3D GIS

3D Models

Blender is a powerful, open-source 3D computer graphics application used for 3D modeling and creating animated films, visual effects, and motion graphics. Over this session, we'll explore how to create 3D models using Blender, understand the fundamental concepts of mesh geometry, learn the tools and workflows for 3D modeling, and discover how to integrate these models with geospatial software like ArcGIS Pro. By the end, you'll have a solid foundation in 3D modeling with Blender and understand how to use these models in geographic information systems.

Note that Blender I not the only 3D modeling software environment. We chose to use it in this course since it is free and open-source, very powerful, widely used, fairly intuitive, and offers some integration with geospatial software tools.

Module Topics

1. Mesh geometry
2. Rendering engines
3. View modes
4. Normals
5. Mesh creation and editing
6. Modifiers
7. Shade smooth
8. Snapping
9. Parenting
10. Change origin
11. Materials
12. Textures
13. UV mapping
14. Export and data types
15. Blender → GIS

2

These are the topics covered in this module.

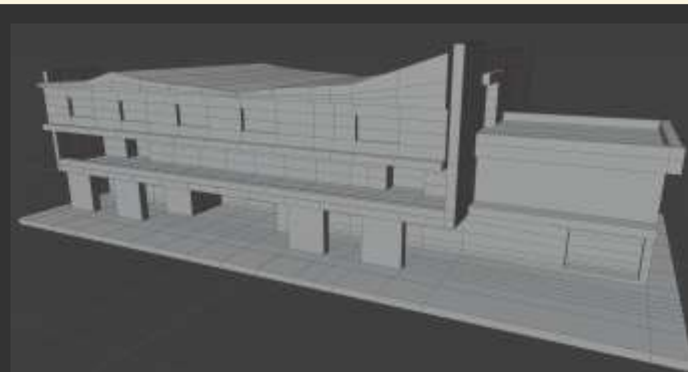
3D Modeling In Blender

3

Blender is an incredibly versatile tool for 3D modeling and rendering. It's free, open-source, and runs on multiple platforms including Windows, macOS, and Linux. Blender is used professionally in the film and game industries, and it's increasingly being adopted in geospatial and scientific applications because it can handle complex 3D data visualization and integration with GIS platforms like ArcGIS Pro. The breadth of Blender's capabilities can seem overwhelming at first, but we'll focus specifically on 3D modeling workflows that are most relevant to geospatial applications.

Mesh Geometry

- Vertices
  - *x*, *y*, *z* coordinates
- Edges
  - Connect 2 vertices
  - Wireframe of object
- Faces
  - Polygons
  - Triangles = defined by 3 edges
  - Quads = defined by 4 edges
  - Generally best to avoid faces defined by more than 4 edges (N-gon)

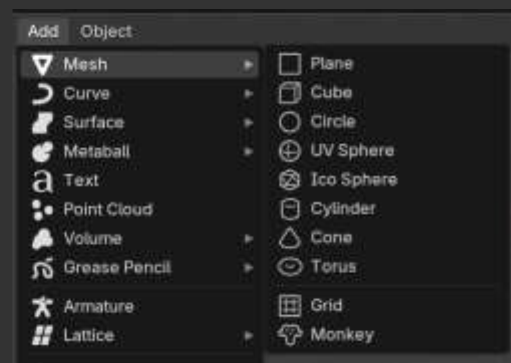


4

All 3D models in Blender are built from three fundamental geometric components. Vertices are points in 3D space, defined by x, y, and z coordinates. Edges connect two vertices together and form the wireframe of your object; if you could see only the edges, you'd see the skeleton or outline of your model. Faces are polygonal surfaces made from edges and vertices. Most commonly, faces are either triangles, defined by three edges and three vertices, or quads, defined by four edges and four vertices. Generally, it's best to avoid creating faces with more than four edges, called N-gons, because they can cause rendering and editing problems. Understanding this three-level hierarchy, vertices, edges, and faces, is fundamental to everything you'll do in Blender.

Add Mesh

- Plane
- Cube
- Circle
- UV Sphere
- Ico Sphere
- Cylinder
- Cone
- Torus
- Grid
- Monkey



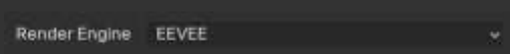
5

When you start creating a new 3D model in Blender, you don't begin from scratch. Instead, Blender provides a library of basic primitive meshes that you can add to your scene. These primitives include a Plane, which is a flat square surface, Cube, a six-faced box, Circle, a flat circular shape, UVSphere and IcoSphere, both sphere shapes created differently, Cylinder, a tube-like shape, Cone, a pointed shape, Torus, a donut-like shape, Grid, a flat subdivided plane, and Monkey, a stylized monkey head used for testing. You can add these primitives to your scene and then modify them using various tools and techniques to create more complex geometry.

Rendering Engines

Eevee

- Real-time
- Uses rasterization
- Cannot render complex lighting, materials, and textures



Cycles

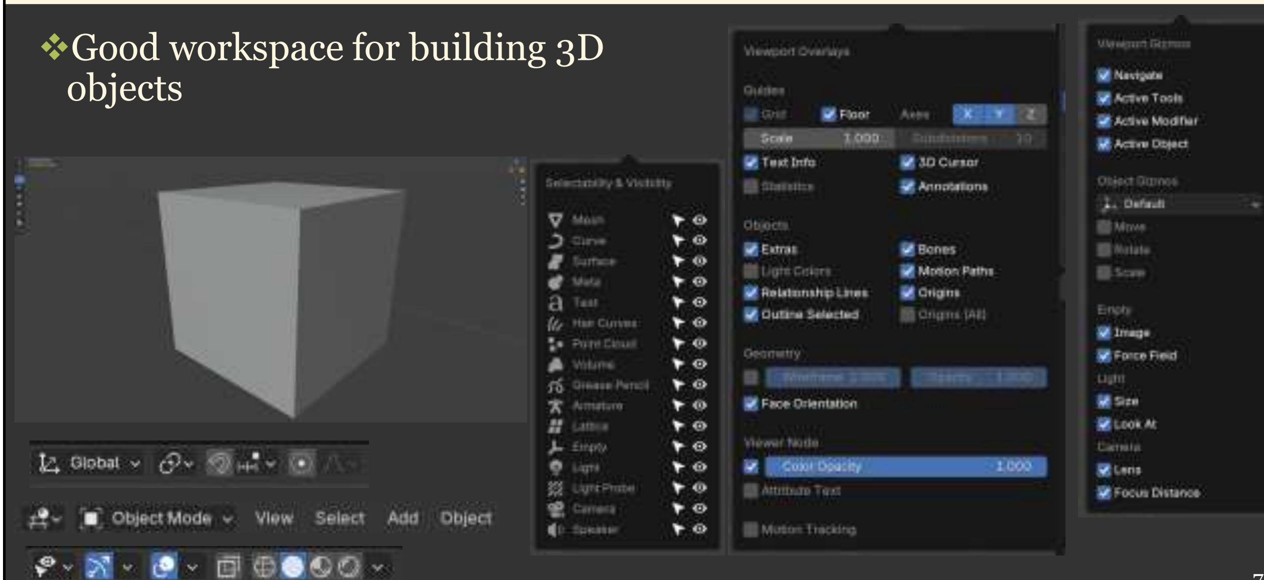
- Ray tracing
- Can render complex lighting, materials, and textures
- Models reflections, refractions, and light bouncing
- Can be highly realistic
- Speed up with GPU-based computation

6

Blender offers two primary rendering engines, each with different strengths and tradeoffs. Eevee is a real-time rendering engine that uses rasterization, the traditional graphics rendering technique used in games. Eevee is very fast and provides immediate visual feedback, making it excellent for interactive work. However, it cannot render complex lighting effects, advanced materials, and textures as accurately as other approaches. Cycles is Blender's ray-tracing rendering engine, which simulates how light actually behaves in the physical world. Cycles can model reflections, refractions, and light bouncing between surfaces, allowing for highly realistic rendering. Cycles is much slower than Eevee but can produce photorealistic results. You can also accelerate Cycles with GPU-based computation if your graphics card supports it. For most geospatial modeling, Eevee provides sufficient quality with much faster rendering.

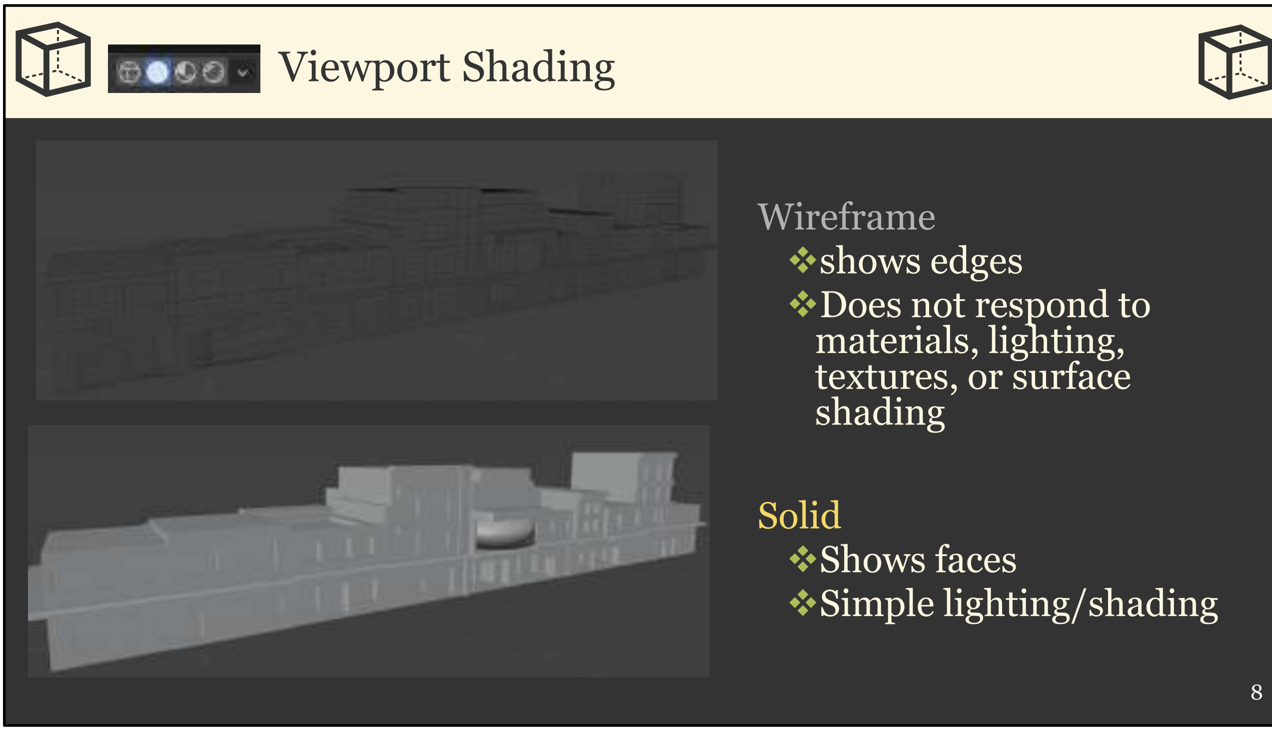
Layout Mode

- Good workspace for building 3D objects



7

The Layout workspace is the primary workspace for building 3D objects in Blender. It provides a good balance of visibility and tools for creating and manipulating 3D geometry. By default, the viewport occupies much of the screen, allowing you to see your model from any angle. To the right are panels for properties and settings, and on the left is the outliner showing your scene hierarchy. The bottom contains a timeline for animation, though for static 3D models, you won't use this much. As you become more comfortable with Blender, you'll discover other specialized workspaces optimized for specific tasks like UV unwrapping, shading, and rendering.



Blender provides multiple viewport shading modes to help you see your model in different ways while working. Wireframe mode shows only the edges of your geometry, allowing you to see the underlying structure. In wireframe mode, materials, lighting, and textures are not rendered, so you see only the skeleton of your model. This is useful for understanding the topology and structure of your mesh. Solid mode shows the faces of your geometry with simple lighting and shading, giving you a better sense of form and volume. Solid mode is usually the primary mode for modeling work.

 Viewport Shading

Material Preview
- Simplified representation of materials
- Responds to lighting
- Fast rendering using Eevee

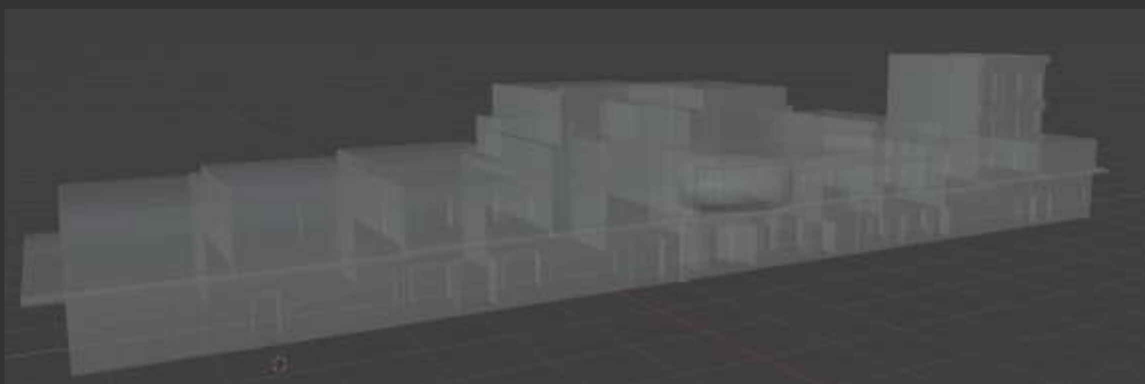
Rendered
- Final material rendering
- Responds to lighting
- Uses Cycles or Eevee
- Can be slow

9

Blender also offers two additional shading modes for more detailed visualization. Material Preview mode shows a simplified representation of your materials and how they respond to lighting. It renders much faster than the final render because it's using the Eevee real-time engine, but it still gives you a good sense of what your materials will look like. Rendered mode shows the final material rendering using either Cycles or Eevee, depending on what you've set up in your render settings. Rendered mode can be quite slow, especially with Cycles, as it's computing realistic light simulation. During modeling work, you'll typically use Solid or Material Preview modes to maintain interactivity.

