HOUDINI FOUNDATIONS

SMASHING WINE GLASS

In this lesson, you will smash a wine glass then slow down time to hold onto the big splash. This effect involves both an RBD simulation for the shattered glass and a fluid simulation for the wine. You will learn how to set up the dynamic network and output the simulations. Visual effect shots often involve a combination of different kinds of dynamic solvers and Houdini's dynamic network is designed to achieve a unified result with these different solvers.

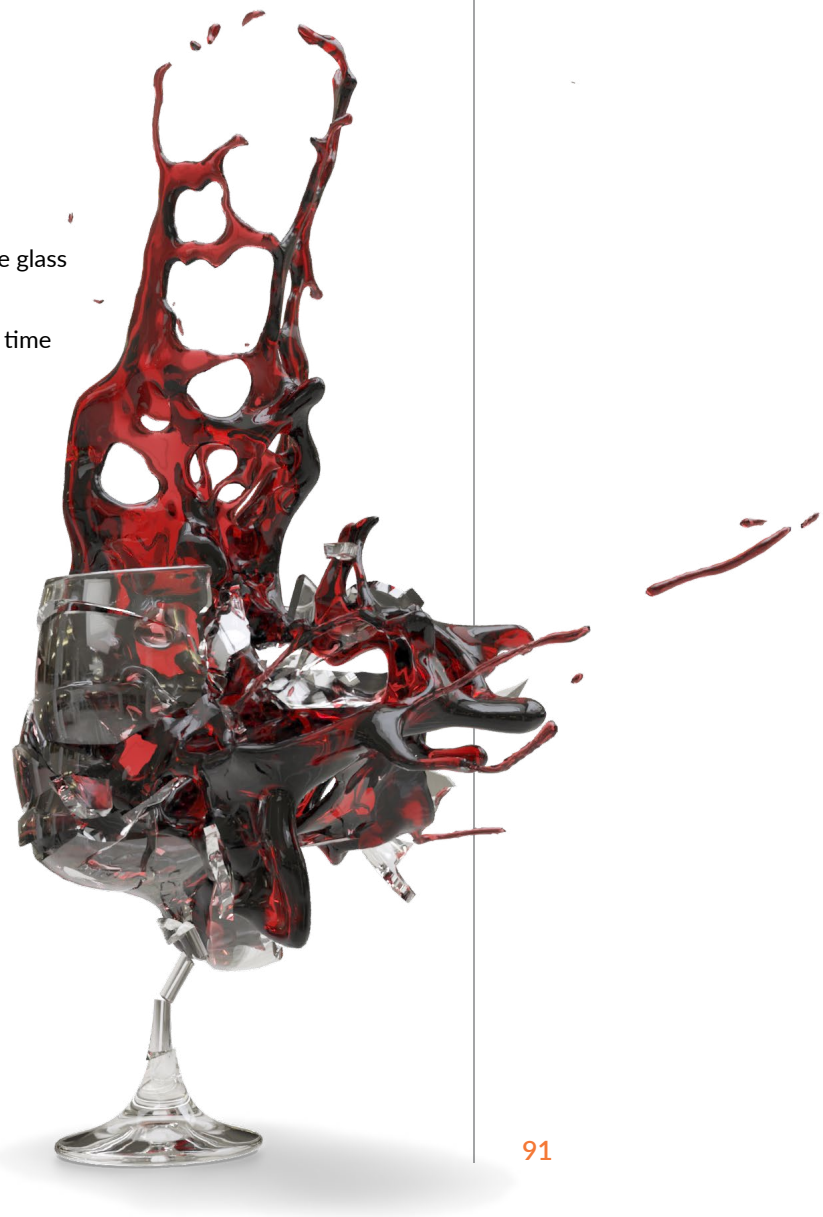
You will also use a retime node to slow down the simulation when it is at its most explosive then reverse time to return to the starting point. You will then move the simulations into Solaris/LOPS, set up lights and a camera, then render the shot using the Karma renderer.

LESSON GOAL

To simulate a bullet smashing through a wine glass causing the glass to break and the liquid to splash.

WHAT YOU WILL LEARN

- How to model the **Wine Glass, Bullet** and **Liquid** geometry
- How to **pre-fracture** the glass geometry using **Booleans**
- How to run a **Rigid Body Simulation** of the bullet smashing the glass
- How to run a **FLIP Fluid Simulation** of the liquid splashing
- How to **retime** the simulation to slow it down then go back in time
- How to export the results as **USD** for use in **Solaris/LOPS**
- How to set up **lights** and **materials** in **Solaris/LOPS**
- How to **render** the final shot with **Karma**



LESSON COMPATIBILITY

Written for the features in Houdini 19.5+

The steps in this lesson can be completed using the following Houdini Products:

Houdini Core	✘
Houdini FX	✔
Houdini Indie	✔
Houdini Apprentice	✔
Houdini Education	✔

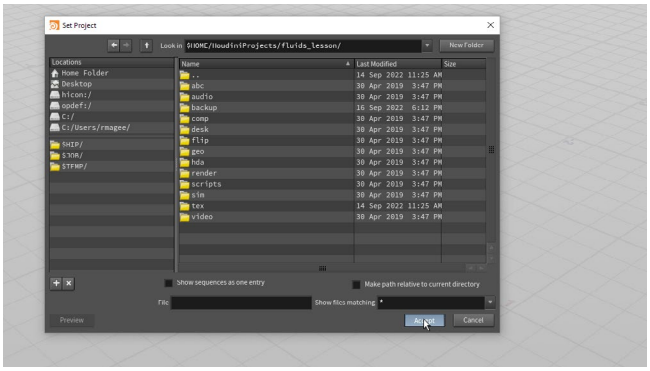
Document Version 2 | Sept 2022

PART ONE
Model the Wine Glass

To start, you will draw a polygonal curve then revolve it to create the wine glass. Creasing will be used to sharpen some edges and then you will subdivide to create denser geometry for fracturing. You will then extract geometry from the wine glass to create a shape that you will use to simulate the fluid.

