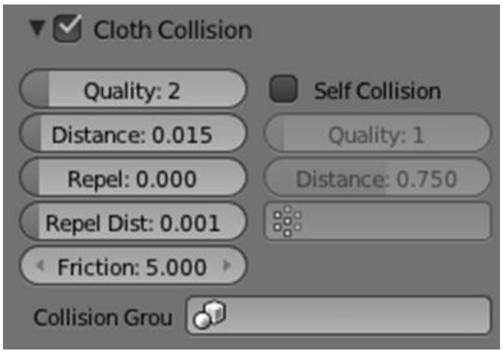
Collisions

In most cases, a piece of Cloth **does not just hang** there in 3D space, it **collides with other** objects in the environment. To ensureproper Simulation, there are several items that must be set up and working together:

- The *Cloth* object must be told to participate in collisions.
- Optionally (but recommended) tell the Cloth to collide withitself.
- Other objects must be visible to the *Cloth* object *via* sharedlayers.
- The other objects must be Mesh objects.
- The other objects may move or be themselves deformed by other objects (like an armature or shape key).
- The other Mesh objects must be told to deflect the Cloth object.
- The blend-file must be saved in a directory so that Simulation results can be saved.
- You then *Bake* the Simulation. The simulator computes the shape of the Cloth for a frame range.
- You can then edit the Simulation results, or make adjustments to the Cloth Mesh, at specific frames.

You can make adjustments to the environment or deforming objects, and then re-run the Cloth Simulation from the current frame forward.

Collision Settings



Title-Img. 3. 2Cloth Collisions panel.

Attribution-Source-

Link-https://docs.blender.org/manual/en/dev/physics/cloth/settings/collisions.html

Now you must tell the *Cloth* object that you want it to participate in collisions. For the Cloth object, locate the *Cloth Collision* panel, shown to the right:

- Quality

A general setting for how fine and good a Simulation you wish. Higher numbers take more time but ensure less tearsand penetrations through the cloth.

- Distance

As another object gets this close to it (in Blender Units),the Simulation will start to push the Cloth out of the way.

- Repel

Repulsion force to apply when Cloth is close to colliding.

- Repel Distance

Maximum distance to apply repulsion force. Must be greater than minimum distance.

- Friction

A coefficient for how slippery the Cloth is when it collides with the Mesh object. For example, silk has a lower coefficient of friction than cotton.

Self-Collisions

Real Cloth cannot permeate itself, so you normally want the Clothto self-collide.

- Enable Self Collisions

Click this to tell the Cloth object that it should not penetrate itself. This adds to Simulation compute time, but provides more realistic results. A flag, viewed from a distance does not need this enabled, but a close-up of a cape or blouse on a character should have this enabled.

- Quality

For higher self-collision quality just increase the *Quality*and more self-collision layers can be solved. Just keep in mind that you need to have at least the same *Collision Quality* value as the *Quality* value.

- Distance

If you encounter problems, you could also change the *Min Distance* value for the self-collisions.

The best value is 0.75;for fast things, you better take 1.0. The value 0.5 is quite risky (most likely many penetrations) but also gives some speedup.

- Regression blend-file:

  https://wiki.blender.org/index.php/Media:Cloth- regression-selfcollisions.blend

Shared Layers

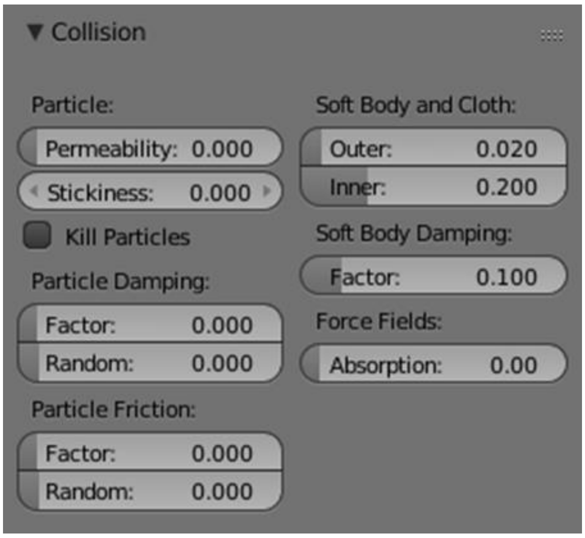
Suppose you have two objects: a pair of **Pants on layers 2 and 3**, and your **Character Mesh on layers 1 and 2.** You have enabled the Pants as Cloth as described above. You must now make the Character "visible" to the Cloth object, so that as your character bends its leg, it will push the cloth. This principle is the same for allSimulations; Simulations only interact with objects on a shared layer. In this example, both objects share layer 2.

- To view/change an object's layers, RMB click to select the object in *Object Mode* in the 3D View.
- To bring up the "Move Layers" pop-up, which shows you allthe layers that the object is on.
- To put the object on a single layer, LMB click the layer button.
- To put the object on multiple layers, Shift-LMB the layer buttons.
- To remove an object from a selected layer, simply Shift- LMB the layer button again to toggle it.

Mesh Objects Collide

If your colliding object is not a Mesh object, such as a **NURBS surface**, or text object, you must convert it to a Mesh object. Todo so, select the object in object mode, and in the 3D View header, select **Object ‣ Convert Object Type Alt-C,** and select Mesh from the pop-up menu.

Cloth - Object collisions



Title-Img. 3. 3Collision settings.

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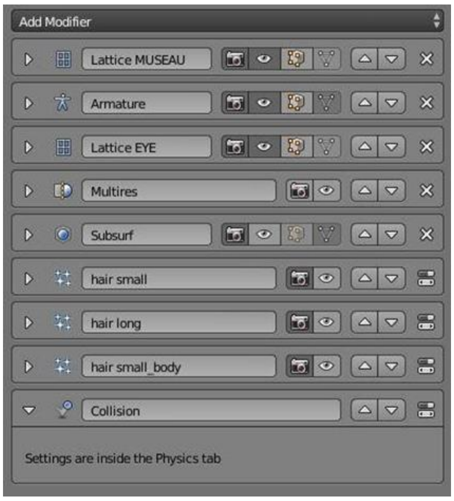
Link-https://docs.blender.org/manual/en/dev/physics/cloth/settings/collisions.html

The Cloth object needs to be deflected by some other object.

- To deflect a cloth, the object must be enabled as an objectthat collides with the Cloth object.
- To enable Cloth - Object collisions, you must enabledeflections on the collision object (not on the Cloth object).

In the Properties editor, *Object* tab and *Physics* tab, locate the *Collision* panel shown to the right. It is also important to note that this collision panel is used to tell all Simulations that this object is to participate in colliding/deflecting other objects on a shared layer (particles, soft bodies, and cloth).

Mesh Object Modifier Stack



Title-Img. 3. 4Collision stack.