X-Ray Mode

- Partially transparent view
- For selecting through components

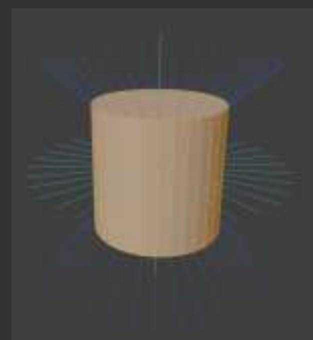


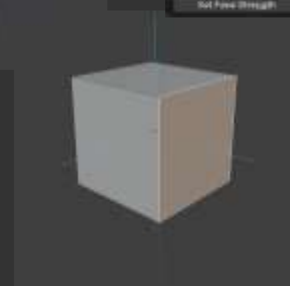
10

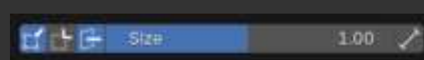
X-Ray mode is a special visualization mode in Blender that makes your model partially transparent. This allows you to see through the surfaces of your model and select components on the far side of the model that would otherwise be hidden. X-Ray mode is particularly useful when you're working with dense geometry or trying to select vertices, edges, or faces that are occluded by other parts of your model. You can toggle X-Ray mode on-and-off depending on what you need to select.

Normals

- Direction of face or vertex
- Defines inside and outside face
- Impacts lighting and some editing
- Flat shading = use normals to calculate how bright a face should be
- Smooth Shading = considers vertex normal to create variability in lighting of a face
- Normals can be edited
- Should point in the direction being rendered







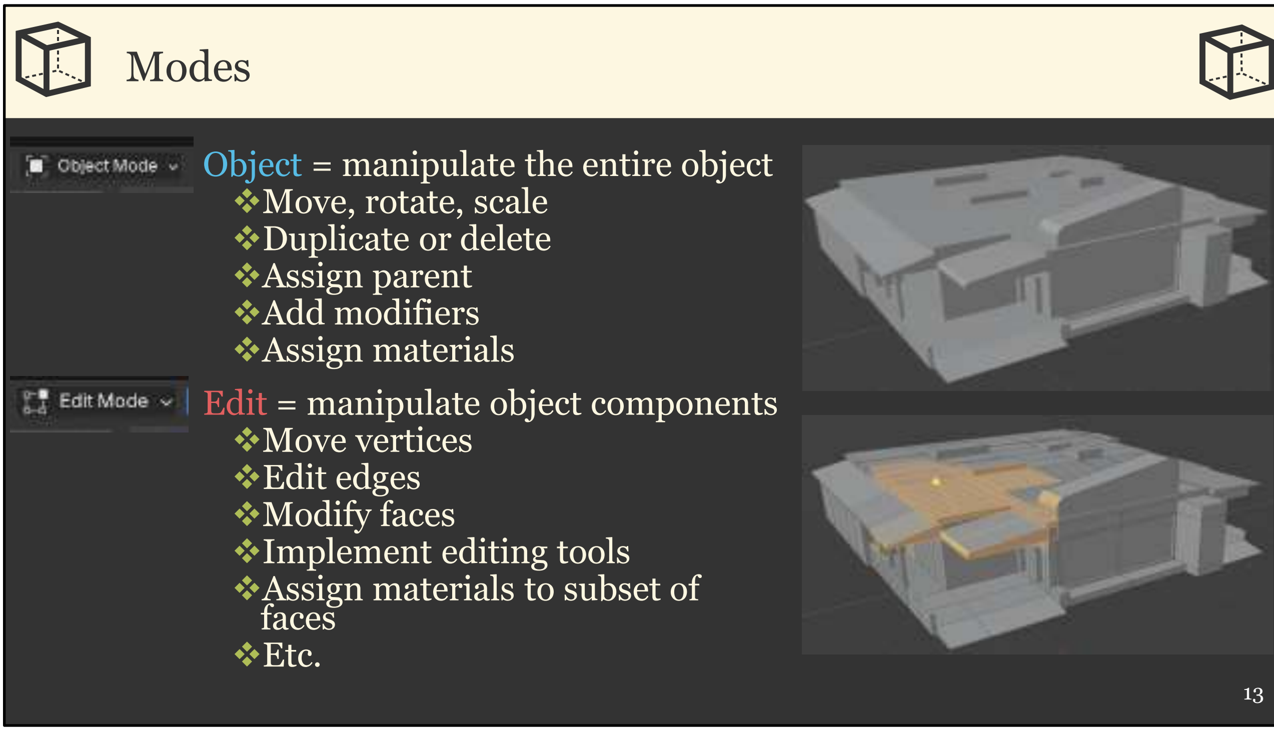
11

Normals are a fundamental concept in 3D graphics that many new users find confusing at first. A normal is a direction vector that points perpendicular to a surface, defining which way the surface is facing. Normals determine which side of a face is the 'inside' and which is the 'outside,' and they have a major impact on how lighting affects your model. Flat shading uses the normal of the entire face to calculate how bright that face should appear. Smooth shading, by contrast, considers the vertex normals and creates variation in shading across a face, producing smoother, more organic-looking surfaces. You can edit normals if needed, and they should generally point in the direction that's being rendered; if they point the wrong way, your surfaces will appear dark or invisible. Understanding and managing normals correctly is crucial for getting good rendering results.

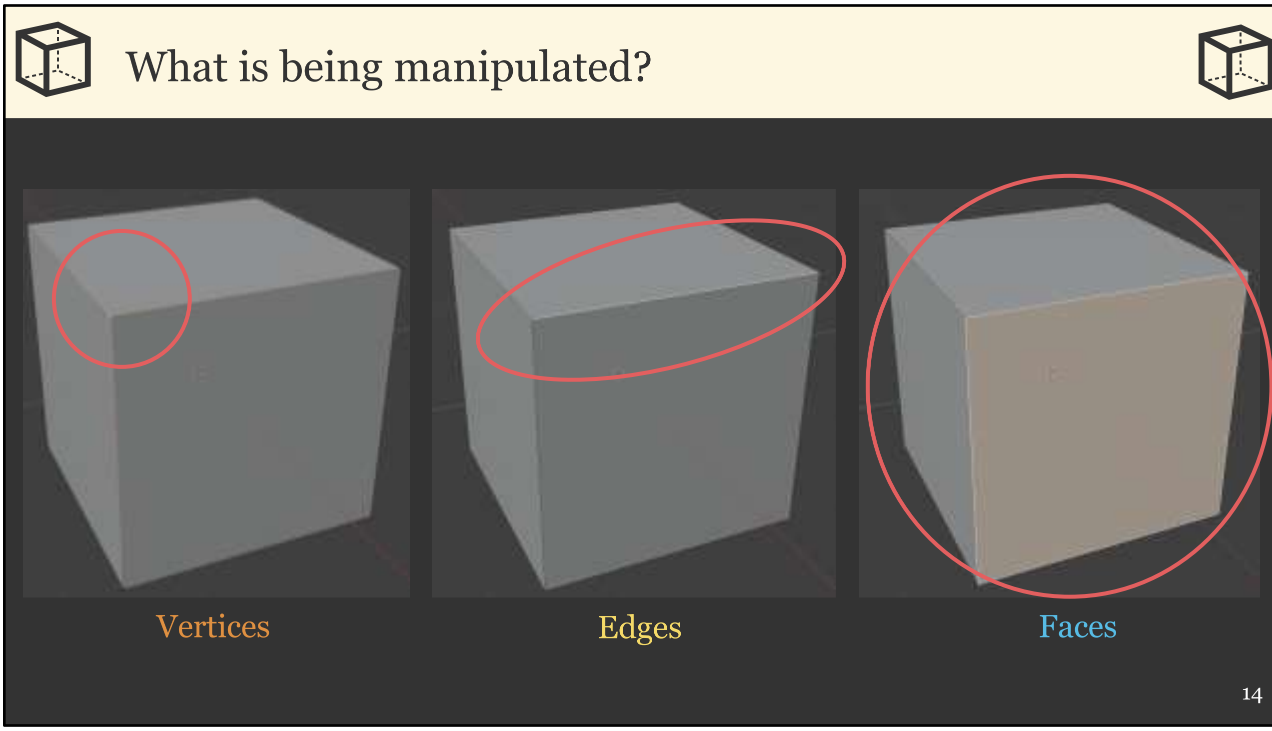
Editing Tools

12

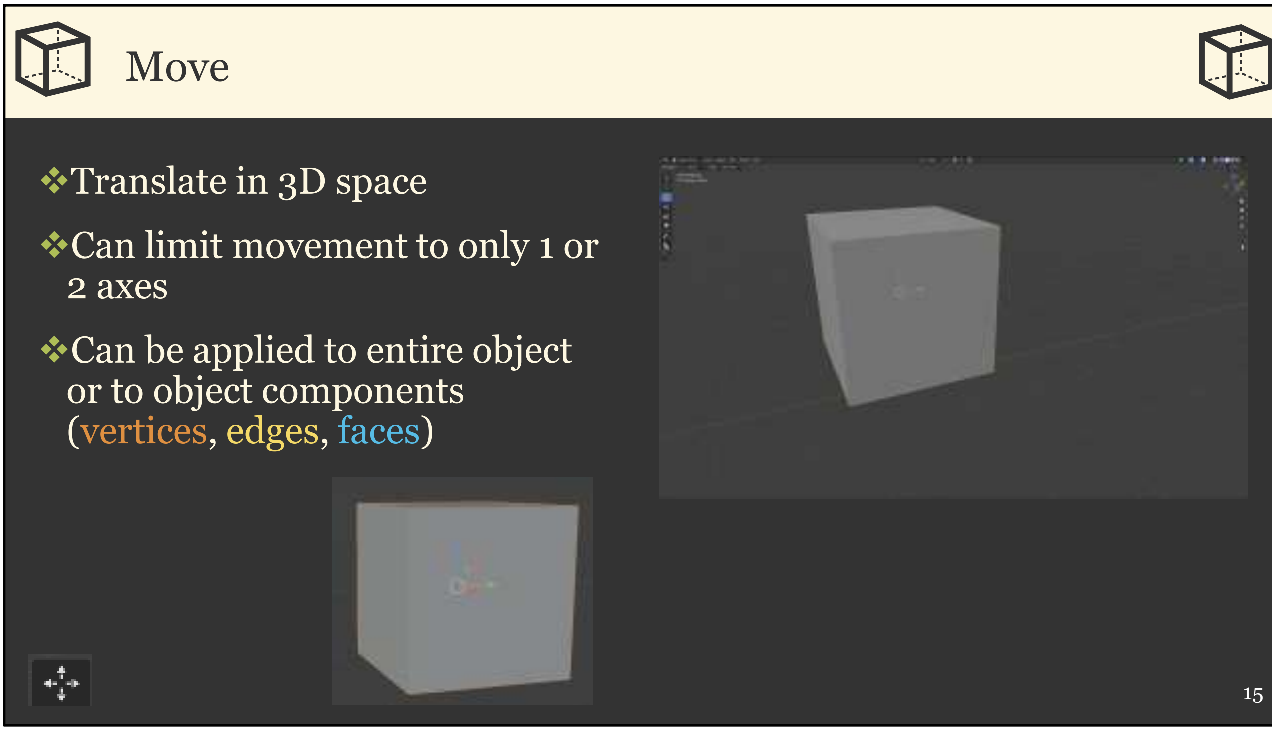
Now we'll explore the editing tools available in Blender for modifying your geometry. These tools allow you to manipulate vertices, edges, and faces in sophisticated ways. Most editing tools can be accessed through the Mesh menu when in Edit mode or through keyboard shortcuts. Understanding and mastering these tools is essential for efficient and effective 3D modeling.



Blender distinguishes between two fundamental modes of working with objects. In Object mode, you manipulate entire objects as single units. You can move, rotate, and scale objects, duplicate or delete them, assign parent relationships, add modifiers, and assign materials. In Edit mode, you manipulate individual components of an object (i.e., vertices, edges, and faces). You can move individual vertices, edit edges, modify faces, and assign materials to subsets of faces. Understanding when to work in each mode is fundamental to efficient modeling.



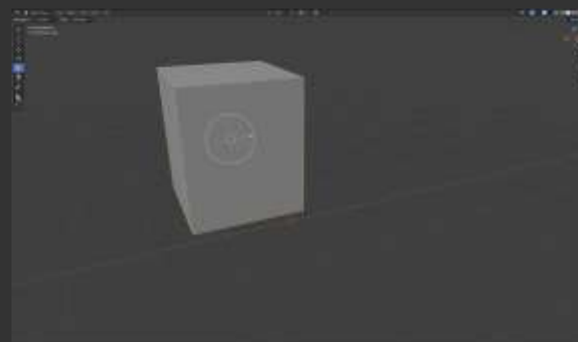
When working in Edit mode, you need to specify what you're manipulating. You can select and modify vertices, edges, or faces depending on which selection mode is active. Switching between these selection modes allows you to perform different operations on different components of your geometry.

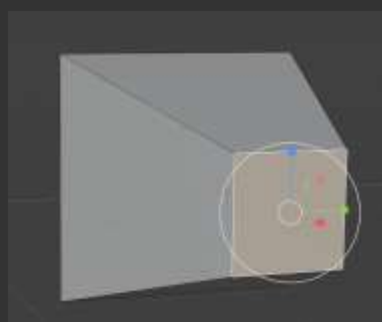


The Move tool, also called Translate, lets you move selected geometry in 3D space. You can limit movement to only one or two axes to maintain alignment with your scene's coordinate system. The Move tool can be applied to entire objects or to individual components like vertices, edges, and faces. This is one of the most fundamental operations in 3D modeling.