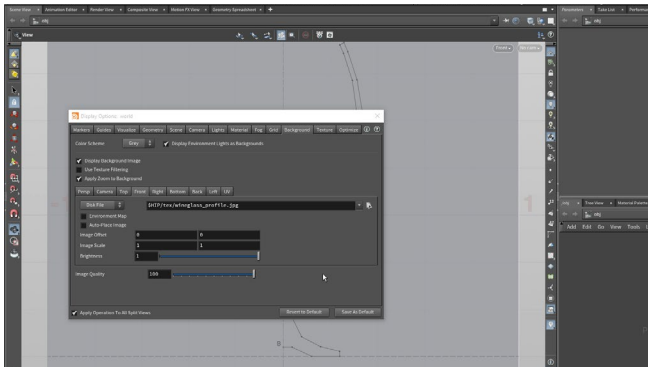
PROJECT FILES

Go to the **fluids tutorial** page on **SideFX.com**, where you got this document and download the *fluids_lesson_start* directory. Rename it *fluids_lesson* then put it into the **Houdini Projects** directory.



01 Select **File > Set Project.** Find the *fluids_lesson* directory (see instructions above) and press **Accept**. This makes the project directory and its sub folders the focus for all the files associated with this shot.

Select **File > Save As...** You should be looking into the new *fluids_lesson* directory. Set the file name to *wineglass_01.hip* and click **Accept** to save. Now you will be able to access the reference images in the *Tex* folder.

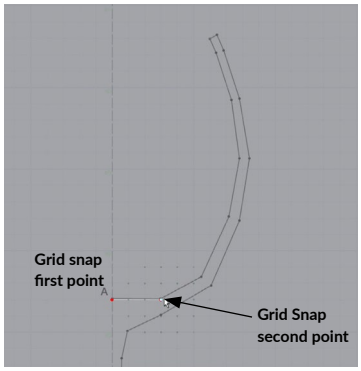


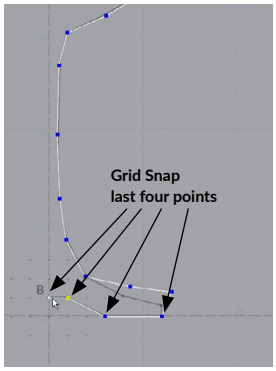
02 In the Scene view, **Press v** to bring up a radial menu and choose **Viewport Layout > Four Views** Move your cursor over the *Front* panel and **press spacebar-b** to expand it.

Hit **D** with the mouse in the viewport. Click on the **Background** tab and on the **Front** tab , use the file picker to navigate to *$HIP* then *tex>wineglass_profile.jpg*. Set the following:

- Make sure **Auto-Place** is turned **OFF**
- **Image Offset** to **0, 3**
- **Image Scale** to **5, 5**

Now if you dolly or pan the view, the background moves with it.

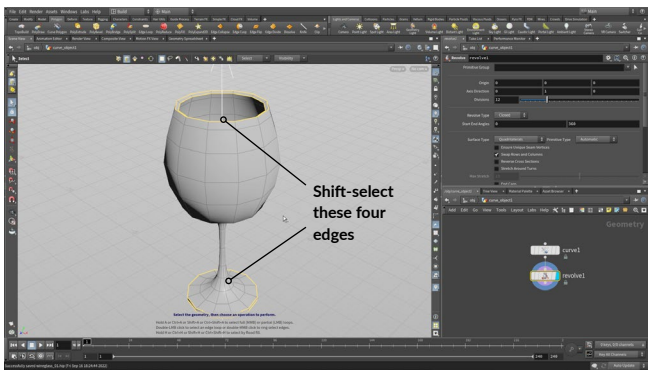




03 On the **Polygon** shelf, click on the **Curve Polygon** tool. This creates a **Curve** node with the **Primitive Type** set to **Polygon**. **Press x** and choose **Grid** to turn on grid snapping then click on **point A** and then to the second point which also sits on a grid point. Turn **Grid snapping** to **OFF** then keep tracing the image.

Turn **Grid snapping** back **ON** for the final four points at the base of the glass to make sure they are aligned. When you finish at point B, press **Enter** to complete the curve. Turn **Grid snapping** to **OFF**.

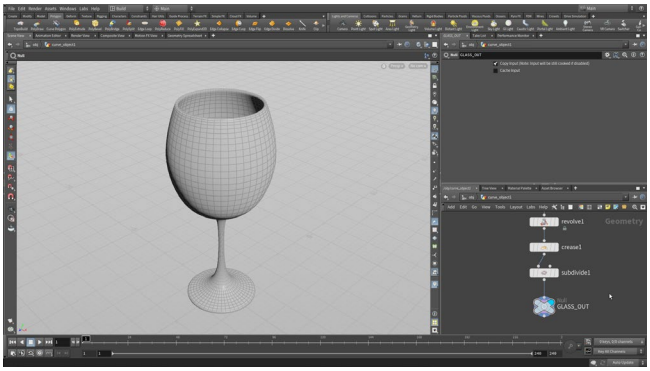
You can then click on the **Edit Mode** button in the Operation Controls bar to move any points that missed their mark.