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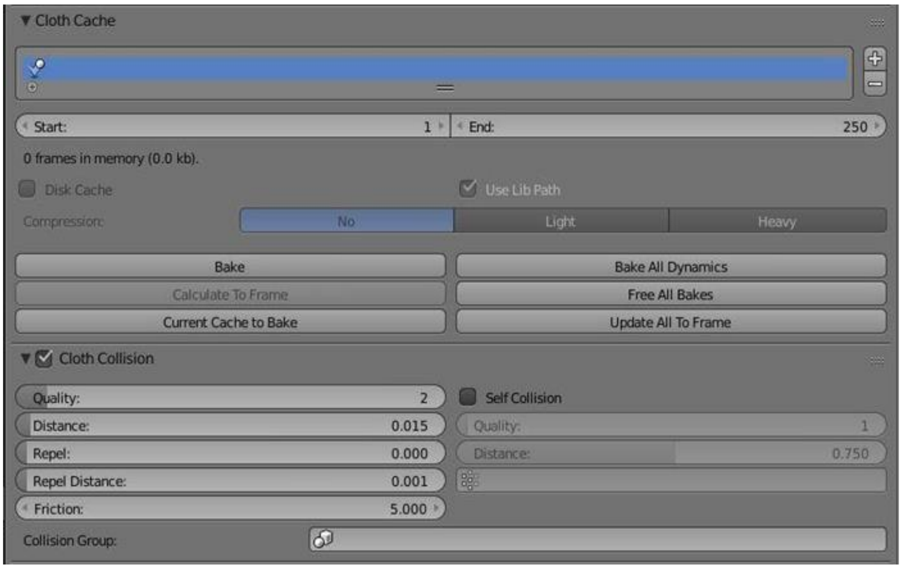
Link-https://docs.blender.org/manual/en/dev/physics/cloth/settings/collisions.html

The object's shape deforms the cloth, so the Cloth Simulation must know the "true" shape of that Mesh object at that frame. This true shape is the basis shape as modified by shape keys or armatures. Therefore, the *Collision* Modifier must be after any ofthose. The image to the right shows the *Modifiers* panel for the Character Mesh object (not the Cloth object).

Cloth Cache

Cache settings for Cloth are the same as with other dynamicsystems.

Bake Collision



Title-Img. 3. 5After Baking.

Attribution-Source-

Linkhttps://docs.blender.org/manual/en/dev/physics/cloth/settings/collisions.html

After you have set up the deflection Mesh for the frame range youintend to run the Simulation (including animating that Mesh *via* armatures), you can now tell the **Cloth Simulation** to compute (and avoid) collisions.

- Select the Cloth object
- In the *Object* tab, *Physics* tab, set the *Start* and *End* settingsfor the Simulation frames you wish to compute,
- Click the *Bake* button.

You cannot change *Start* or *End* without clearing the Bake Simulation. When the Simulation has finished, you will notice you have the option to **free the bake**, edit the bake and re-bake:

Editing the Cached Simulation

The cache contains the **shape of the Mesh** at each frame. You canedit the **Cached Simulation**, after you have baked the Simulation and pressed the ***Bake Editing*** **button**. Just go to the frame you want to fix and Tab into ***Edit Mode***. There you can move your vertices using all of Blender's Mesh shaping tools. When you exit, the shape of the Mesh will be recorded for that frame of the animation. If you want Blender to resume the Simulation using thenew shape going forward, LMB click ***Rebake*** *from next Frame* and play the animation. Blender will then pick up with that shape and resume the Simulation.

Edit the Mesh to correct minor tears and places where the colliding object has punctured the cloth.

If you add, delete, extrude, or remove vertices in the Mesh, Blender will take the new Mesh as the starting shape of the Mesh back to the *first frame* of the animation, replacing the original shape you started with, up to the frame you were on when you edited the Mesh. Therefore, if you change the content of a Mesh, when you Tab out of *Edit Mode*, you should unprotect and clear the cache so that Blender will make a consistent Simulation.

Troubleshooting

If you encounter some problems with collision detection, there aretwo ways to fix them:

- The fastest solution is to increase the ***Min Distance*** setting under the ***Cloth Collision*** panel. This will be the fastest wayto fix the clipping; however, it will be less accurate and will not look as good. Using this method tends to make it look like the Cloth is resting on air, and gives it a very rounded look.
- A second method is to increase the *Quality* (in the first *Cloth* panel). This results in smaller steps for the simulator and therefore to a higher probability that fast-moving collisions get caught. You can also increase the *Collision Quality* to perform more iterations to get collisions solved.
- If none of the methods help, you can easily edit the cached/baked result in *Edit Mode* afterwards.
- The Cloth is torn by the deforming Mesh – he "Hulks Out": Increase its structural stiffness (*Structure Stiffness* setting, *Cloth* panel), very high, like 1000.

Examples

To start with cloth, the first thing you need, of course, is **somefabric**. So,

- Let us delete the default cube and add a plane.
- In order to get some good floppy and flexible fabric,you will need to subdivide it several times; about eight is a good number.
- So, Tab into *Edit Mode*, and **press W ‣ Subdivide multi**,and set it to **8**.
- Now, we will make this Cloth by going to the Physics tab.
- Scroll down until you see the *Cloth* panel, and press the *Cloth* button.
- Now, a lot of settings will appear, most of which we willignore for now.
- That is all you need to do to set your Cloth up foranimating, but if you press Alt-A, your lovely fabric will just drop very un-spectacularly.

That is what we will cover in the next two sections about **Pinningand Colliding.**

Using Simulation to Shape/Sculpt a Mesh

You can *apply* the ***Cloth* Modifier** at any point to **freeze the Mesh** in position at that frame. You can then re-enable the cloth, setting the start and end frames from which to run the Simulation forward.

Another example of **Aging is a Flag.**

- Define the flag as a simple grid shape and
- Pin the edge against the flagpole.
- Simulate for 50 frames or so, and the flag will drop toits “rest” position.
- Apply the *Cloth* Modifier.

If you want the flag to flap or otherwise move in the scene, re- enable it for the frame range when it is in camera view.

Smoothing of Cloth

Now, if you followed this from the previous section, your Cloth is probably looking a little blocky. In order to make it look nice and smooth like the picture you need to apply a *Smooth* and/or *Subdivision Surface* Modifier in the *Modifiers* tab. Then, in thesame editor, find the *Links and Materials* panel (the same one you used for vertex groups) and press *Set Smooth*.

Now, if you **press Alt-A**, things are starting to look pretty nice, do not you think?

Cloth on armature

- **Cloth deformed by armature and also, respecting anadditional collision object: https://wiki.blender.org/index.php/Media:Cloth- regression-armature.blend**

Cloth with animated vertex groups

- Cloth with animated pinned vertices:https://wiki.blender.org/index.php/Media:Cloth_ani m_vertex.blend

UNSUPPORTED: Starting with a goal of 0 and increasing it, but still having the vertex not pinned will not work (e.g. from goal = 0 to goal = 0.5).