Scale

- Change size
- Can be applied to entire object, edges, and faces
- Can be limited to specific axes



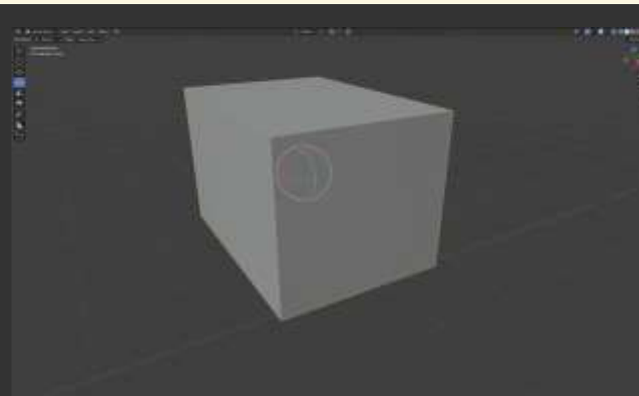


16

The Scale tool lets you change the size of your geometry. You can scale entire objects, edges, and faces. Scaling can be limited to specific axes, allowing you to stretch or compress geometry in particular directions. Combined with other tools, scaling is essential for refining your model's proportions and creating specific shapes.

Rotate

- Rotate around a point of rotation
- Can change point of rotation
- Applied to entire object, edges, or faces
- Limit rotation along specific axes

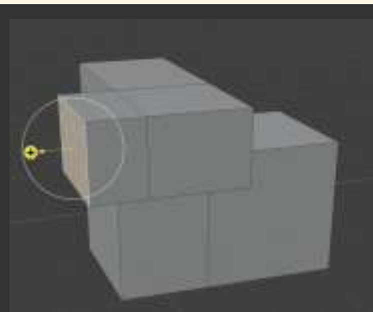


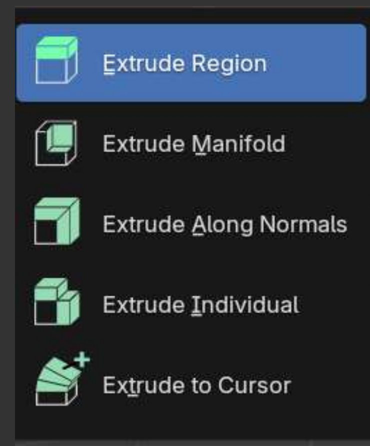
17

The Rotate tool lets you rotate geometry around a point of rotation. You can change the point of rotation depending on your needs. Rotation can be applied to entire objects, edges, or faces. You can limit rotation along specific axes. Rotation is essential for positioning geometry correctly relative to other parts of your model.

Extrude

- Extrude Region
- Extrude Manifold
- Extrude Along Normals
- Extrude Individual
- Extrude to Cursor

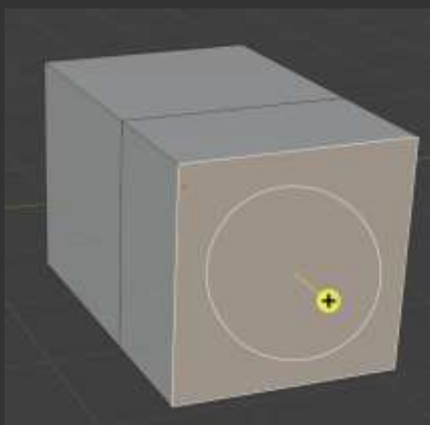


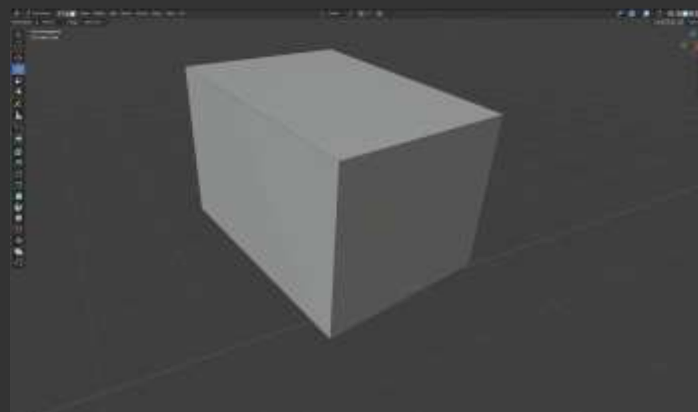


Extrusion is a fundamental modeling technique where you pull faces, edges, or vertices outward to create new geometry. Blender provides several extrusion variations, each with different characteristics and uses. Understanding these different extrusion methods expands your modeling capabilities significantly and allows you to create complex geometry efficiently.

Extrude

- **Extrude Region** = Extrude freely or along an axis



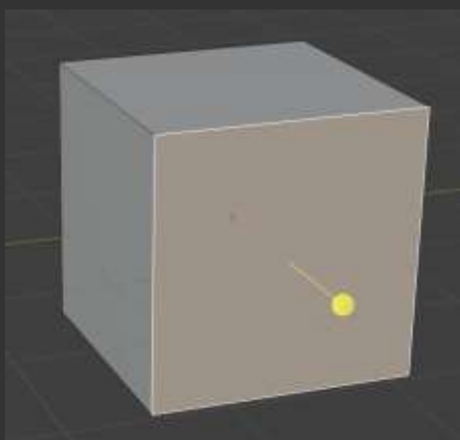


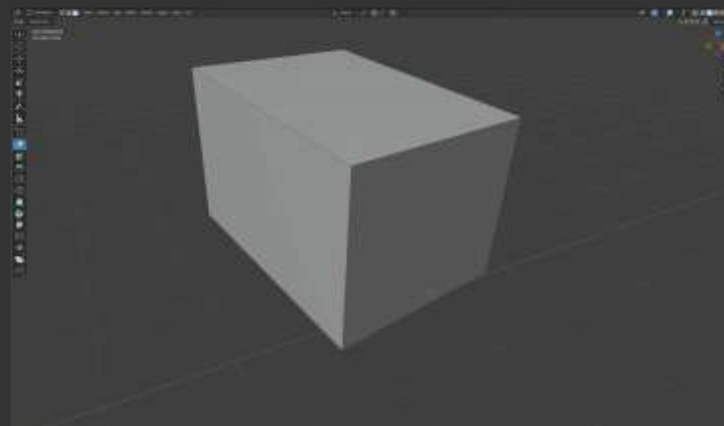
19

Extrude Region allows you to extrude freely or along an axis, creating new geometry from the selected region.

Extrude

- **Extrude Manifold** = Extrude and dissolve flat faces



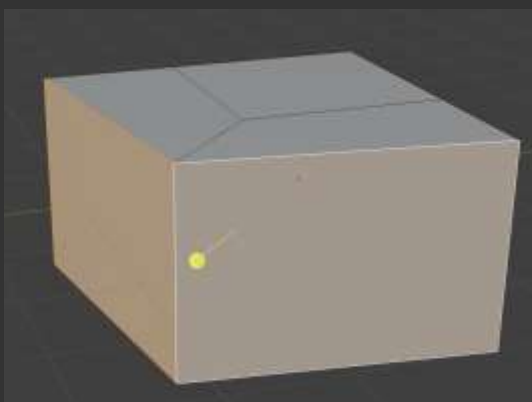


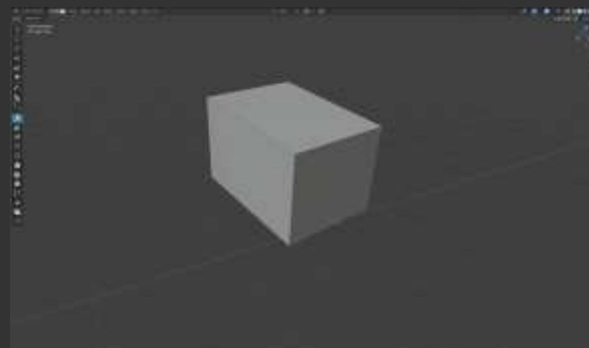
20

Extrude Manifold extrudes and dissolves flat faces. These methods are commonly used for creating complex geometry from simple starting forms.

Extrude

- **Extrude Along Normals** = Extrude regions together along local normals



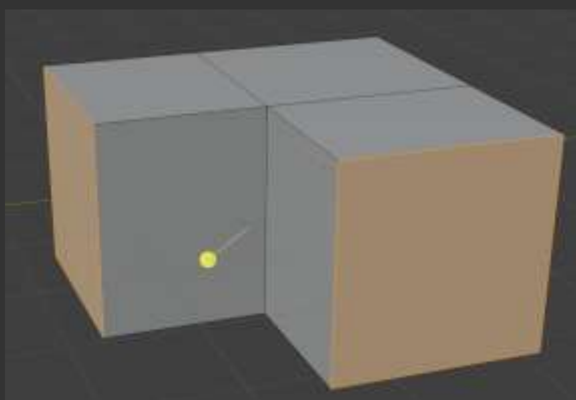


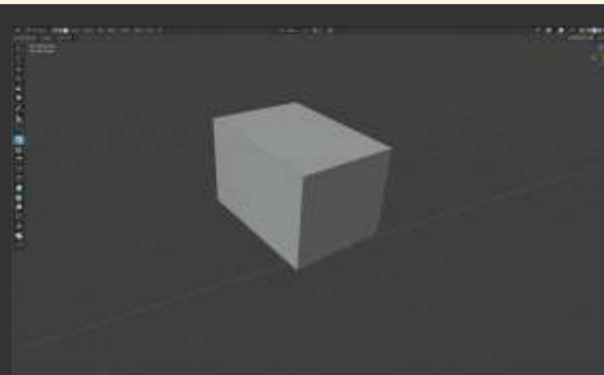
21

Extrude Along Normals extrudes regions together along local normals, following the direction the surface is facing.

Extrude

❖ Extrude Individual = Extrude faces individually relative to normals



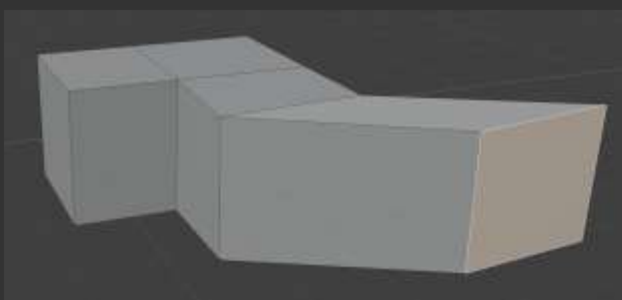


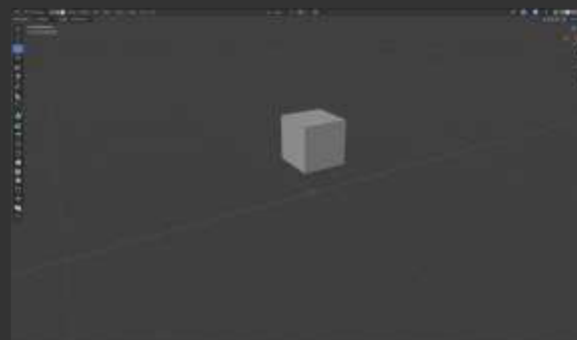
22

Extrude Individual extrudes faces individually relative to their normals.

Extrude

❖ Extrude Cursor = Duplicate and extrude toward mouse cursor



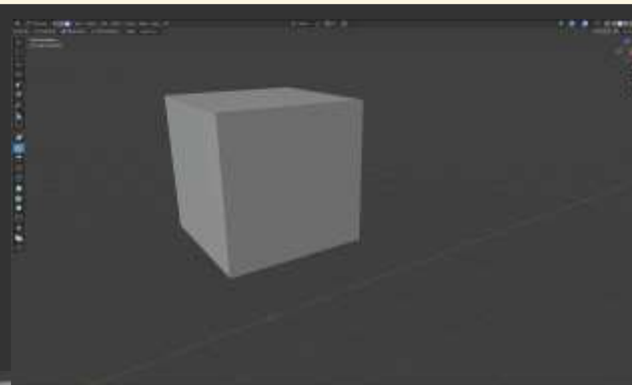


23

Extrude Cursor duplicates selected geometry and extrudes it toward the mouse cursor. This provides an intuitive way to extrude geometry directly toward a specific location in your viewport.

Insert Face

- Insert face into selected face
- Can move and scale new face after creating it
- If multiple faces are selected, can insert new faces collectively or separately

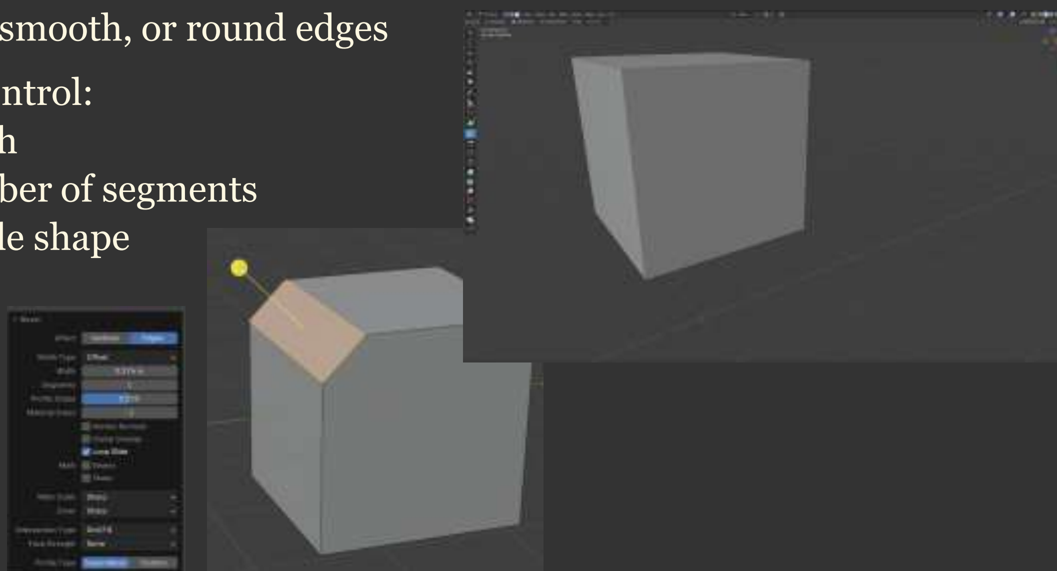


24

The Inset Face tool inserts a face into a selected face, creating a smaller face inside. You can move and scale the new face after creating it. If multiple faces are selected, you can insert new faces collectively or separately. Inset is useful for creating panels, details, and surface features.