04 Press **Spacebar-B** to go back to a four view layout then mouse over the perspective view and press **spacebar-b** again to expand it. Now you can see the curve in 3D.

Press s to get the **Select** tool and **press n** to select all the primitives on the curve. **Press c** and choose **Model > Curves > Revolve**. This will turn it into the wine glass model.

Press 3 to go to edge selection then **double click** on the top edge of the glass then press **Shift** and **double click** on the second top edge and the two edges of the base. Press **tab > Crease** then set **Crease** to **0.75**.



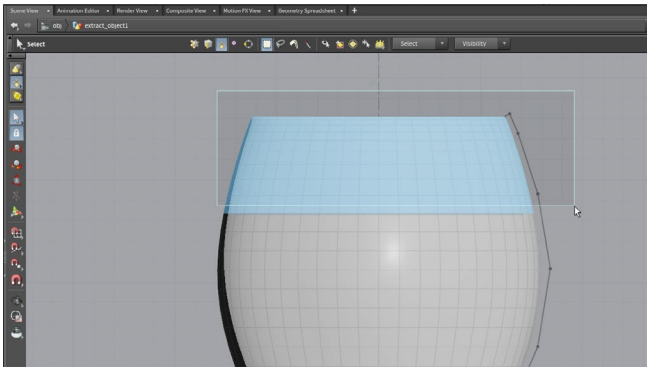
05

Press 4 to switch to primitive selection then **press n** to select all. Now **press tab > Subdivide**. Set **Depth** to **2**.

This will subdivide the model with the creased edges set up to be sharper than the other areas of the model. A higher **Crease** weight could make these edges completely sharp but for now a softer look works better.

In the Network editor, add a **null** node to the end of the chain and set its display flag. Rename this node to *GLASS_OUT*.

Go back up to the object level and rename the object to *wine_glass*.

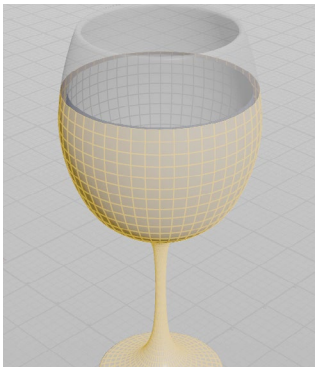


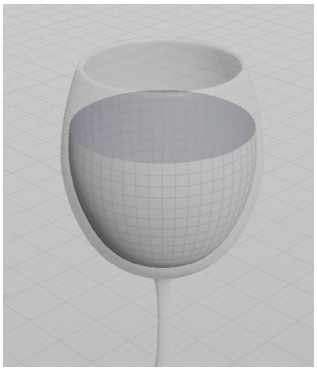
06

With the *wine_glass* node selected, **press n** to select all the primitives then go to the **Modify** shelf and click on the **Extract** tool. This will create an *objectmerge* of the wine glass geometry and place it into a new object.

From the Front view, **select** the faces at the top of the wine glass and then press **delete**. This adds a *Blast* node into the network that removes the faces.

Note: You can still see a ghosted version of the original wine glass because the Scene View is set to **Ghost Other Objects**. This setting is useful to add context to your work.

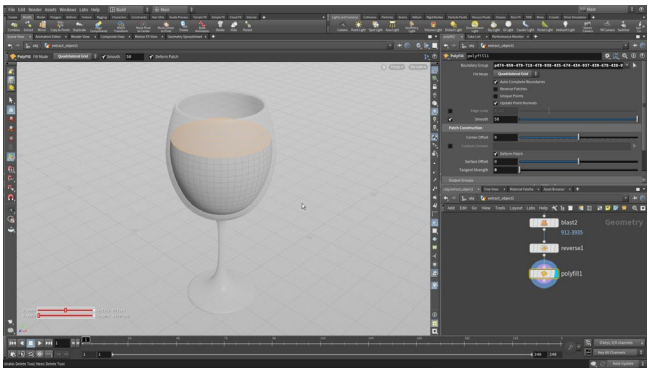




07

Now go back to a Perspective view and **double-click** on the base of the wine glass and press **delete**. This adds a second blast node. Now you are left with interior faces where you want the liquid to be. The faces of the wine geometry will appear dark on the outside. This means that they are the back sides of the primitives.

Press n to select all the primitives. **Press tab > reverse** to reverse the normals so that they are facing out. The darker side of each primitive will now be on the inside of the shape.



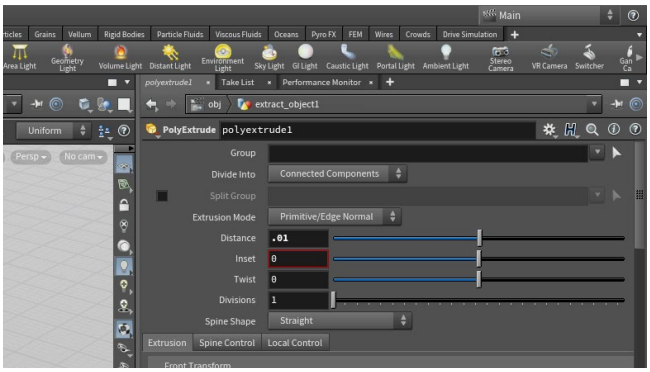
08

Press 3 to change to edge selection then double-click on the edge of the shape to select the open edge. **Press tab** and start typing **polyfill.** With **Polyfill** highlighted, press **Enter**.