Cloth with Dynamic Paint

- Cloth with Dynamic Paint using animated vertexgroups: https://wiki.blender.org/index.php/Media:Cloth_dyn amic_paint.blend

UNSUPPORTED: Starting with a goal of 0 and increasing it, but still having the vertex not pinned will not work (e.g. from goal = 0 to goal = 0.5) because the necessary "goal springs" cannot be generated on the fly.

Using Cloth for Soft bodies

Title-Img. 3. 6Using Cloth for soft bodies.

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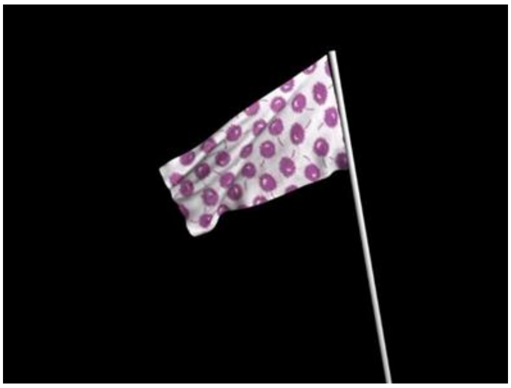
Source-

Link- https://docs.blender.org/manual/en/dev/physics/cloth/examples.html

Cloth can also be used to simulate soft bodies. It is for sure not its main purpose but it works nonetheless. The example image uses standard *Rubber* material, no fancy settings, just Alt-A.

- **Blend file for the example image:https://wiki.blender.org/index.php/Media:Cloth-sb1.blend**

Cloth with Wind



Title-Img. 3. 7Flag with wind applied.

Attribution-

Source-

Link- *https://docs.blender.org/manual/en/dev/physics/cloth/examples.html*

- Regression blend-file for Cloth with wind and self-collisions (also the blend for the image above):https://wiki.blender.org/index.php/Media:Cloth- flag2.blend

Unit summary

In this Unit, you have learnt what is Cloth Simulation and how to

- Use the Simulation to create effects to 3D Characters, 3D Assets and 3D Environment.
- Bake and save Simulation on moving objects using Cache.
- Create Modifier stacks and smooth Cloth Simulation.
- Create different types of Cloth Simulation like cape, flag, curtain, banners and fabrics, its use with the help of 3D assets to effectively work on 3D scene.

After learning this Unit, you can download the Open Source Software available on the internet for free of cost to practice the possibilities of creating 3D Interface.

Assignment

- Create a **Pole with a Flag** and apply external forces likewind to simulate flag fluttering

- Use the key words **“flag fluttering”** on www.google.com tocollect the reference video to build your scene.

Assessment

1. Describe Cloth Simulation
2. Explain Dynamic Mesh
3. Define Sewing Force
4. Define Self-Collision
5. Explain Cloth Pinning with the steps and illustration
6. Describe Smoothing of Cloth
7. List out the Properties of Clothing inSimulation.

Fill in the Blanks

1. The first thing you need when pinning Cloth is a ________________
2. When animating or posing the character, you must begin from the ________________ pose
3. Sewing Springs are__________________that pull vertices in one part of a Cloth Mesh toward vertices in another part of the Cloth Mesh.
4. If your colliding object is not a Mesh object, you must convert it toa___.
5. The cache contains the shape of the Mesh at ____________________

Resources

While studying this Unit, you can browse the following internet links foronline video tutorials and several books and training DVDs available in theBlender Storeand on theBlender Cloud.

Links to download 3D Files for practice

1. https://en.wikibooks.org/wiki/Blender_3D:_Noob_to_Pro/Parti cles_forming_Shapes
2. https://cloud.blender.org/training
3. wiki.blender.org
4. ia600207.us.archive.org
5. archive.org
6. www.blender.org

7. docs.blender.org

Unit-4 Welcome to Fluid Simulation

Introduction

Fluid Simulation refers to Computer Graphics techniques for generating realistic animations of fluids such as liquid, water and smoke. You would come across Fluid Simulation that are typically focused on emulating the qualitative visual behavior of a fluid, with less emphasis placed on rigorously correct physical results, although they often still rely on approximate solutions that governreal fluid physics. You will also learn that Fluid Simulation can be performed with different levels of complexity, ranging from time - consuming, and high-quality animations for films or visual effects, to simple and fast animations for real-time animations like computer games.

Outcomes

Upon completion of this unit you will be able to:

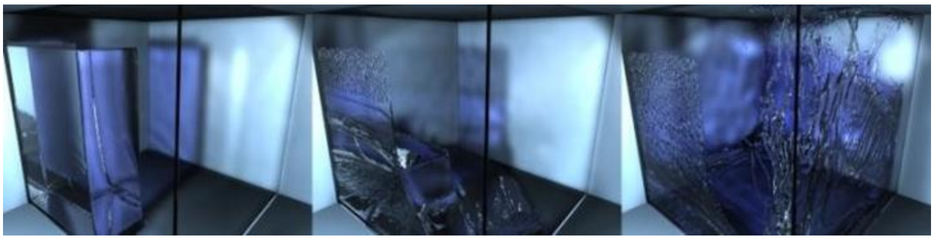
- Define and Use Fluid Simulation in your 3D project forcreating extra effects
- Describe to control the flow of the fluid
- Demonstrate the use of physical properties of the fluid
- Use bake simulation to save performance
- Reuse Existing simulation

Terminology

Volume	:	The inside of the object is initialized as fluid all. This works only if the closed mesh.
Shell	:	It is initialized as a thin fluid layer of the surface of the mesh. This can also be used in the mesh open.
Viscosity	:	The “thickness” of the fluid and actually theforce needed to move an object of a certain surface area through it at a certain speed.
Inflow Velocity	:	Speed of the fluid that is created inside of theobject.

How Materials Works

Fluid physics are used to simulate physical properties of liquids especially water. While creating a scene in Blender, certain objectscan be marked to participate in the **Fluid Simulation**. These can include but not limited to, being a fluid or as an obstacle. For a **Fluid Simulation**, you must have a domain to define the space thatthe simulation takes up. In the domain settings, you will be able todefine the global simulation parameters (such as viscosity andgravity).



Title-Img. 4. 1Example of Fluid Simulation.

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Link- *https://docs.blender.org/manual/en/dev/physics/fluid/introduction.html*

Workflow

In general, you follow these steps:

1. First you want to set the simulation domain,
2. Next set the fluid source(s), and specify the physical properties.
3. In some cases, you may want to set other objects to Control the Flow of the fluid.
4. You can also depend on your scene add other objects related to the fluid, like: Obstacles, Particles floating on thefluid.
5. And lastly you must Bake the Simulation.

Common Options

Animated Mesh/Export

Click this button if the network is animated (Example: Deformed by an armature, shape keys, or lattice). It can become very slow and is not necessary if the network's position and rotation are animated. (i.e. only object transformations).

Volume Initialization Type

A common option among the different fluid types is ***Volume Initialization***.

- Volume

The inside of the object is initialized as fluid all. This worksonly if the closed mesh.

- Shell

It is initialized as a thin fluid layer of the surface of themesh. This can also be used in the mesh open.