Bevel

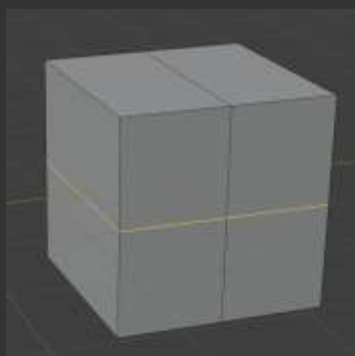
- Bevel, smooth, or round edges
- Can control:
  - Width
  - Number of segments
  - Profile shape
  - Etc.

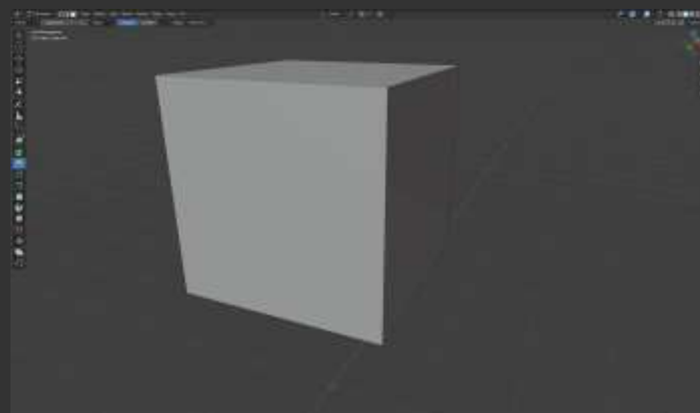


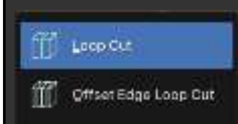
The Bevel tool bevels, smooths, or rounds edges of your geometry. You can control the width of the bevel, the number of segments in the bevel, the profile shape, and other parameters. Beveling makes models look more realistic and polished, and it helps reduce rendering artifacts.

Loop Cut

❖ Cut mesh loop and slide to place





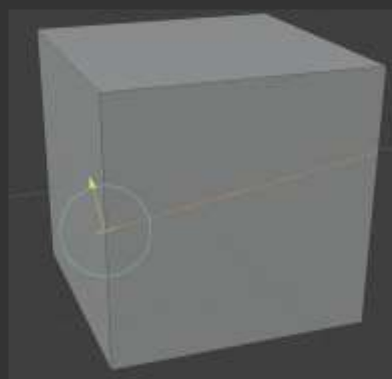


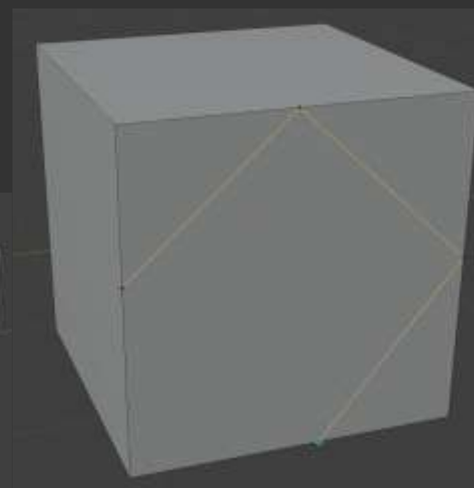
26

The Loop Cut tool cuts a mesh loop through your geometry and allows you to slide it to place. This creates new edge loops across your mesh, essential for adding detail where needed and for properly managing topology.

Knife

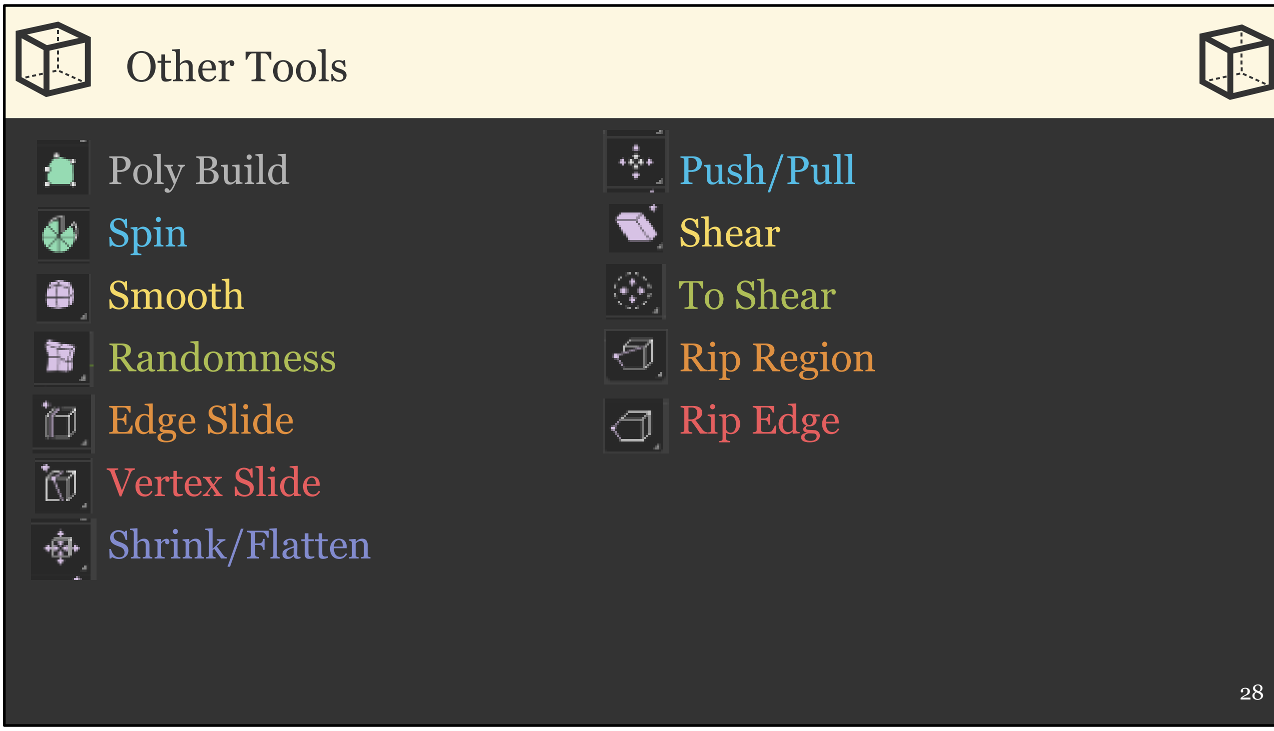
- Knife = Add edges to cut up shapes and modify topology
- Bisect = cut along a plane





27

The Knife tool adds edges to cut up shapes and modify topology, giving you fine control over geometry structure. The Bisect tool cuts geometry along a plane. Both tools are useful for creating complex geometry and refining your model's topology.



Beyond the major editing tools, Blender provides many other specialized tools. Poly Build lets you build geometry vertex by vertex. Spin creates rotational duplicates. Smooth smooths selected geometry. Randomness adds random variation. Edge Slide and Vertex Slide let you reposition edges and vertices. Push/Pull moves geometry. Shear creates deformation. These tools expand your modeling capabilities.

Things to Avoid

1. N-gons
2. Overly complex geometry
3. Gaps or unclosed volumes
4. Self-Intersections
5. Incorrect Face Orientation

29

As you model, it's important to be aware of and avoid certain issues. N-gons with too many sides are overly complex and can cause rendering problems. Gaps or unclosed volumes prevent proper shading and rendering. Self-intersections where faces overlap cause lighting and rendering issues. Incorrect face orientation where normals point the wrong direction causes shading problems. Being aware helps you create clean, renderable geometry.

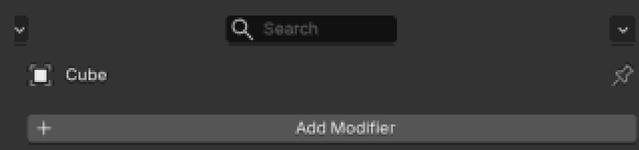
Modifiers

30

Modifiers in Blender are non-destructive effects that change your geometry without permanently altering it. This means you can add a modifier, see its effect, adjust parameters, or remove it entirely without losing your original geometry. Modifiers form a core part of advanced 3D modeling workflows and are incredibly powerful for creating complex geometry efficiently.

Modifiers

- Non-destructive
- Can stack and change order
- Can edit settings later
- Can turn them on-and-off
- Can apply them to the object permanently (destructive)

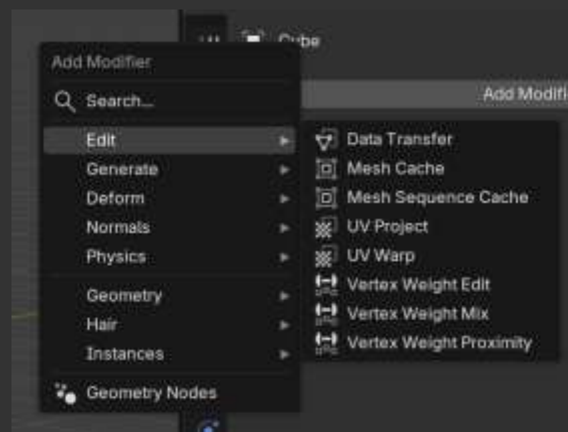


31

Modifiers are non-destructive, allowing you to preserve your original geometry throughout your workflow. You can stack multiple modifiers and change their order to control how they interact. You can edit modifier settings at any time. You can turn modifiers on and off to see their effects. You can also apply modifiers permanently to the object if needed. This flexibility makes modifiers essential for modern 3D modeling.

Modify

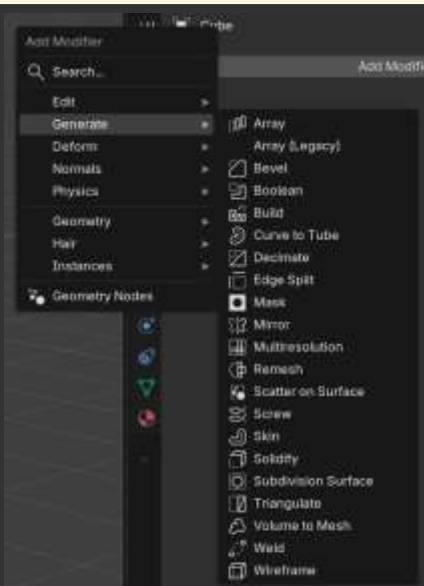
- Data Transfer
- Mesh Cache
- Mesh Sequence Cache
- Normal Edit
- UV Project
- UV Warp
- Vertex Weight Edit
- Vertex Weight Mix
- Vertex Weight Proximity
- Weight Normal



32

Blender provides modifiers in the Modify category for modifying existing geometry. Data Transfer copies data from one object to another. Mesh Cache and Mesh Sequence Cache handle animation data. Normal Edit controls normals. UV Project and UV Warp work with texture coordinates. Vertex Weight tools control how other modifiers affect geometry.

Generate

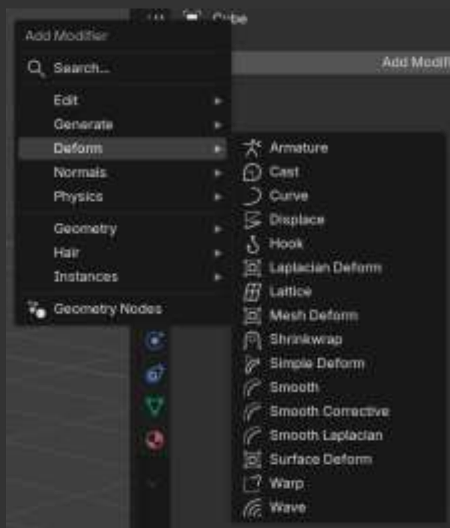


- Array
- Bevel
- Boolean
- Build
- Decimate
- Edge Split
- Mask
- Mirror
- Multiresolution
- Remesh
- Screw
- Skin
- Solidify
- Subdivision Surface
- Triangulate
- Wireframe

33

The Generate category includes modifiers for creating new geometry. Array duplicates geometry in patterns. Bevel bevels edges. Boolean combines objects. Build creates construction animations. Decimate reduces geometry. Edge Split splits edges. Mask hides geometry. Mirror creates mirrored copies. Multiresolution handles subdivision. Remesh remeshes geometry. Screw, Skin, Solidify, Subdivision Surface, Triangulate, and Wireframe provide additional generation options.