Set the following:

- **Fill mode** to **Quadrilateral Grid**
- **Tangent Strength** to **0**.

This creates a closed shape that will become the source for the FLIP Fluid later in the lesson.



09

Press 4 to change to primitive selection then **press n** select all of the primitives. **Press c** and choose **Model > Polygons > PolyExtrude**. Set **Distance** to **0.01** to create an overlap with the wineglass to help the fluid render properly.

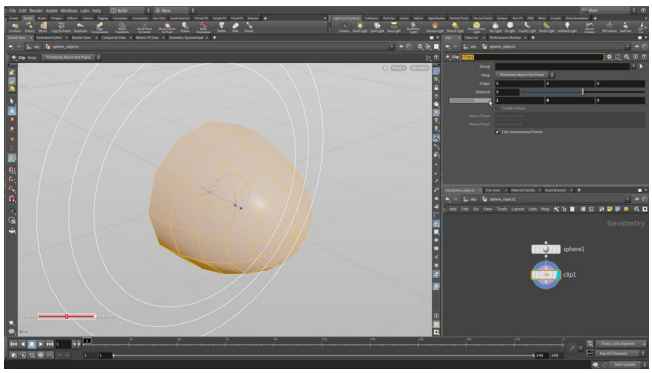
In the Network editor, add a **null** node to the end of the chain and set its **display flag**. Rename this node to *FLUID_OUT*.

Go up to the object level, rename this object to *wine*.

PART TWO

Model the Bullet

To create the bullet geometry, you will start with a primitive sphere and slice it in half. Next you will polyextrude the open end then use polyfill to close the shape using quad topology. You will then subdivide to define the final shape. This object will be moving very quickly therefore lots of detail isn't required.

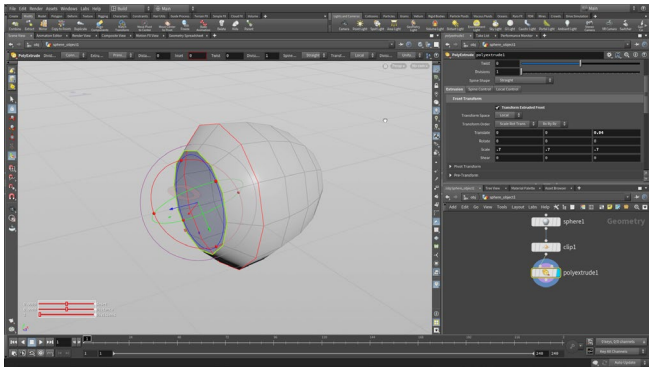


01

Go to the object level and in the Network view, turn off the **Display Flags** for the *wine* and *wine_glass* objects. In the Scene View, **press c** and choose **Create > Geometry > Sphere**. Press **Enter** to place it at the origin then dive inside and set the following:

- **Orientation** to **X axis**
- **Radius** to **0.2, 0.125, 0.125**
- **Columns** to **12**

Press **tab > clip** in the Scene view then **press n** to select all the primitives and press **Enter** and set the **Direction** to **1, 0, 0**.



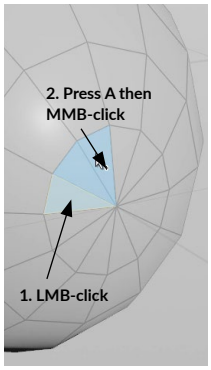
02

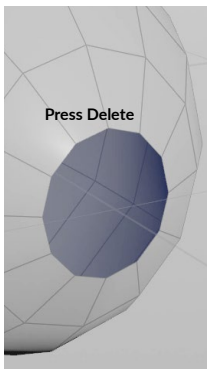
Click on the **Select** tool then **press 3** to turn on edge selection and **double click** on the open end of the sphere. **Press c** and choose **Model > Polygons > PolyExtrude**.

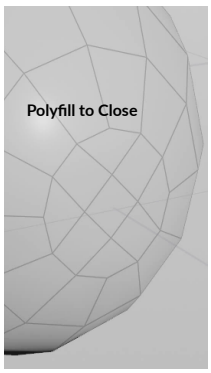
In the **Extrusion** tab, set the following:

- **Transform Extruded Front** to **ON**
- **Translate Z** to **0.04**
- **Scale** to **0.7, 0.7, 0.7**

This adds a little extra geometry before you remove the triangles at the front of the bullet then close the shape.



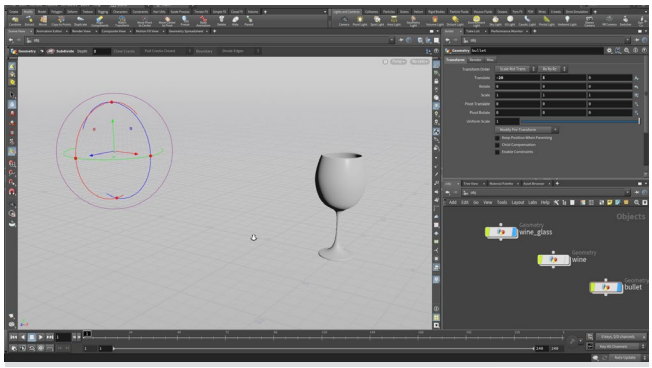




03

Tumble around and **press s** to get the select tool and **4** to get **face/primitive** selection. Select one of the triangles at the tip of the bullet then **press and hold** the **a key** and then **middle click** two triangles over to select all the triangular faces. Press the **Delete** key to remove them. This adds a *blast* node to the network.