- Both

It is a state, such as the sum of the Volume and Shell. Thisalso must be a closed mesh.

Title-Img. 4. 2 Example of different types of initiation of volume

Attribution-Source-

Link-https://docs.blender.org/manual/en/dev/physics/fluid/types/introduction.html

Fluid Domain

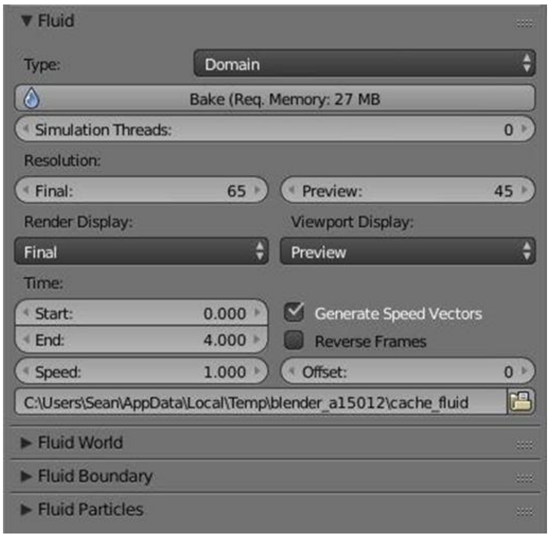
The Domain Object

The bounding box of the object serves as the boundary of the simulation. All fluid objects **must be in the domain**. Fluid objects outside the domain will not bake. No tiny droplets can move outside this domain; it's as if the fluid is contained within the 3D space by invisible force fields. There can be only a single Fluid Simulation domain object in the scene.

The shape of the object does **not** matter because it will *always* be treated like **a box** (The lengths of the bounding box sides can be different). So, usually there will not be any reason to use another shape than a box. If you need obstacles or other boundaries than abox to interfere with the fluid flow, you need to insert additional obstacle objects *inside* the domain boundary.

This object will be ***replaced*** **by the fluid** during the simulation.

Options



Title-Img. 4. 3Fluid Domain Settings.

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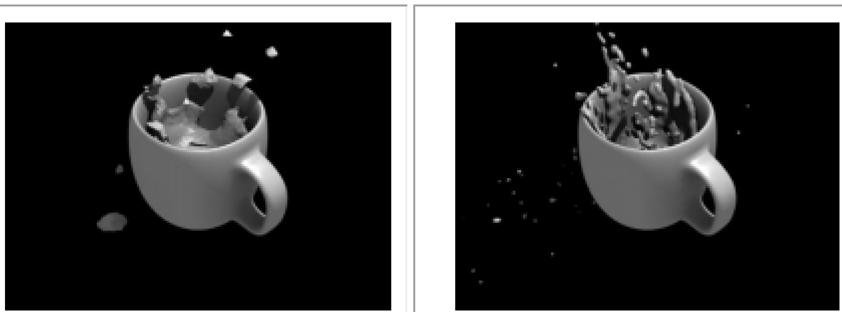
Link-https://docs.blender.org/manual/en/dev/physics/fluid/types/domain.html

Resolution

- **Render resolution**

The granularity at which the actual Fluid Simulation is performed. This is probably the most important setting for the simulation as it determines the amount of details in thefluid, the memory and disk usage as well as computational time.



10cm mug at Resolution 70. *10cm mug at Resolution 200.*

Title-Img. 4. 4 Render resolution

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Link-https://docs.blender.org/manual/en/dev/physics/fluid/types/domain.html

- **Preview resolution**

This is the resolution at which the preview surface meshes will be generated. So, it does not influence the actual simulation. Even if “there is nothing to see” in the preview,there might be a thin fluid surface that cannot be resolved in the preview.

Display quality

How to display a baked simulation in the **3D View** (menu *ViewportDisplay*) and for **rendering** (menu *Render Display*):

- **Geometry**

Use the original geometry (before simulation).

- **Preview**

Use the preview mesh.

- **Final**

  Use the final high definition mesh.

When no baked data is found, the original mesh will be displayed by default. After you have baked a domain, it is displayed (usually) in the Blender window as the preview mesh. To see the size and scope ofthe original domain box, select ***Geometry*** in the left selector.

Time

- **Start**

  It is the simulation start time (in seconds).

  This option makes the simulation computation in Blender start later in the simulation. The domain deformations and fluid flow prior to the start time are not saved.

  For example, if you wanted the fluid to appear to already have been flowing for 4 seconds before the actual first frame of data, you would **enter 4.0** here.

- **End**

  It is the simulation ending time (in seconds).

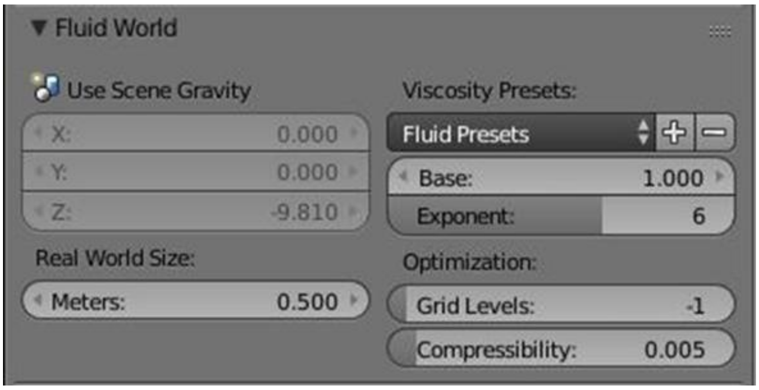
Generate Speed Vector

If this button is clicked, no speed vectors will be exported. So, by default, speed vectors are generated and stored on disk. They can be used to compute image based **motion blur** with the compositing nodes.

Reverse fluid frames

The simulation is calculated **backward**

Fluid World



Title-Img. 4. 4Fluid World options.

Attribution-Source-

Link-https://docs.blender.org/manual/en/dev/physics/fluid/types/domain.html

Viscosity Presets

The “thickness” of the fluid and actually the force needed to movean object of a certain surface area through it at a certain speed.

For manual entry, please note that the normal real-world viscosity (the so-called Dynamic Viscosity) is measured in **Pascal-seconds (Pa.s),** or in Poise units (P, equal to **0.1 Pa.s,** pronounced ***pwaz,*** from the Frenchman ***Jean-Louis Poiseuille***, who discovered the laws on “the laminar flow of viscous fluids”), and commonly **centiPoise units (cP**, equal to 0.001 Pa.s, *sentipwaz*). Blender, on the other hand, uses the kinematic viscosity (which is dynamic viscosity in Pa.s, divided by the density in kg.m^{-3}, unit m^{2}.s^{-1}). The table below gives some examples of fluids together with theirdynamic and kinematic viscosities.