Deform

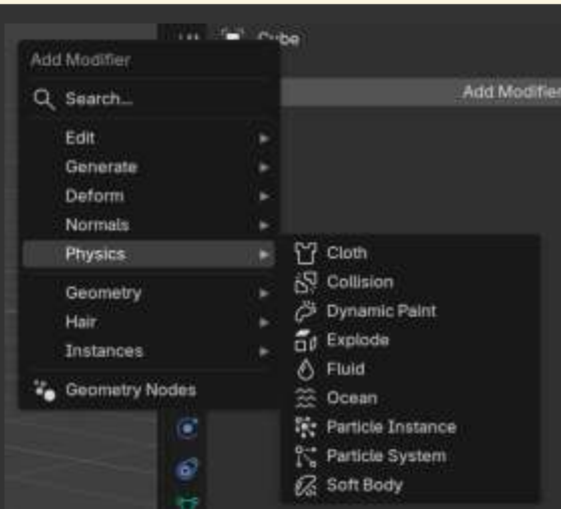


- Armature
- Cast
- Corrective Smooth
- Curve
- Displace
- Hook
- Laplacian Smooth
- Laplacian Deform
- Lattice
- Mesh
- Shinkwrap
- Simple
- Smooth
- Surface Deform
- Warp
- Wave

34

The Deform category includes modifiers that reshape geometry. Armature uses bones for animation. Cast transforms to simple shapes. Corrective Smooth corrects deformations. Curve bends geometry along a curve. Displace moves geometry based on textures. Hook, Lattice, and Shinkwrap deform with external objects. Laplacian Smooth and Warp provide advanced deformation.

Simulate



- Cloth
- Collision
- Dynamic Paint
- Explode
- Fluid
- Ocean
- Particle Instance
- Particle System
- Soft Body

35

The Simulate category includes modifiers for dynamic effects. Cloth simulates cloth physics. Collision defines collision boundaries. Dynamic Paint allows painting. Explode creates explosion effects. Fluid simulates fluid dynamics. Ocean creates ocean surfaces. Particle Instance and Particle System manage particles. Soft Body simulates soft physics.

We will explore some of these simulations in the Animation module.

Example: Bevel

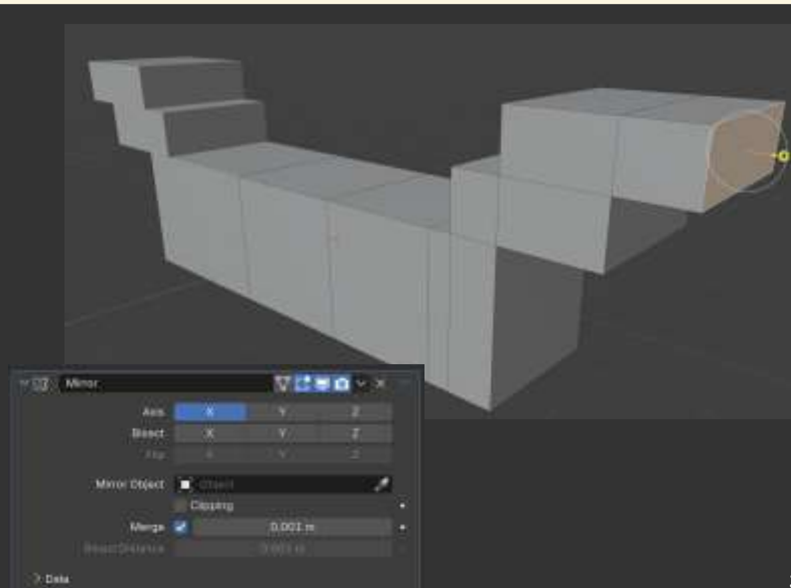
- Non-destructive bevel

36

Here's an example of using the Bevel modifier non-destructively. The Bevel modifier creates rounded edges without permanently changing your base geometry. You can adjust the bevel amount, number of segments, and profile shape at any time. This is much more flexible than manually beveling geometry.

Example 2: Mirror

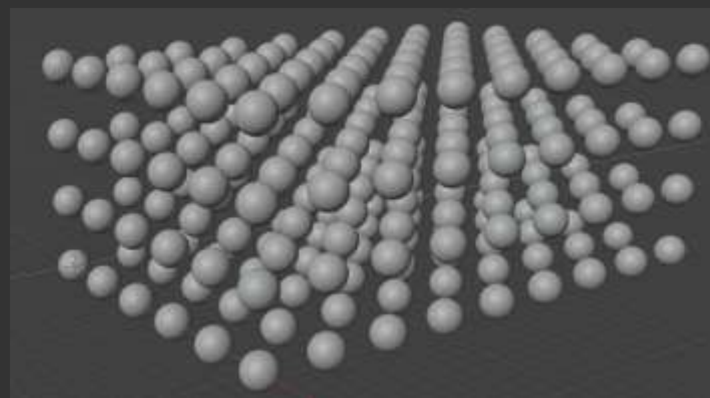
- Mirror created geometry relative to an axis or axes
- Great for creating symmetrical objects
- Can apply to generate the mirrored features (destructive)



The Mirror modifier creates geometry relative to an axis or axes. It's great for creating symmetrical objects—you can model half an object and mirror it to create the full object. You can apply the modifier to generate the actual mirrored features destructively if needed.

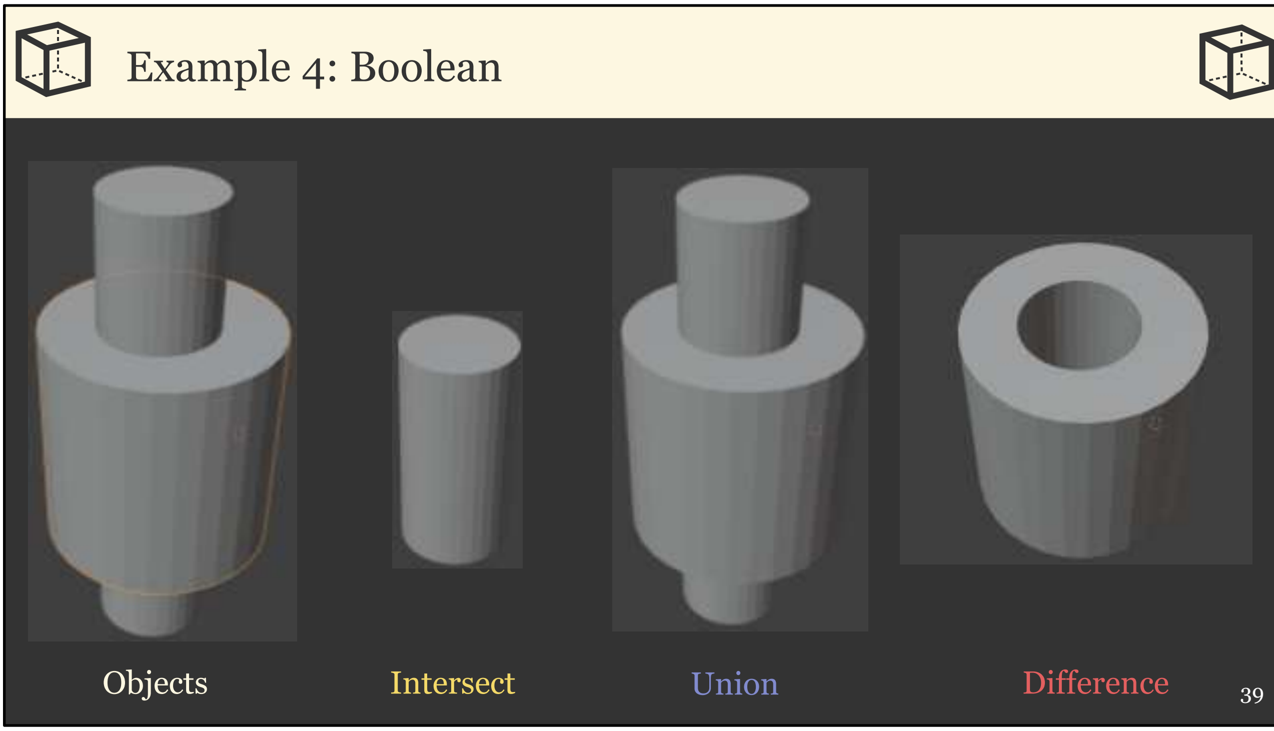
Example 3: Array

- Repeat an object along a dimension



38

The Array modifier repeats an object along a dimension, creating multiple copies in a pattern. This is useful for creating repeating structures like fences, columns, or tiled patterns without manually duplicating geometry.

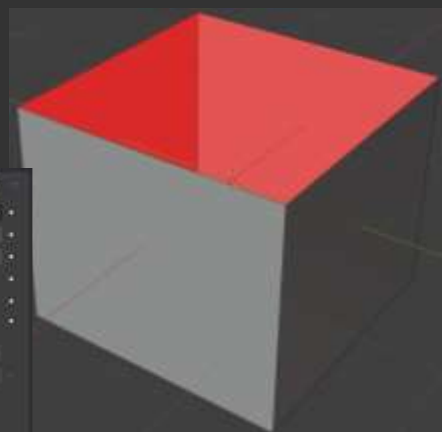


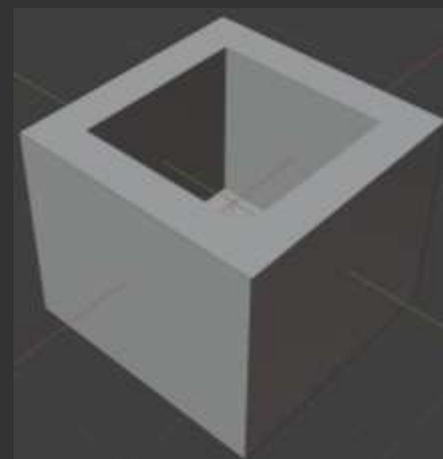
The Boolean modifier combines objects using operations. Intersect keeps only overlapping volume. Union combines objects into one. Difference removes one object from another. Boolean operations let you create complex shapes by combining simple ones.

These are similar to vector overlay methods (e.g., intersect, union, erase, and symmetrical difference) used in GIS.

Example 5: Solidify

❖Add thickness to faces



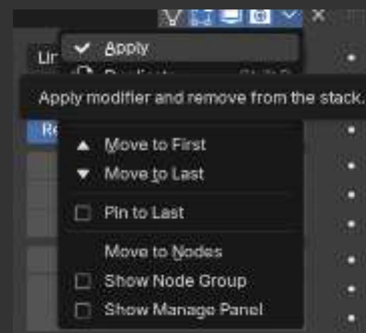


40

The Solidify modifier adds thickness to faces, useful for creating hollow objects from single-sided geometry. This is particularly useful for converting 2D surfaces into 3D solid objects.

Make Permanent (Destructive)

- Permanently alter the geometry/model
- Modifier order matters
- If you have a stack of modifiers, generally must apply all modifiers applied before the one you want to make permanent



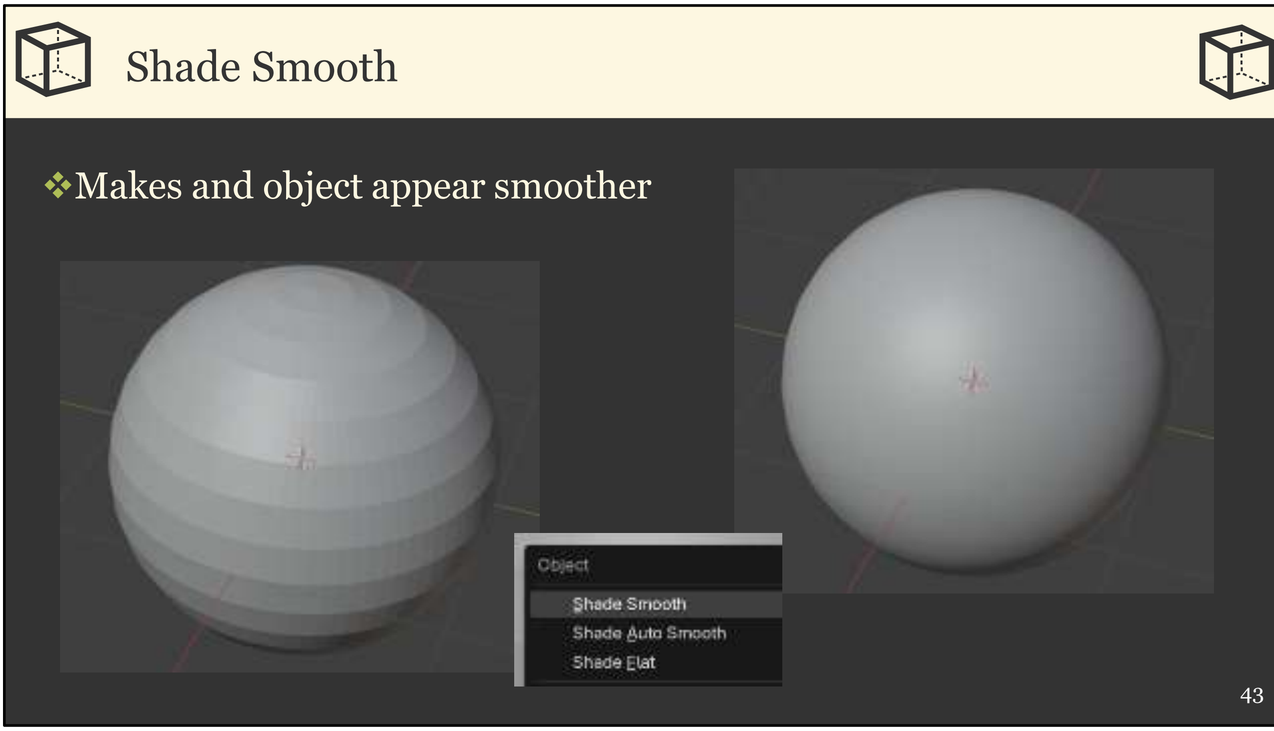
41

You can make modifiers permanent by applying them, which permanently alters the geometry. Note that modifier order matters: if you have a stack of modifiers, you must generally apply all modifiers before the one you want to make permanent. Planning your modifier stack is important.

Other Useful Operations

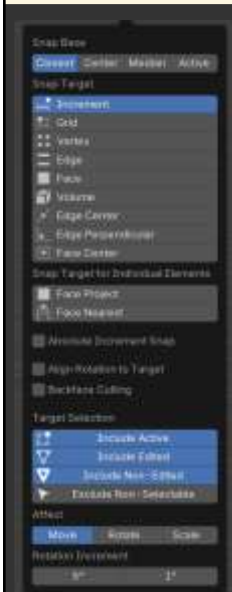
42

Beyond modifiers, Blender provides other useful operations for refining your models. These operations help you achieve specific effects and optimize your workflow for different modeling tasks.