In the Network View, press **tab > polyfill** and place the node after the *blast*. Set **Fill mode** to **Quadrilateral Grid** and **Corner Offset** to **1** then turn on its **display flag**. This will close both ends of the bullet with good quad topology.



04

Now add a **Subdivide** node at the end, set **Depth** to **2** and then set its **display flag**.

In the Network editor, add a **null** node to the end of the chain and set its **display flag**. Rename this node to *BULLET_OUT*.

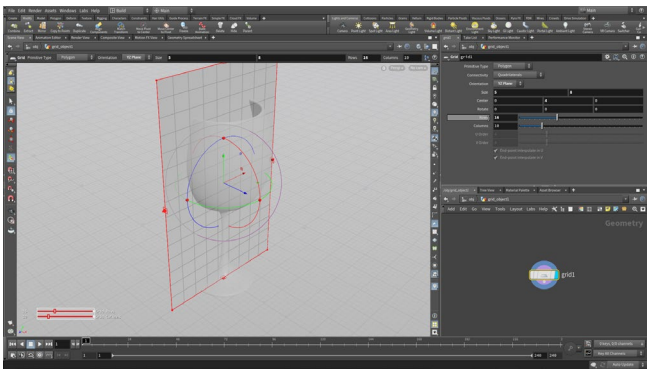
Go back to the object level and rename this object *bullet*. Turn on the **display flag** for the *wine_glass*. **Translate** the bullet to about **-20** in **X** and **5** in **Y**. You may want to go back to the *Front* orthographic view to make sure it is aimed at the desired impact point on the wine glass.

Save your work.

PART THREE

Fracture the Wine Glass

To define the cracks in the wine glass, you will create natural looking lines using the draw curve tool then extrude them into sheets of geometry. You will then agitate the surfaces using the mountain tool. This chaotic looking shape can then be merged into the wine glass object where you will set up a boolean operation that uses the sheets to shatter the glass.

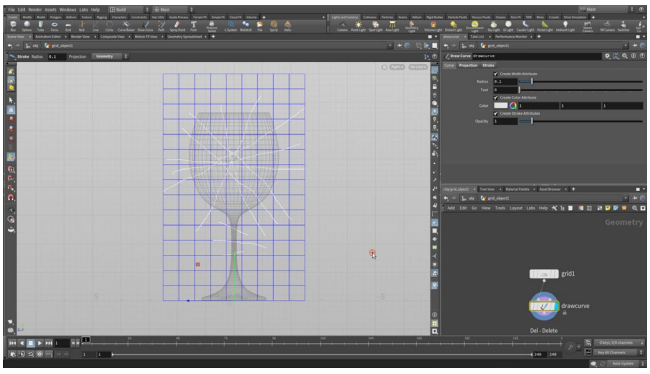


01

In the Scene View, go to the object level then **press c** and choose **Create > Geometry > Grid**. Press **Enter** to place it at the origin then **i** to dive inside and set the following:

- **Orientation** to **YZ Plane**
- **Center Y** to **4**
- **Size X** to **5**
- **Size Y** to **8**
- **Rows** to **16**

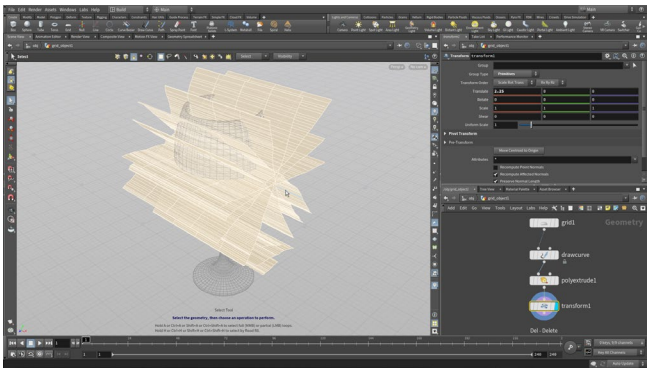
This will create a drawing surface for the **Draw Curve** tool that matches the shape of your wine glass.



02

Go to a *Right* view and **press v > Shading > Wireframe** to go into wireframe mode. You can see the bullet sitting behind the grid and the wine glass. **Press n** to select the whole grid then go to the **Create** shelf and click on the **Draw Curve** tool.

Draw curves over the wine glass that converge where the bullet hits the glass. Also add some curves across the stem of the glass since that will shatter as well. If at any point you draw a curve you don't like, press **Ctrl-Z** to undo it.



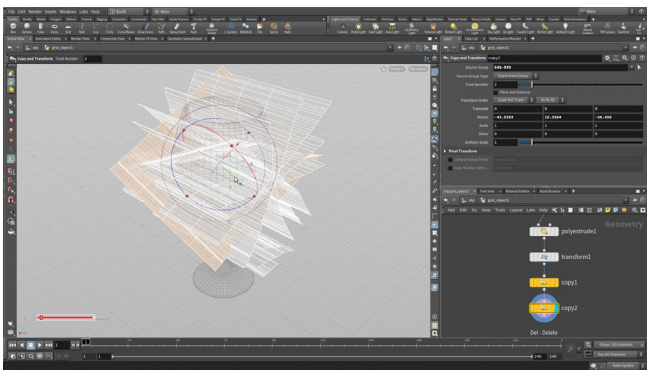
03

Go to the **Select** tool then **Press n** to **Select** all the curves then **press c** and choose **Model > Polygons > PolyExtrude**. Set **Divisions** to **4**.