Blender Viscosity Unit Conversion		
Fluid	**Dynamic Viscosity(in cP)**	**Kinematic Viscosity (Blender, in m^{2}.s^{-1})**
Water (20- C)	1.002×10^{0} (1.002)	1.002×10^{-6} (0.000001002)

Oil SAE 50	5.0×10^{2} (500)	5.0×10^{-5} (0.00005)
Honey (20- C)	1.0×10^{4} (10,000)	2.0×10^{-3} (0.002)
Chocolate Syrup	3.0×10^{4} (30,000)	3.0×10^{-3} (0.003)
Ketchup	1.0×10^{5} (100,000)	1.0×10^{-1} (0.1)
Melting Glass	1.0×10^{15}	1.0×10^{0} (1.0)

Manual entries are specified by a floating-point number and an exponent. These floating point and exponent entry fields (scientific notation) simplify entering very small or large numbers. The viscosity of water at room temperature is **1.002 cP, ou 0.001002 Pa.s**; the density of water is about 1000 kg.m^{-3}, which gives a kinematic viscosity of 0.000001002 m^{2}.s^{-1} – so the entry would be **1.002 times 10 to the minus six (1.002×10^{-6}** in scientific notation). Hot Glass and melting iron is a fluid, but very thick; you should enter something like **1.0×10^{0} (= 1.0)** as its kinematicviscosity (indicating a value of **1.0×10^{6}cP**).

Note that the simulator is not suitable for non-fluids, such as materials that do not “flow”. Simply setting the viscosity to very large values will not result in rigid body behavior, but might cause instabilities.

Real World **Size**

Size of the domain object in the real world in meters. If you want to create a **mug of coffee,** this might be **10 cm (0.1 meters**), while a swimming pool might be **10m**. The size set here is for the longestside of the domain bounding box.

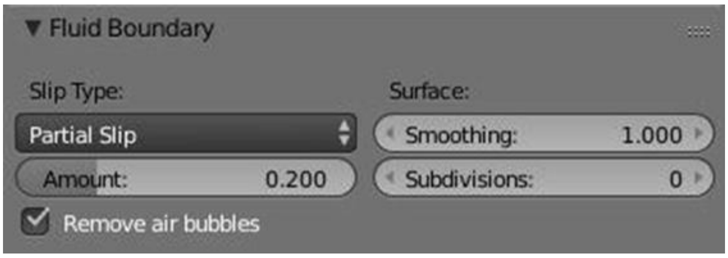
Optimization

- **Grid level**

  How many adaptive grid levels to be used during simulation. Setting this **to -1** will perform automatic selection.

- **Compressibility**

If you have problems with large standing fluid regions at high resolution, it might help to reduce this number (note that this will increase computation times).



Title-Img. 4. 5Fluid Boundary panel.

Attribution-Source-

Link-https://docs.blender.org/manual/en/dev/physics/fluid/types/domain.html

This box has all the slip and surface options.

Boundary type

The stickiness of the surface of the obstacle, to determine the "tacky surface (Surface Adhesion)." In the real world, and the tackiness and fluid, the granularity of the object surface, tack,determined by the elasticity.

- **No Slip**

Fluid will stick to snugly (speed 0).

- **Free Slip**

Fluid will move on the object (0 normal direction of speed).

- **Part Slip**

It is a two intermediate. It is almost No slip, 1 in the Free exactly the same in 0.

Surface

- **Surface Smoothing**

Amount of smoothing to be applied to the fluid surface. 1.0is standard, 0 is off, while larger values increase the amount of smoothing.

- **Subdivisions**

Allows the creation of high-res surface meshes directly during the simulation (as opposed to doing it afterwards like a subdivision modifier). A value of 1 means no subdivision, and each increase results in one further subdivision of each fluid voxel. The resulting meshes thus quickly become large, and can require large amounts of disk space. Be careful in combination with large smoothing values – this can lead to long computation times due to thesurface mesh generation.

Fluid Particles

Title-Img. 4. 6Fluid Particles Panel.

Attribution-Source-

Link-https://docs.blender.org/manual/en/dev/physics/fluid/types/domain.html

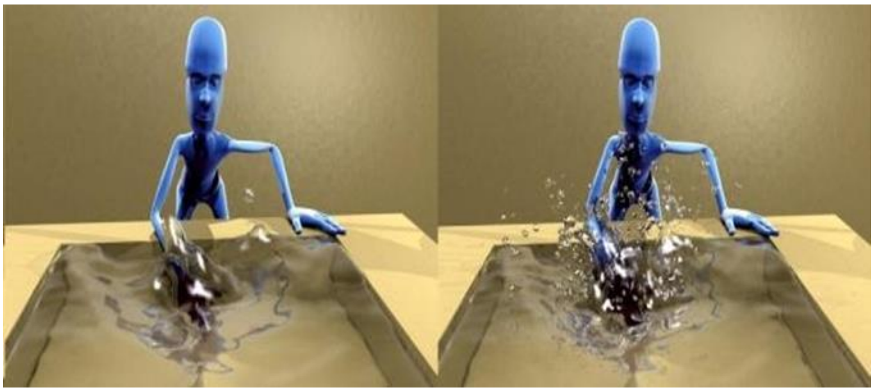
Here you can add particles to the fluid simulated, to enhance thevisual effect.

- **Tracer Particles**

Number of tracer particles to be put into the fluid at the beginning of the simulation. To display them createanother object with the *Particle* fluid type, explained below, that uses the same bake directory as the domain.

- **Generate Particles**

Controls the amount of fluid particles to create (**0=off, 1=normal, >1=more**). To use it, you have to have a surface subdivision value of at least 2.



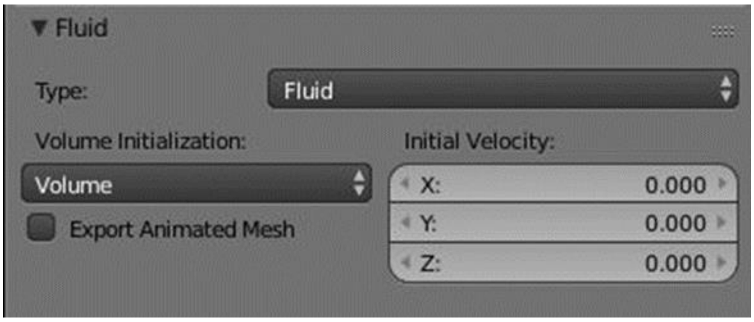
Title-Img. 4. 7An example of Particles' effects.

Attribution-Source-

Link-https://docs.blender.org/manual/en/dev/physics/fluid/types/domain.html

Left: Simulated without; **Right:** With particles and subdivisionenabled

Fluid Object



Title-Img. 4. 8Fluid object settings.

Attribution-Source-

Link-https://docs.blender.org/manual/en/dev/physics/fluid/types/fluid_object.html

All regions of this object that are inside the domain bounding box will be used as actual fluid in the simulation. If you place more than one fluid object inside the domain, they should currently not intersect. Also make sure the surface normals are pointing outwards. In contrast to domain objects, the actual mesh geometry is used for fluid objects.

- **Volume Initialization Type**

  Refer Volume Initialization Type

- **Animated Mesh/Export**

  Refer Animated Mesh/Export

- **Initial velocity**

  Speed of the fluid at the beginning of the simulation, inmeters per second.