The Shade Smooth operation makes an object appear smoother without actually adding geometry. By interpolating normals, smooth shading creates the appearance of smooth curvature even on faceted geometry. This is essential for making low-geometry models appear smooth in renders.

Snapping



Increment = snaps to increments of length or angle with translation, rotation, or scaling

Grid = similar to increment except snaps to absolute grid position rather than using a relative offset

Vertex = vertex of other geometries

Edge = points along edges of other geometry

Face Project = projects the selection onto face surfaces along the view direction

Face Nearest = snaps to the nearest point on any face surface; useful for conforming geometry to another mesh regardless of view angle

Volume = center of volume

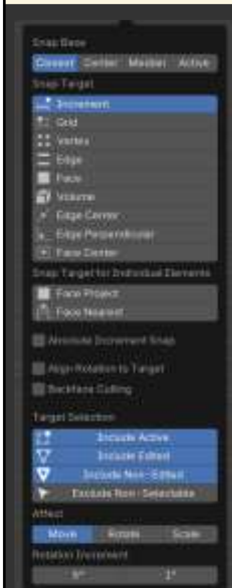
Edge Center = midpoint of edges

Edge Perpendicular = transform forms a perpendicular line to the target edge

44

Snapping is useful for maintaining alignment or connections between objects. This slide describes some of the methods available for determining what the selected object snaps to.

Snapping



- ❖Closest = point on the selection closest to the target
- ❖Center = transform pivot point
- ❖Median = median of the selection
- ❖Active = active element

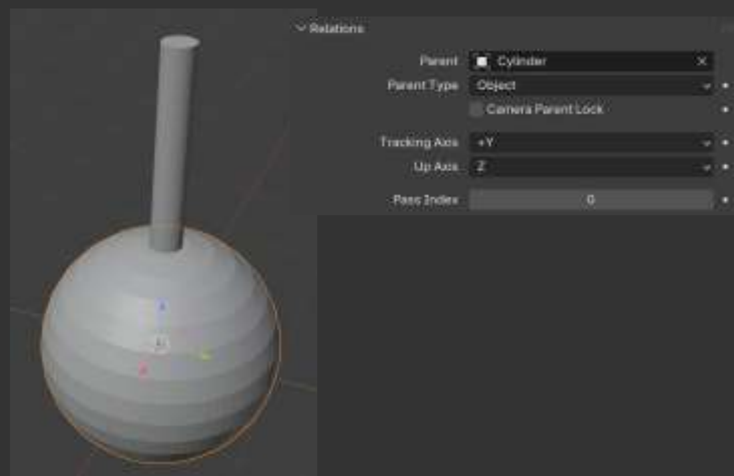
- ❖Snapping can affect translation, rotation, and/or scale

45

There are also options available for determining which part of the selection is used as the snapping reference point. Snapping can be configured to impact translation, rotation, and/or scale transforms.

Define Parent

- ❖Used to tie objects together
- ❖Make objects move together or relative to each other
- ❖Useful for animation

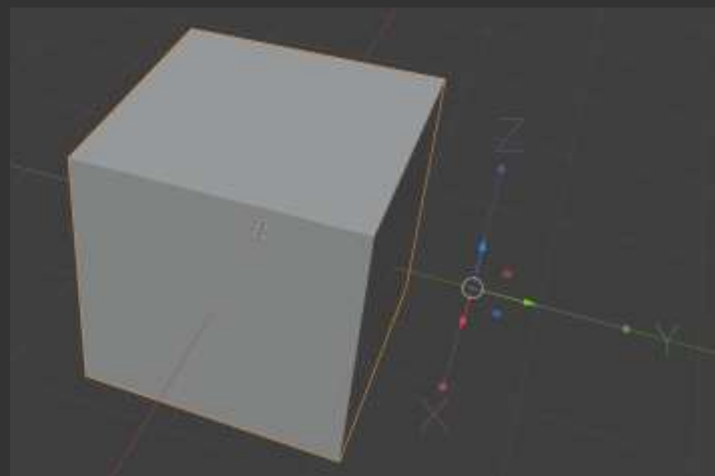


46

Defining parent relationships ties objects together, making them move together or relative to each other. This is particularly useful for animation and for managing complex scenes with multiple related objects.

Change Origin

- Useful for animations and rotations



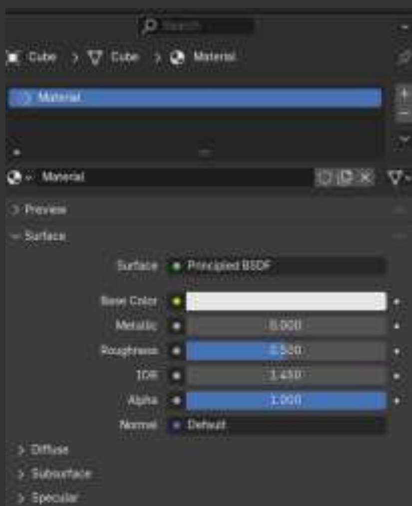
47

Changing the origin of an object is useful for animations and precise rotations. The origin point is where transforms like rotation are applied, so moving it can significantly affect how your object behaves.

Materials

Materials define how objects look and how they interact with light. Creating and managing materials is essential for achieving realistic renders and visual quality in your 3D models.

Adding Materials



- Define how objects looks and interacts with light
- Can be applied to entire object
- Can be applied to selected faces of an object
- Can apply multiple materials
- Can re-use materials between objects
- Most be in Material Preview or Rendered Viewport Shading to see
- Rendering engine can impact look of materials

49

Materials define how objects look and interact with light. You can apply materials to entire objects or to selected faces of an object. You can apply multiple different materials to different parts. You can reuse materials between objects for consistency. To see materials properly, you must be in Material Preview or Rendered Viewport Shading. Your rendering engine choice impacts the appearance of materials.

Impact of Mode

- Object Mode = define for entire object
- Edit Mode = define for selected faces

50

The mode you're working in affects how materials are applied. In Object Mode, you define materials for the entire object. In Edit Mode, you define materials for selected faces.

Material Types

- ❖Diffuse BSDF
- ❖Emission
- ❖Glass BSDF
- ❖Glossy BSDF
- ❖Metallic BSDF
- ❖Principle BSDF
- ❖Specular BSDF
- ❖Subsurface Scattering
- ❖Translucent BSDF
- ❖Transparent BSDF
- ❖Volume Absorption
- ❖Volume Coefficient
- ❖Volume Scatter

51

Blender provides many material types in the Shader Editor. Diffuse BSDF, Emission, Glass BSDF, Glossy BSDF, Metallic BSDF, Principled BSDF, Specular BSDF, Subsurface Scattering, Translucent BSDF, Transparent BSDF, and Volume options provide flexibility for creating different material effects.

Material Properties

Property	Description	Values
Base Color	Color of light diffusely reflected from the surface	RGB + Alpha; HSV + Alpha
Metallic	Behave like a metal or non-metal	0 = dielectric (diffuse color + white reflections) 1.0 = no diffuse color, colored reflections
Roughness	Sharpness of reflections	0 = perfect mirror; 0.2 = polished; 0.5 – satin/plastic; 0.8 = chalk/stone; 1.0 = matte
IOR (Index of Refraction	How much light bends and reflects at grazing angles	1 = Air; 1.33 = Water; 1.45 = Plastic; 1.5 = Glass; 2.42 = Diamond
Alpha	How much light passes through	1 = opaque; 0.5 = semitransparent; 0.0 = invisible
Normal	Surface orientation perturbations	

Material properties control the appearance of surfaces. Base Color defines the color and reflectivity. Metallic determines metal-like or non-metal appearance. Roughness controls reflection sharpness. IOR affects light bending and reflection. Alpha controls opacity. Normal maps affect surface orientation. Understanding these properties is essential for creating realistic materials.

Material Properties (Lobes)

Lobe	Description
Diffuse	Light scattering inside opaque surface
Subsurface	Light penetrates material and exists elsewhere
Specular	Surface reflection (plastic/glass shine)
Transmission	Light passes through
Coat	Clear varnish layer
Sheen	Microfiber edge flow
Emission	Object produces light
Thin Film	Soap bubble/oil rainbow interference

53

Material lobes represent different light scattering behaviors. Diffuse scatters light inside opaque surfaces. Subsurface penetrates material and exits elsewhere. Specular reflects from surfaces. Transmission passes through. Coat adds a varnish layer. Sheen creates microfiber effects. Emission makes objects produce light. Thin Film creates interference colors.

Non-Surface Properties

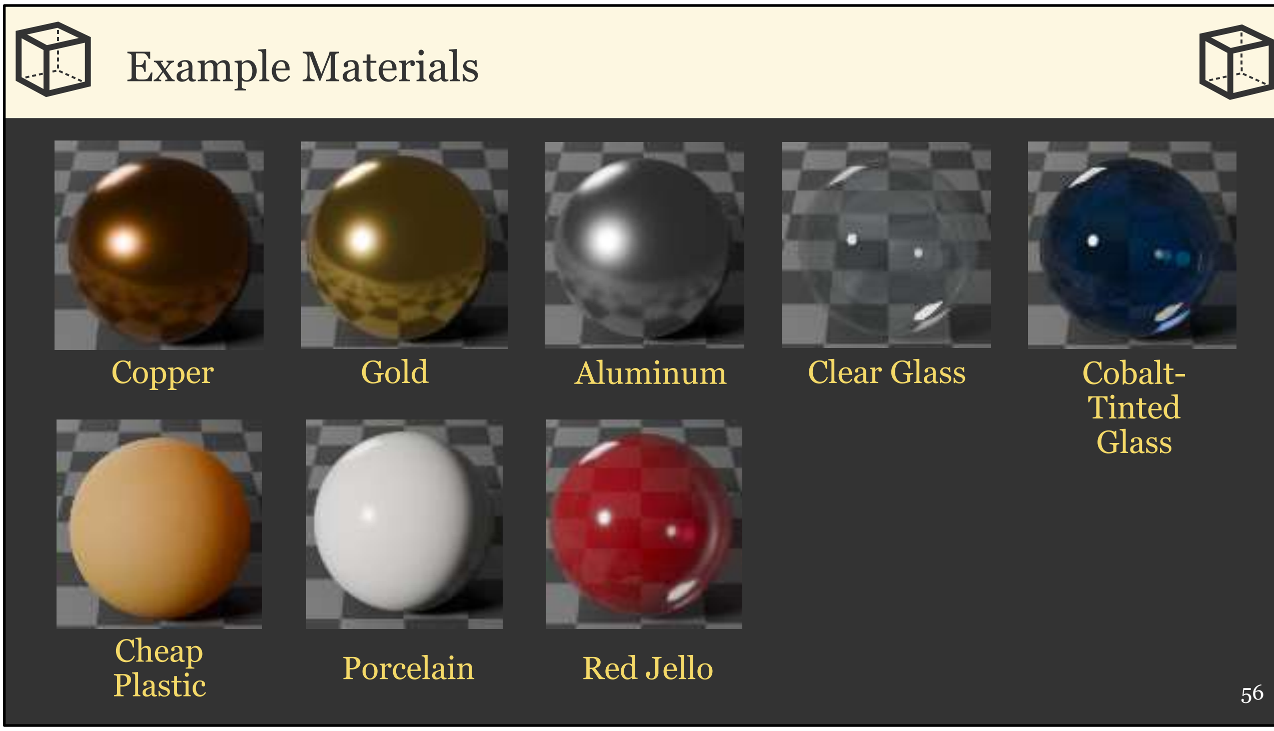
- **Volume** = controls simulation of light interacting with the material throughout its interior
- **Displacement** = impacts silhouette
- **Thickness** = how far light travels inside of a thin object before exiting

Non-surface properties affect how light interacts throughout the material. Volume controls light simulation in the material interior. Displacement impacts silhouette. Thickness controls how far light travels inside thin objects.

Example Materials

Material	Base Color / Tint	Metallic	Roughness	Transparency / Transmission	Key Extra Settings
Copper	#B87333	1	0.22–0.38	None	Anisotropic 0.2–0.5 for brushed copper
Gold	#D4AF37 or #FFD36A	1	0.18–0.32	None	Use warm orange-yellow, not pure yellow
Chrome	#F2F2F2	1	0.02–0.08	None	Needs HDRI or strong reflections
Aluminum	#BFC3C6	1	0.25–0.45	None	Anisotropic 0.4–0.8 for brushed aluminum
Clear Glass	Pale blue/gray	0	0.00–0.05	Transmission 1.0; Alpha 0.1–0.4	IOR 1.45; optional Volume Absorption
Cobalt Glass	#0047AB	0	0.00–0.08	Transmission 1.0; Alpha 0.25–0.6	IOR 1.45; blue Volume Absorption
Cheap Plastic	Any color	0	0.45–0.75	None	Optional subtle Noise → Bump texture
Red Jello	#C00020	0	0.08–0.20	Transmission 0.4–0.8; Alpha 0.35–0.65	IOR 1.33–1.38; Subsurface 0.3–0.7
Porcelain	Warm white #F7F3EA	0	0.18–0.35	None	Coat 0.3–0.7; Coat Roughness 0.03–0.12

Here are example materials with specific property values. Copper uses orange-gold color, metallic setting, and moderate roughness. Gold uses warm yellow, metallic, and low roughness. Chrome is highly reflective with very low roughness. Glass is transparent with transmission enabled. Each material type has specific requirements for realistic appearance.



These example materials show how different properties combine to create realistic appearances. Each material demonstrates proper use of color, metallic, roughness, and transparency settings for photorealistic results.