In the **Extrusion** tab, set the following:

- **Transform Extruded Front** to **ON**
- **Transform Space** to **Global**
- **Translate X** to **-4.5**

Next, click away then select all the geometry and **press tab > Transform**. Set **Translate X** to **2.25** to center this geometry around the origin.



04

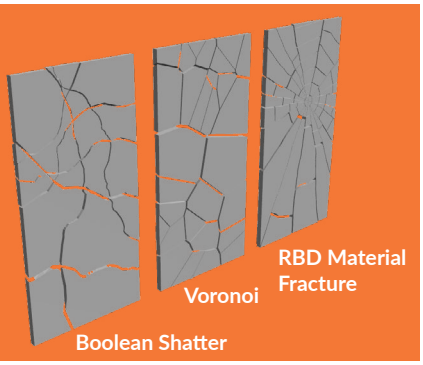
Press s to bring up select tool, then **press 4** to go to primitive selection. **Double click** on one of the sheets to select the whole thing. Press **tab > Duplicate** to create a copy. Use the **Rotate [r]** handle to reorient the duplicated sheet to be almost orthogonal to the others, making sure it cuts through the cup but avoids the stem. This will break the cup in the other direction to create more realistic slivers of glass.

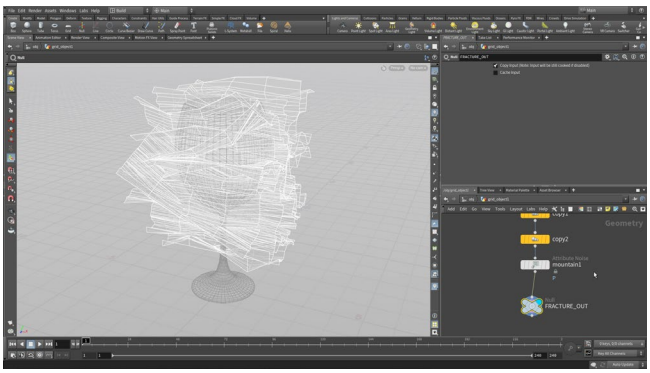
Repeat with another sheet to create another surface for cutting at a different angle.

BOOLEAN SHATTER

The Boolean node is often used to create traditional booleans such as **Union, Intersect** and **Subtract**. While these work well with closed shapes, you can use the **Shatter** option to slice up the geometry with sheets.

Houdini has a **Voronoi Shatter** tool that can also be used but it will not give you the jagged look you need for broken glass. There is also an **RBD Material Fracture** node that can create glass-like fractures. These work best with flat surfaces which is why it wasn't used in this lesson for the wine glass.

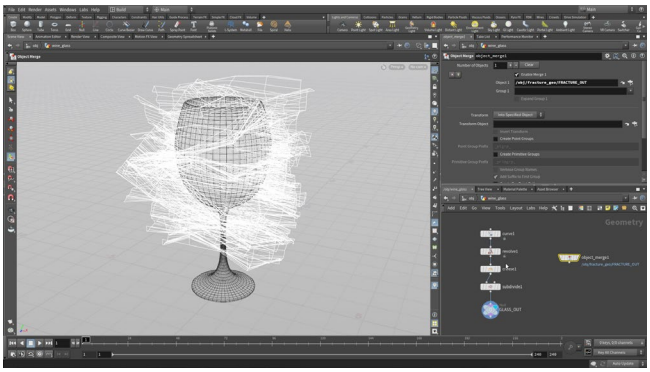




05 Select all the geometry and then press **tab > Mountain** to add some noise to the points on the different sheets. Set **Amplitude** to **0.75**. This will create more interesting cracks in the glass.

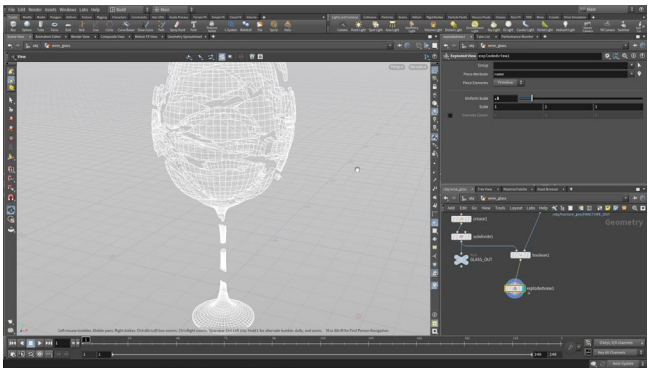
In the Network view, add a **Null** node to the end of the chain and rename it *FRACTURE_OUT*. Set the **display flag** on this node.

Go to the object level and name this node to *fracture_geo* then turn **OFF** its **display flag** to hide it.



06 Next dive into the *wine_glass* object. In the Network view, press **tab > object merge** and place the node down. Click on the node selector next to **Object 1** and navigate to **fracture_geo > FRACTURE_OUT** and select that node. Make sure that **Transform** is set to **Into Specified Object** .