Fluid Obstacle

This object will be used as **an obstacle in the simulation**. As with a fluid object, obstacle objects currently should not intersect. As for fluid objects, the actual mesh geometry is used for obstacles. For objects with a volume, make sure that the normals of the obstacle are calculated correctly, and radiating properly (use the ***Flip Normal*** **button, in *Edit Mode, Mesh Tools* panel, in the Tool shelf**), particularly when using a spinned container. Applying a Subdivision Surface Modifier before baking the simulation could also be a good idea if the mesh is not animated.

- **Volume Initialization Type**

  Refer Volume Initialization Type

- **Boundary type**

Determines the stickiness of the obstacle surface, called “**Surface Adhesion**”. Surface Adhesion depends in real- world on the fluid and the graininess or friction/adhesion/absorption qualities of the surface.

- ✓ **No Slip**

  Causes the fluid to stick to the obstacle (zero velocity).

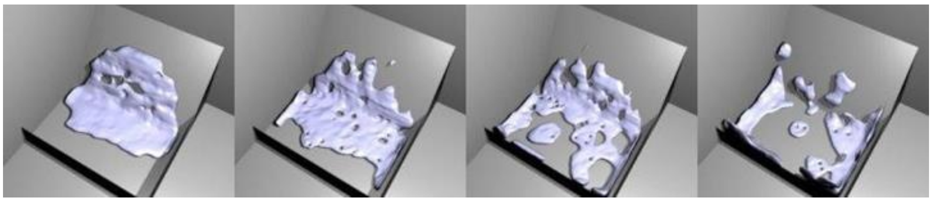
- ✓ **Free Slip**

  Allows movement along the obstacle (only zero normalvelocity).

- ✓ **Part Slip**

  Mixes both types, with 0 being mostly no slip, and 1being identical to free slip.

Note that if the mesh is moving, it will be treated as no slip automatically.



Title-Img. 4. 9 Example of the different boundary types for a drop falling onto the slanted wall. From left to right: no-slip, part-slip 0.3, part-slip 0.7 and free-slip.

Attribution-Source-

Link-https://docs.blender.org/manual/en/dev/physics/fluid/types/obstacle.html

- **Animated Mesh/Export**

Refer Animated Mesh/Export

- **Part Slip Amount**

Amount of mixing between no- and free-slip, describedabove.

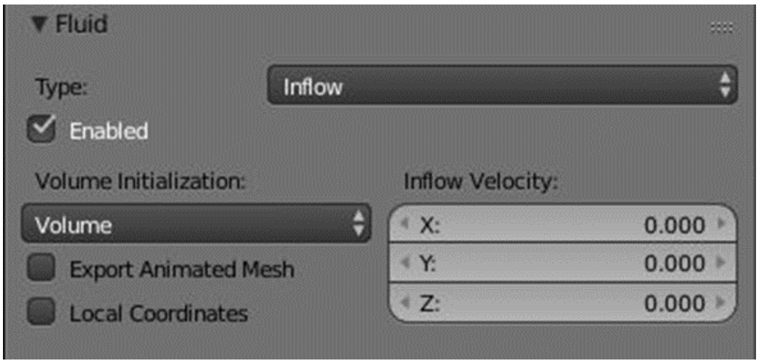
- **Impact Factor**

Amount of fluid volume correction for gain/loss from impacting with moving objects. If this object is not moving, this setting has no effect. However, it if is and the fluid collides with it, a negative value takes volume away from the Domain, and a positive number adds to it. Ranges from **-2.0 to 10.0**.

Fluid Inflow / Outflow

To control the volume of the Fluid Simulation, you can set objectsin the scene to add or absorb fluid within the Fluid Domain.

Inflow



Title-Img. 4. 10Fluid Inflow Settings.

Attribution-Source-

Link- *https://docs.blender.org/manual/en/dev/physics/fluid/types/flow.html*

- **Volume Initialization Type**

Refer Volume Initialization Type

This object will put fluid into the simulation, like a **water tap**.

- **Inflow Velocity**

  Speed of the fluid that is created inside of the object.

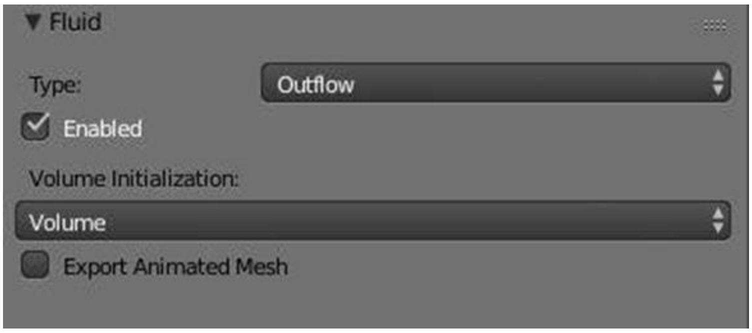
- **Local Coordinates/Enable**

  Use local coordinates for the inflow. This is useful if the inflow object is moving or rotating, as the inflow stream will follow/copy that motion. If disabled, the inflowlocation and direction do not change.

- Animated Mesh/Export

  Refer Animated Mesh/Export

Outflow



Title-Img. 4. 11Fluid Outflow Settings.

Attribution-Source-

Link- *https://docs.blender.org/manual/en/dev/physics/fluid/types/flow.html*

Any fluid that enters the region of this object will be deleted (thinkof a drain or a black hole). This can be useful in combination with an inflow to prevent the whole domain from filling up. When enabled, this is like a **tornado** (waterspout) or "**wet vac**" vacuum cleaner, and the part where the fluid disappears will follow the object as it moves around.

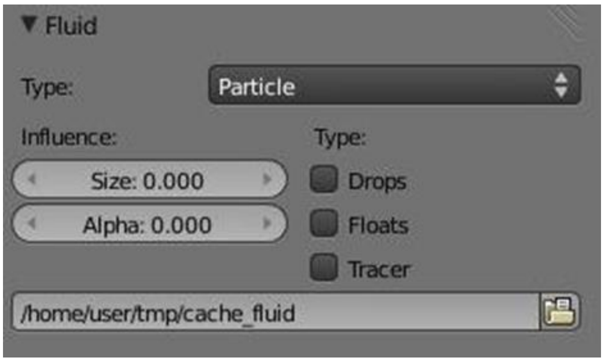
- **Volume Initialization Type**

Refer Volume Initialization Type

- **Animated Mesh/Export**

Refer Animated Mesh/Export

Fluid Particle



Title-Img. 4. 12Fluid particle settings.

Attribution-Source-

Link-https://docs.blender.org/manual/en/dev/physics/fluid/types/particle.html

This type can be used to display particles created during the simulation. For now, only tracers swimming along with the fluidare supported.

Note that the object can have any shape, position or type. Once the particle button is pressed, a particle system with the Fluid Simulation particles will be created for it at the correct position. When moving the original object, it might be necessary to delete the particle system, disable the fluidism particles, and enable them again. The fluidism particles are currently also unaffected by any other particle forces or settings.