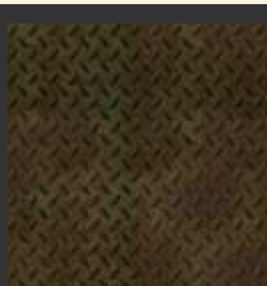
Textures

57

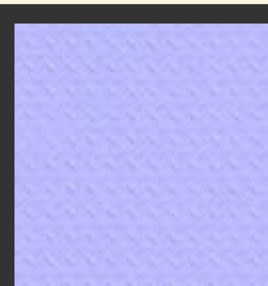
Textures are image files that provide detailed visual information to your materials. Rather than having a single color, textures can be photographs or procedurally generated patterns that provide surface detail variation.

Texture Components

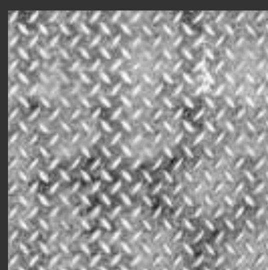
- **Base Color** = image



- **Normal** = "bumpiness"



- **Metallic** = where object is metallic



- **Roughness** = "shininess"

https://polyhaven.com/a/metal_plate

58

Textures serve specific purposes in materials. Base Color textures provide detailed color information. Metallic textures define where objects are metallic. Normal textures provide bumpiness and surface detail. Roughness textures define shininess. Using appropriate textures creates realistic, detailed models.

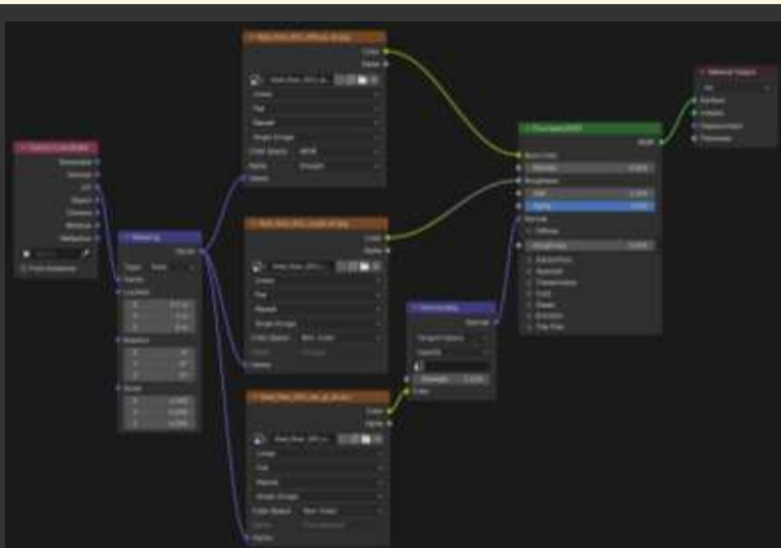
UV Mapping

- Process of flattening a 3D mesh into a 2D plane to apply textures
- u = horizontal
- v = vertical
- 3D vector now has x, y, z, u, and v coordinates

59

UV Mapping is the process of flattening your 3D mesh into a 2D plane so textures can be applied. UV coordinates use U for horizontal and V for vertical dimensions. Your 3D model now has X, Y, Z, U, and V coordinates. Proper UV mapping is essential for correct texture application.

Shader Editor

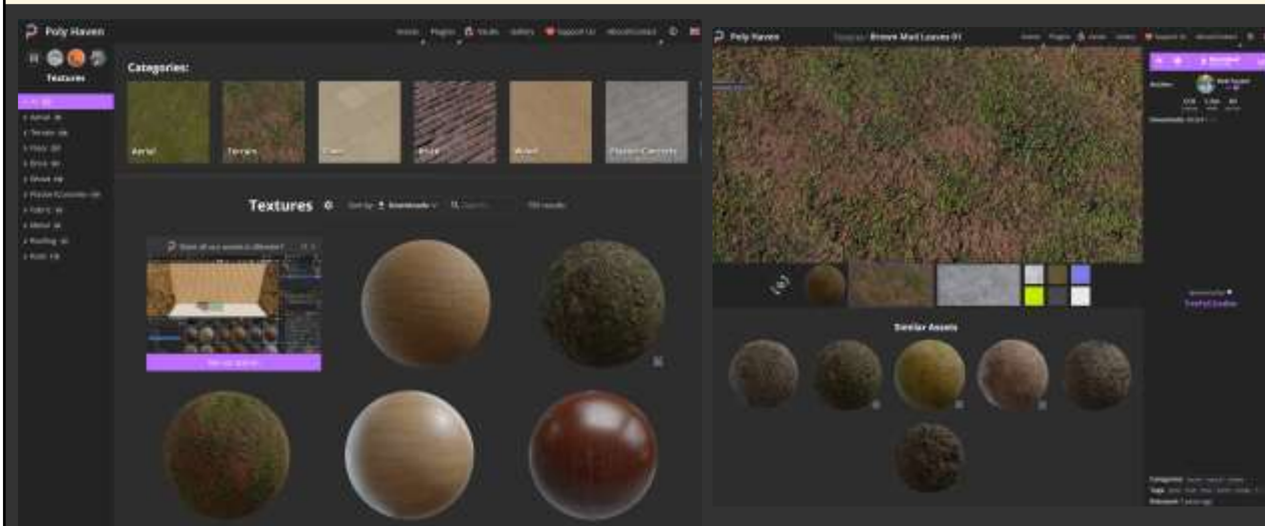


https://polyhaven.com/a/tiled_floor_001

60

The Shader Editor is where you build material networks using shader nodes. This is where you connect textures, adjust properties, and create complex material effects. The Shader Editor gives you precise control over material appearance.

Poly Haven



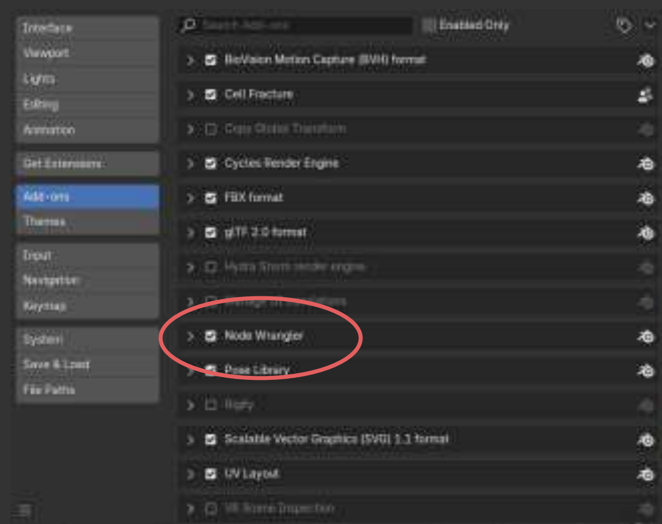
https://polyhaven.com/

61

Poly Haven is an excellent resource for free, high-quality textures and materials. The website provides textures for various surfaces that you can use in your Blender projects. Using quality textures significantly improves the realism of your renders.

Node Wrangler Plugin

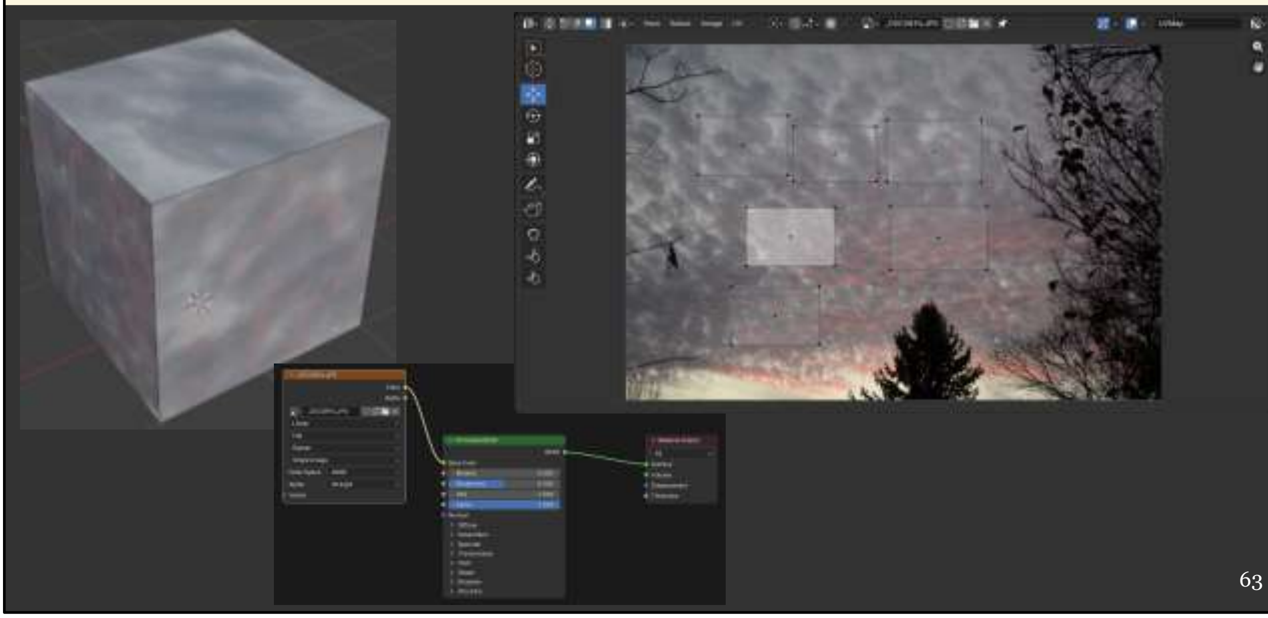
- ❖Must turn on
- ❖Edit → Preferences → Add Ons
- ❖Click on Principled BSDF Node in Shader Editor
- ❖CTRL+SHIFT+T
- ❖Add all files
- ❖Automatically set up the node tree



62

The Node Wrangler plugin makes it easier to set up materials/textures for an object. Once the plugin is turned on, you can use CTRL+Shift+T to find the texture files in your folder directory. The plugin will automatically set up the node tree.

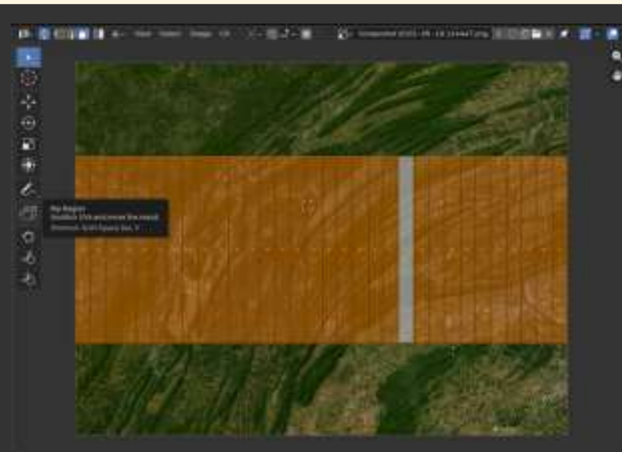
UV Editor



The UV Editor allows you to view and edit your UV coordinates. This is where you can optimize your UV layout, fix overlapping UVs, and ensure textures map correctly to your geometry.

Unwrapping

- Unwrap to map 3D surface to 2D surface
- Determine what edges should be continuous
- Often requires manual editing
- Blend can do Smart UV Project



64

Unwrapping is the process of mapping your 3D surface to a 2D plane so you can apply textures. This requires determining which edges should be continuous and which should be cut. This often requires manual editing. Blender can do Smart UV Project for automatic unwrapping.

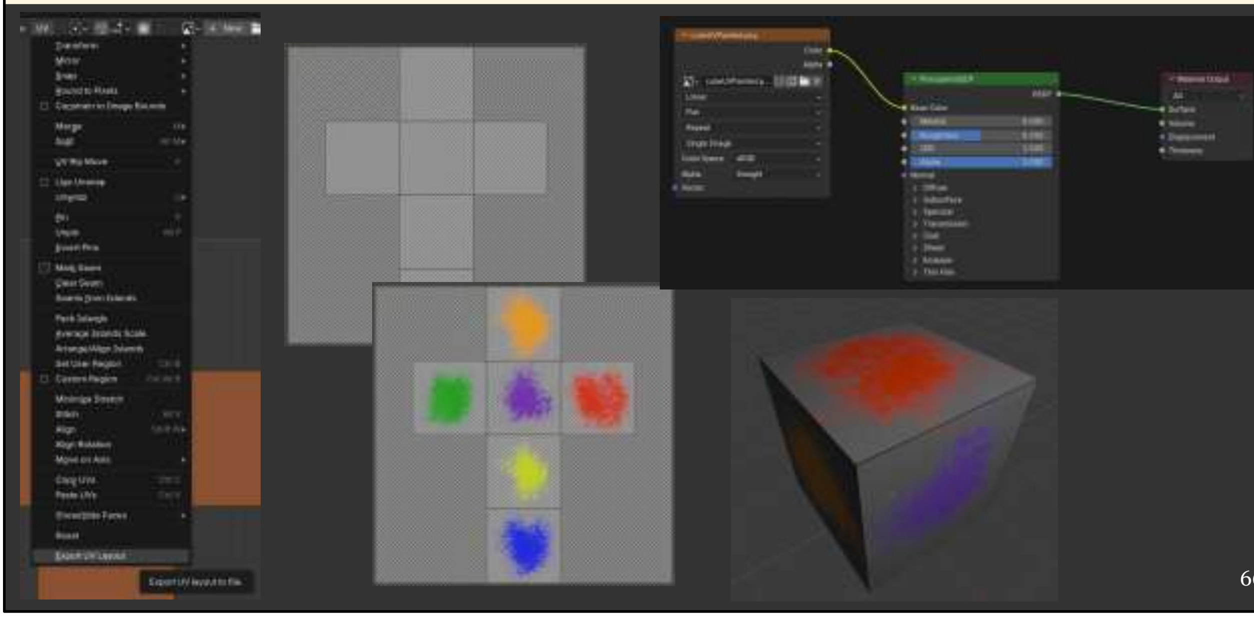
Seams

- Can add seams to help with unwrapping
- These can be placed where the textured surface has natural breaks or does not need to be continuous
- Must select edge while in editing mode

65

You can define seams in the 3D object to aid in the unwrapping process. Seams are edges where there are natural breaks or the texture does not need to be continuous.