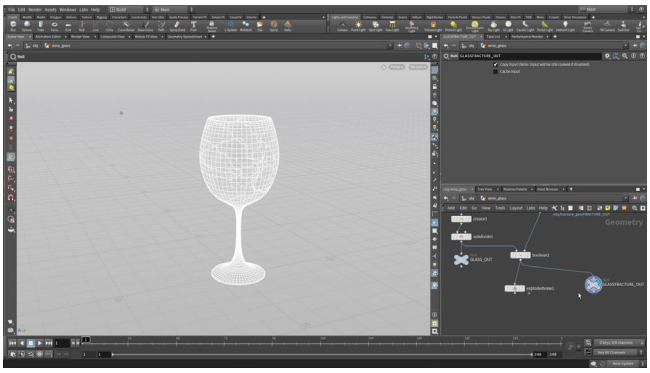
This brings the agitated sheets into the wine glass geometry network where you can use it to boolean shatter the glass.



07 In the Network view, press **tab > boolean** and click to place down the new node. Wire the *subdivide* node (not *GLASS_OUT*) into the first input and the *object_merge* into the second. Set its **Display flag** then set the following:

- **Set B: Treat As** to **Surface**
- **Operation** to **Shatter (Pieces of A)**

To visualize the cracks, add an **exploded view** node at the end of the chain. If you want to change how things work then you can go back to the *fracture_geo* object and edit the sheets. Those edits will update procedurally.



08 In the Network view, add a **Null** node that bypasses the *exploded_view* node and rename it *GLASSFRACTURE_OUT*. Set the **display flag** on this node.

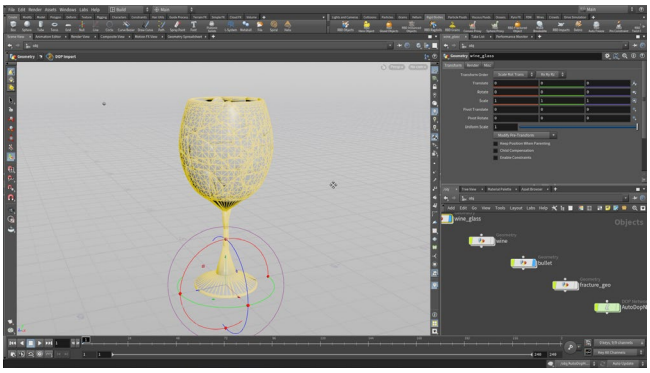
You now have two output nodes for this network. GLASS_OUT gives you the wine glass in its original form and GLASSFRACTURE_OUT gives you the shattered glass. You will use them both down the line to complete the shot.

Save your work.

PART FOUR

Set up the RBD Simulation

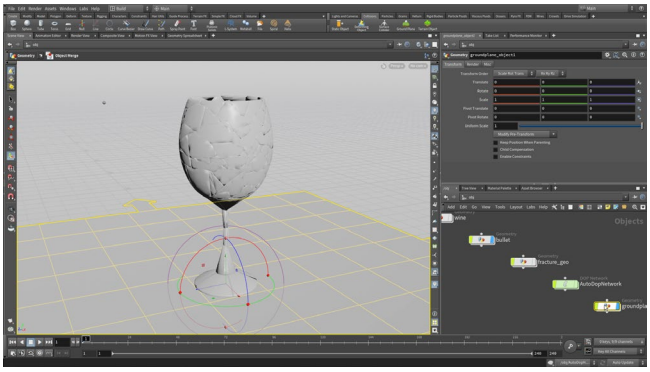
You are now going to create a rigid body simulation using shelf tools. This will add a DOP (Dynamic Operator) network that brings together geometry, forces and a solver node. In the wine glass geometry network, nodes will be added to prepare the geometry for simulation. You will use convex proxies so the Bullet RBD solver can handle the odd-shaped pieces of glass.



01

Go up the object level, select the *wine_glass* object then from the **Rigid Bodies** shelf, click on the **RBD Convex Proxy** tool. This will set up the initial dynamics network for you. It is called *AutoDopNetwork*. **Press v > Shading > Smooth Wire Shaded.**

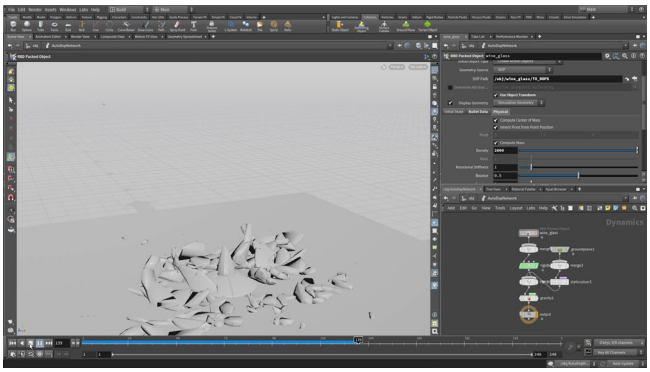
This tool is used to break down the parts of the wine glass into convex shapes that can be used to create complex collisions. These will appear rougher than the source geometry but after the simulation, you can go back to visualizing the cleaner topology.



02

Go to the **Collisions** tab and click on the **Ground Plane** shelf tool. This will create an infinite ground plane for your geometry to collide with.

You can turn **Off** the **Display flag** on the *groundplane_object* to hide it from the scene view. It will still function as a colliding surface in the simulation.



03

Dive into the *AutoDopNetwork* node. Select the *wine_glass* node and in the **Physical** tab set **Density** to **2000**, which is approximately the density of glass.