- **Influence**
  - **Size Influence**

    The particles can have different sizes, if this value is 0 allare forced to be the same size.

- **Alpha Influence**

  If this value is >0, the alpha values of the particles are changed according to their size.

- **Particle type**
- **Drops**

  Surface splashes of the fluid result in droplets being strewnabout, like fresh water, with low Surface Tension.

- **Floats**

  The surface tension of the fluid is higher and the fluidheavier, like cold seawater and soup. Breakaways are clumpier and fall back to the surface faster than *Drops*, as with high Surface Tension.

- **Tracer**

  Droplets follow the surface of the water where it existed, like a fog suspended above previous fluid levels. Use this tosee where the fluid level has been.

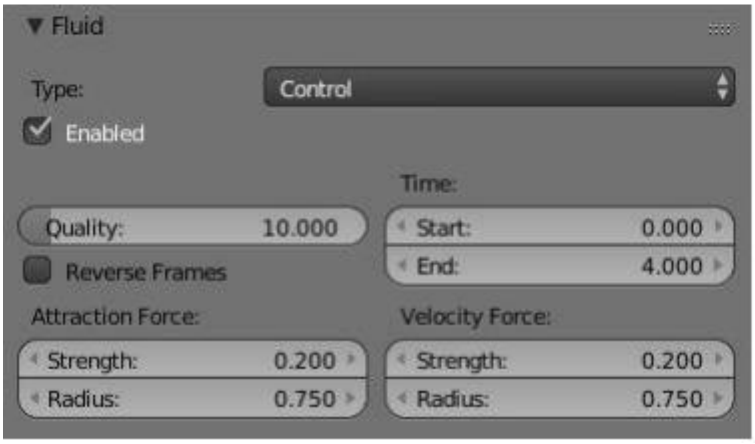
- **Path (bake directory)**

  The simulation runs to load the particles. This should usually have the same value as the fluid domain object (e.g. copy by **Ctrl-C, Ctrl-V).**

Fluid Control

Using the **Lattice-boltzman method**, the fluid is controlled using particles which define local force fields and are generatedautomatically from either a physical simulation or a sequence of target shapes. At the same time, as much as possible of the natural fluid motion is preserved.

Options



Title-Img. 4. 13Fluid control options.

Attribution-Source-

Link- *http://blender-manual- i18n.readthedocs.io/ja/latest/physics/fluid/control.html*

- **Enabled**

Controls weather the control object contributes to the fluidsystem. This is useful when animating the fluid control object.

- **Quality**

Higher quality results in more control particles for the fluid control object.

- **Reverse Frames**

The control particle movement gets reversed.

- **Time**

You specify the start and end time during which time the fluid control object is active.

- **Attraction force**

The attraction force specifies the force which gets emitted by the fluid control object. Positive force results inattraction of the fluid, negative force in avoidance.

- **Velocity force**

If the fluid control object moves, the resulting velocity canalso introduce a force to the fluid.

Examples

In this example, we use the **Fluid Control option** to control part of the fluid so that it has a certain shape (the sphere drop or the teapot drop) before it falls in the rest of the fluid:

Title-Img. 4. 14Falling drop.

Attribution-Source-

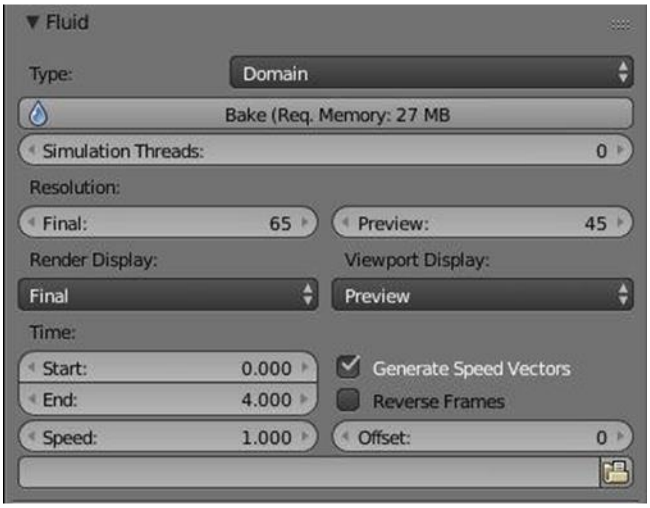
Link-https://docs.blender.org/manual/en/dev/physics/fluid/types/control.html

Title-Img. 4. 15"Magic Fluid Control."

Attribution-Source-

Link-https://docs.blender.org/manual/en/dev/physics/fluid/types/control.html

Baking



Title-Img. 4. 16The Fluid Simulation options with Domain selected.

Attribution-Source-

Link- https://docs.blender.org/manual/en/dev/physics/fluid/baking.html

Bake Button

- Perform the **actual Fluid Simulation**.

Blender will continue to work normally, except there will be a progress bar in the header of the Info Editor, next to the render pulldown. Pressing **Esc or the "x"** next to the status bar will abort the simulation. Afterwards **two.bobj.gz** (one for the *Final* quality, one for the *Preview* quality), plus **one.bvel.gz** (for the *Final* quality) will be in the selected output directory for each frame.

Bake directory

- Directory and file prefix to store baked surfacemeshes.

This is similar to the animation output settings, only selecting a fileis a bit special: when you select any of the previously generated surface meshes (e.g. **test1_fluidsurface_final_0132.bobj.gz**), the prefix will be automatically set (test1_ in this example). This way the simulation can be done several times with different settings, and allows quick changes between the different sets of surface data.

Notes

- **Unique domain**

Because of the possibility of spanning and linking between scenes, there can only be one domain in an entire blend- file.

- **Selecting a Baked Domain**

After a domain, has been baked, it changes to the fluid mesh. To re-select the domain so that you can bake it againafter you have made changes, go to any frame and select RMB the fluid mesh. Then you can click the *bake* button again to recomputed the fluid flows inside that domain.

- **Baking always starts at Frame #1**

The fluid simulator disregards the Start setting in the Animation panel, it will always bake from frame 1. If you wish the simulation to start later than frame 1, you must key the fluid objects in your domain to be inactive until the frame you desire to start the simulation.

- **Baking always ends at the End Frame set in the Animation panel**

If your frame-rate is 25 frames per second, and endingtime is 4.0 seconds, then you should (if your start time is 0)set your animation to end at frame $4.0 \times 25 = 100$

- **Freeing the previous baked solutions**

Deleting the content of the "Bake" directory is a destructive way to achieve this. Be careful if more than one simulation uses the same bake directory (be sure they use different filenames, or they will overwrite one another)!

- **Reusing Bakes**

Manually entering (or searching for) a previously saved (baked) computational directory and filename mask willswitch the fluid flow and mesh deformation to use that which existed during the old bake. Thus, you can re-use baked flows by simply pointing to them in this field.

- **Baking processing time**

Baking takes a lot of compute power (hence time).Depending on the scene, it might be preferable to bake overnight.