Export UV



66

After unwrapping, you can export your UV layout. This is useful if you want to paint textures externally or need to share UV information with other tools.

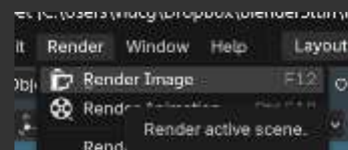
Export

67

Exporting your models and textures is an essential final step. You need to choose the appropriate export format and ensure all resources are properly configured for your intended use.

Render and Image

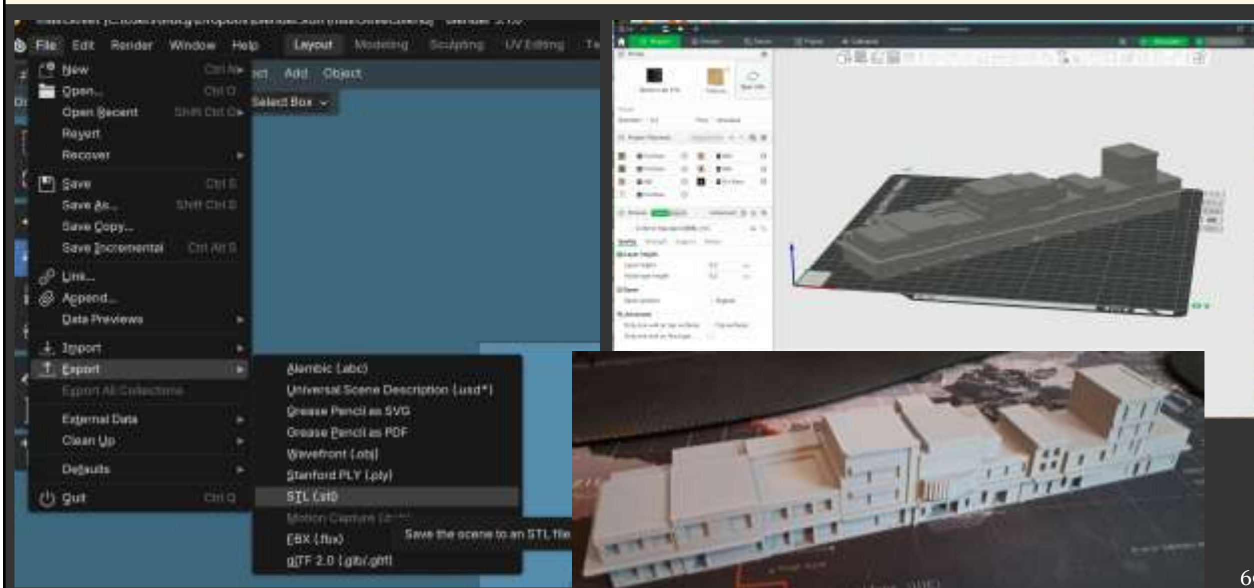
- Impacted by:
  - Materials
  - Lighting
  - Rendering Engine



68

The final appearance of your render is impacted by three major factors. Materials define the intrinsic surface properties of your geometry. Lighting illuminates your scene and affects visibility and drama. Your rendering engine choice determines how realistically these materials and lighting are computed.

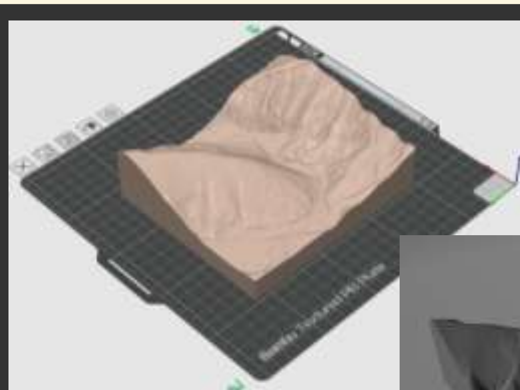
Export for 3D Printing

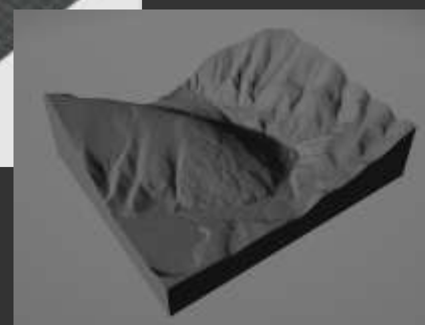


69

3D printing requires special preparation of your models. You need to consider wall thickness, manifold geometry, and proper orientation. Export settings and file formats matter for successful 3D printing.

QGIS: DEMto3D Plugin





https://demto3d.com/

70

The QGIS DEMto3D Plugin converts Digital Elevation Models to 3D mesh files for 3D printing.

Mesh File Types: OBJ

- .obj
- Wavefront Object
- ASCII (text-based)
- Can store vertices, faces, normals, and UVs
- Separate .mtl file for materials
- Widely supported

71

OBJ, Wavefront Object format, is a widely supported ASCII text-based format for 3D geometry. OBJ files store vertices, faces, normals, and UV coordinates with a separate .mtl file for materials. OBJ is an excellent format for interchanging models between different software packages.

Mesh File Types: STL

- .stl
- Stereolithography
- ASCII or binary
- Only stores triangle geometry
- No color, texture, or metadata
- Used for 3D printing

72

STL, Stereolithography format, comes in ASCII or binary variants. STL stores only triangle geometry without colors, textures, or metadata. STL is specifically designed for 3D printing and is the standard format for 3D printer software.

Mesh File Types: PLY

- .ply
- Polygon File Format
- Supports vertices, faces, colors, and normals
- Used for 3D scanning, photogrammetry, and research

73

PLY, Polygon File Format, is flexible and can store vertices, faces, colors, and normals. PLY is commonly used for data from 3D scanning and photogrammetry where color information from each vertex is important.

Mesh File Types: FBX

- .fbx
- Developed by Autodesk
- ASCII or binary
- Stores mesh, materials, textures, animation, and rigging
- Used for game engines and animation pipelines

74

FBX, developed by Autodesk, is a proprietary format that stores mesh geometry, materials, textures, animations, and rigging information. FBX is the standard format for interchange between 3D applications and game engines.

Mesh File Types: COLLADA

- .dae
- Collaborative Design Activity
- XML (text-based)
- Full scenes (geometry, materials, and animation)
- Interoperability between software tools

75

COLLADA, using the .dae file extension, is an XML-based format for storing complete scenes including geometry, materials, and animations. COLLADA was designed for interoperability between different software tools.

Mesh File Types: GLTF or GLB

- .gltf or .glb
- Developed by Khronos Group
- .gltf = JSON + external files
- .glb = binary
- Web friendly

GLTF and GLB are modern web-friendly formats developed by the Khronos Group. GLTF is JSON plus external files, while GLB is self-contained binary. Both formats are designed for efficient transmission and rendering on the web.

Mesh File Types: 3D Tiles/B3DM

- Used in CesiumJS
- For large 3D geospatial datasets
- Spatially indexed
- Used for web-based GIS visualization

https://cesium.com/platform/cesiumjs/

77

3D Tiles and B3DM formats are used by CesiumJS for handling large 3D geospatial datasets. 3D Tiles are spatially indexed for efficient streaming and rendering. These formats are essential for web-based GIS visualization of massive 3D datasets.

Mesh File Types: CityGML

- XML (text-based)
- Geometry and semantic information (attributes)
- Used for urban modeling and digital twins

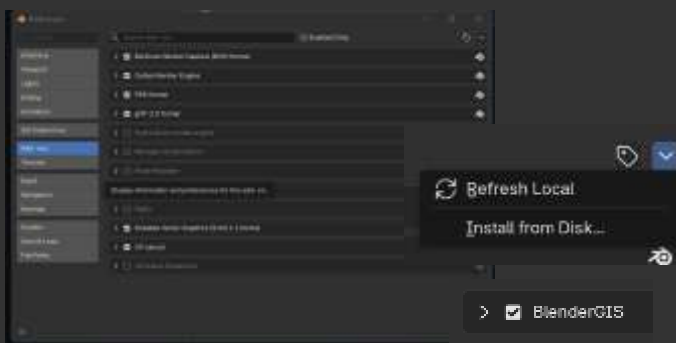
78

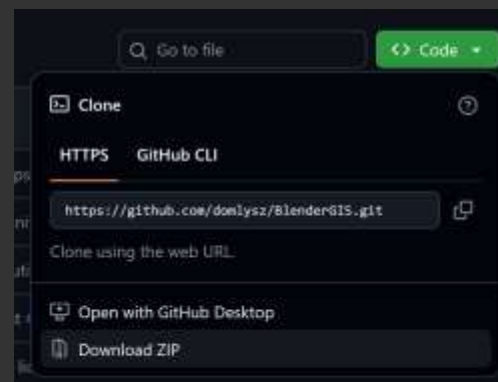
CityGML is an XML-based standard for representing urban 3D models. CityGML encodes both geometric information and semantic attributes, allowing GIS software to understand what different parts represent. CityGML is used for smart city applications.

Now we'll explore how to export Blender models for use in GIS systems. This integration allows you to combine Blender's modeling capabilities with geospatial analysis and visualization.

Blender GIS Plugin

- Download From: https://github.com/domlysz/blendergis
- Edit → Preferences → Add-ons
- Install From Disk (do not need to unzip)



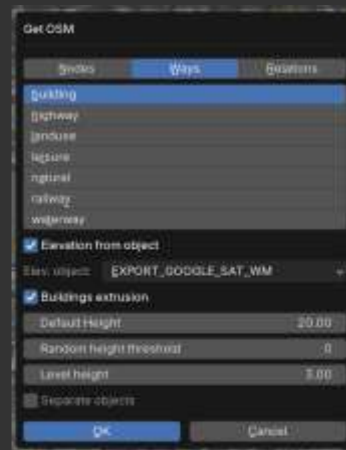


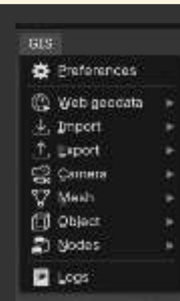
80

To use the Blender GIS plugin, download it from the GitHub repository at github.com/domlysz/blendergis. Installation is straightforward: go to Edit → Preferences → Add-ons → Install From Disk and select the downloaded file. Blender handles extraction automatically.

Blender GIS Plugin

- ❖View base maps
- ❖Get OSM data
- ❖Get elevation data (SRTM)
- ❖Export OSM data
- ❖Import geospatial data

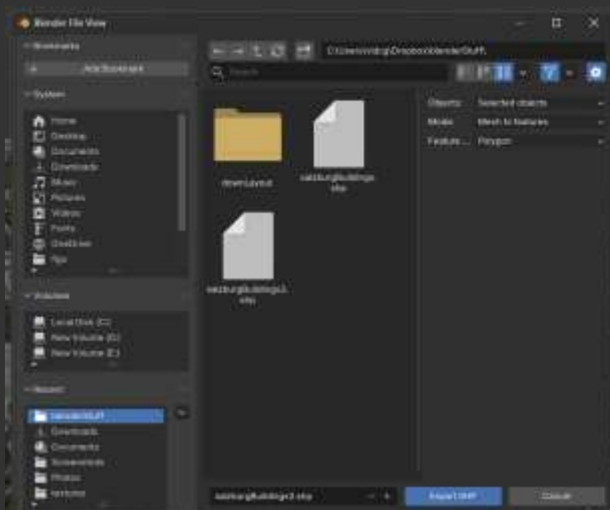




81

The Blender GIS plugin provides several powerful capabilities. You can view base maps to provide geographic context for your modeling. You can download OpenStreetMap data for street networks and building footprints. You can download SRTM elevation data to add terrain. You can export and import geospatial data in standard formats and work with geographic coordinate systems.

Export to GIS



82

Exporting your models from Blender to use in GIS systems requires planning. You need to consider coordinate systems, data organization, and file formats to ensure compatibility.

Export Mesh

- ❖Draw mesh over base map in Blender
- ❖If using textures: pack resources

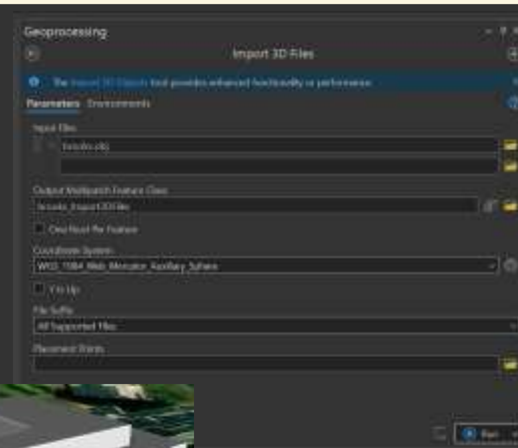
- ❖Export to: OBJ or FBX

83

The process is straightforward: draw or create your mesh over a base map in Blender using the GIS plugin. If using textures, pack resources to ensure all files are self-contained. Export to OBJ or FBX format, which ArcGIS Pro can import.

Use Mesh in ArcGIS Pro

- Import 3D Files → convert to Multipatch Feature Class
- Replace Multipatch → replace an existing object in a Mutipatch Feature Class
- May need to:
  - Define projection
  - Move
  - Rotate
  - Scale
  - Update symbology



84

In ArcGIS Pro, you can import 3D mesh files and convert them to Multipatch Feature Classes. Multipatch is ArcGIS Pro's native 3D geometry type. You may need to define the projection if not already georeferenced, and you may need to adjust position, rotation, or scale to align with other geographic data.

This is the end of this lecture module.

Please return to the West Virginia View Webpage for additional content.

Thanks! Hope you found this useful.