If the mesh has modifiers, the rendering settings are used forexporting the mesh to the fluid solver. Depending on the setting, calculation times and memory use might exponentially increase. For example, when using a moving mesh with Subdivision Surface as an obstacle, it might help to decrease simulation time by switching it off, or to a low subdivision level. When the setup/rig iscorrect, you can always increase settings to yield a more realistic result.

Fluid Appendix

Hints

Some useful hints about Fluid Simulation in Blender:

- Do not be surprised, but you will get whole bunch of mesh (. bobj.gz) files after a simulation. One set for preview, and another for final. Each set has a .gz file foreach frame of the animation. Each file contains thesimulation result – so you will need them.

- Currently these files will not be automatically deleted, so it is a good idea to e.g. create a dedicated directory to keep simulation results. Doing a Fluid Simulation is similar to clicking the *animation* button. Currently you must take care of organizing the fluid surface meshes in some directory by yourself. If you want to stop using the Fluid Simulation, you can simply delete all the *fluid*.bobj.gz files.

- Before running a high-resolution simulation that might take hours, check the overall timing first by doing lowerresolution runs.

- Fluid objects must be completely inside the bounding box of the domain object. If not, baking may not work correctly or at all. Fluid and obstacle objects can be meshed with complex geometries. Very thin objects might not appear in the simulation, if the chosen resolution is too coarse to resolve them (increasing it might solve this problem).

- Do not try to do a complicated scene all at once. Blender has a powerful compositor that you can use to combine multiple animations.
- For example, to produce an animation showing twoseparate fluid flows while keeping your domain small, render one .avi using the one flow. Then move thedomain and render another .avi with the other flow using an alpha channel (in a separate B&W .avi?). Then, composite both .avi's using the compositor's add function. A third .avi is usually the smoke and mist and it is laid on top of everything as well. Add a rain sheet on top of the mist and spray and you will have quite a storm brewing! And then lightning flashes, trash blowing around, all as separate animations, compositing the total for a truly spectacular result.

Limitations & Workarounds

- If the setup seems to go wrong, make sure all the normals are correct (hence, enter ***Edit Mode***, select all, and recalculate normals once in a while).
- Currently there is a problem with **zero gravity simulation**. It could be avoided by simply selecting a very small gravity until this is fixed.
- If an object is initialized as *Volume*, it must be closed and have an inner side (a plane will not work). To use planes, switch to ***Shell,*** or extrude the plane.
- Blender freezes after clicking ***bake***. Pressing **Esc** makes it work again after a while – this can happen if the resolution is too high and memory is swapped to hard disk, making everything horribly slow. Reducing the resolution should help in this case.
- Blender crashes after clicking ***bake*** – this can happen if the resolution is really high and **more than 2GB** are allocated, causing Blender to crash. Reduce the resolution. Many operating systems limit the total amount of memory that can be allocated by a *process*, such as Blender, even if the *machine* has more memory installed.
- The meshes should be closed, so if some parts of e.g. afluid object are not initialized as fluid in the simulation, check that all parts of connected vertices are closed meshes. Unfortunately, the **Suzanne (monkey)** mesh inBlender is **not a closed mesh** (the eyes are separate).
- If the Fluid Simulation exits with an error message (stating e.g. that the "init has failed"), make sure you have valid settings for the domain object, e.g. by resetting them to the defaults.

- Note that first frame may well take only a few hundred MBs of RAM memory, but latter ones go **over one GB**,which may be why your bake fails after a while. If so, try to bake one frame at the middle or end at full res so you will see if it works.

- Memory used doubles when you set surface subdivision from **1 to 2**.

- Using "generate particles" will also add memory requirements, as they increase surface area and complexity. Ordinary fluid-sim generated particlesprobably eat less memory.

Unit summary

In this Unit, you have learnt about Fluid Simulation and how to

- Include the Fluid Simulation in your 3D Scene, using the global simulation parameter.

- Create simulation for water, liquid, oil, flood, ocean etc.

- Control Fluid Simulation using the physical properties of those elements

- Interact with the collusion or obstacle objects.

After learning this Unit, you can download the Open Source Software available on the internet for free of cost to practice thepossibilities of creating 3D Interface.

Assignment

- Create a **Simple Fluid Simulation** of pouring liquid from a tea pot to a cup.
- Use the key words **"Teapot Pouring Tea"** onwww.google.com to collect the reference video to build your scene.

Assessment

1. Describe Domain Object
2. Define Speed Vector
3. Explain Viscosity
4. Describe Fluid Object
5. Explain Fluid Particles
6. Define Baking

State the limitations of Fluid Simulation.

Fill in the Blanks

1. ___ are used to simulate physical properties of liquidsespecially water.
2. Speed Vectors can be used to compute image based____________withthe compositing nodes.
3. The thickness of the fluid is called _______________
4. ___Controls the movement of the liquid.
5. ___is a thin fluid layer of the surface of the mesh.

Resources

While studying this Unit, you can browse the following internet links for online video tutorials and several books and trainingDVDs available in the Blender Store and on the Blender Cloud.

- wiki.blender.org
- ia600207.us.archive.org
- archive.org
- www.blender.org
- docs.blender.org

Links to download 3D Files for practice

1. https://en.wikibooks.org/wiki/Blender_3D:_Noob_to_Pr o/Particles_forming_Shapes
2. https://cloud.blender.org/training

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શિક્ષણ, સંસ્કૃતિ, સદ્‌ભાવ, દિવ્યબોધનું ધામ
ડૉ. બાબાસાહેબ આંબેડકર ઓપન યુનિવર્સિટી નામ;
સૌને સૌની પાંખ મળે, ને સૌને સૌનું આભ,
દશે દિશામાં સ્મિત વહે હો દશે દિશે શુભ-લાભ.

અભણ રહી અજ્ઞાનના શાને, અંધકારને પીવો ?
કહે બુદ્ધ આંબેડકર કહે, તું થા તારો દીવો;
શારદીય અજવાળા પહોંચ્યાં ગુર્જર ગામે ગામ
ધ્રુવ તારકની જેમ ઝળહળે એકલવ્યની શાન.

સરસ્વતીના મયૂર તમારે ફળિયે આવી ગહેકે
અંધકારને હડસેલીને ઉજાસના ફૂલ મહેંકે;
બંધન નહીં કો સ્થાન સમયના જવું ન ઘરથી દૂર
ઘર આવી મા હરે શારદા દૈન્ય તિમિરના પૂર.

સંસ્કારોની સુગંધ મહેંકે, મન મંદિરને ધામે
સુખની ટપાલ પહોંચે સૌને પોતાને સરનામે;
સમાજ કેરે દરિયે હાંકી શિક્ષણ કેરું વહાણ,
આવો કરીયે આપણ સૌ
ભવ્ય રાષ્ટ્ર નિર્માણ...
દિવ્ય રાષ્ટ્ર નિર્માણ...
ભવ્ય રાષ્ટ્ર નિર્માણ

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