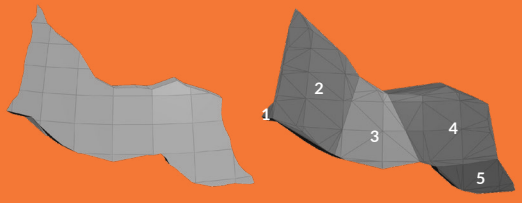
Press **Play** in the playbar to see what happens. The glass falls and hits the ground. Right now gravity is the only force acting on the pieces.

You could set up a **glue network** to hold the pieces together until impact but the bullet will be so fast that connecting the parts is not necessary.

CONVEX DECOMPOSITION

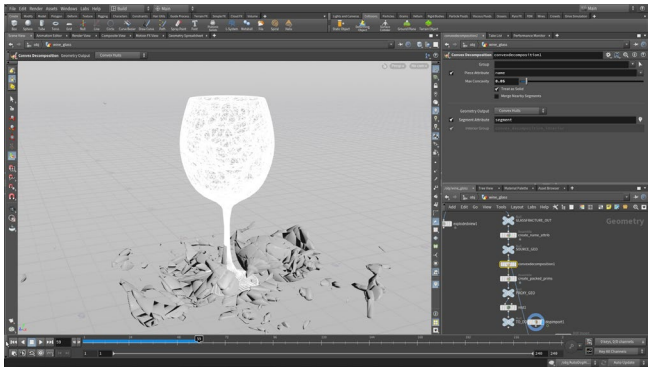
For RBD simulations, Houdini uses the Bullet solver which prefers convex shapes in order to maintain fast simulation speeds. **Convex Decomposition** lets you take shapes that are concave and break them down into convex shapes that are connected together. These are then simulated as one composite piece by the Bullet solver.

Since the wine glass fragments come in a variety of shapes, convex decomposition ensures accurate collisions for all pieces.



Original Geometry

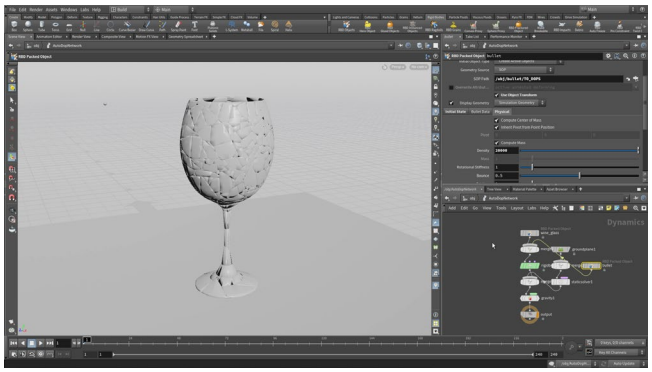
Convex Decomposition



04 Go up to object level and dive into the *wine_glass* object. A number of nodes have been added to create the proxy geometry and this chain ends with the *dopimport* node which is currently displayed.

On the *convexdecomposition* node, you can change **Max Concavity** to **0.05** to adjust your collision geometry.

Press **Play** to watch it simulate.

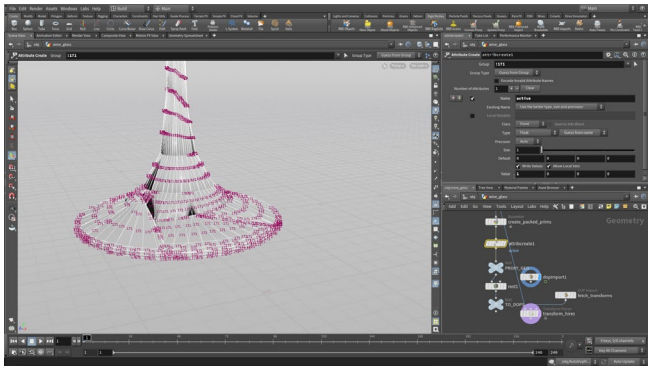


05 Go up to object level and select the *bullet* object and then go to the **Rigid Bodies** shelf and click on the **RBD Objects** tool. This will create a packed rbd object from the bullet and add it to the dynamics network.

Navigate into *AutoDopNetwork* and select the *bullet* node.

- In the **Initial state** tab, set **Velocity** to **400, 0, 0**.
- In the **Physical** tab set **Density** to **20000**

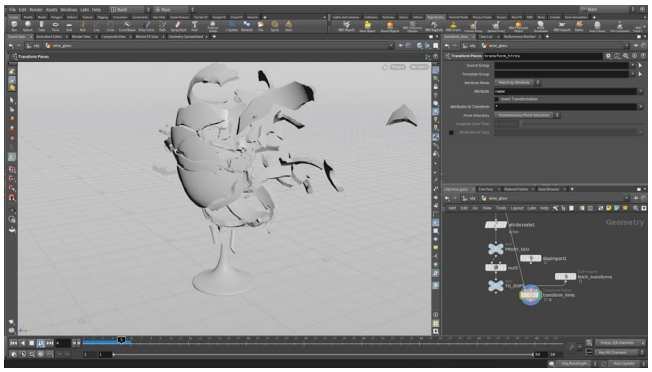
This is the density of lead and should work well for the bullet.



06 Before you simulate, you want to make sure that the base of the glass stays on the ground. Navigate into the *wine_glass* object and in the display bar, turn on **primitive** numbers. You can see that in this case the base packed primitive is 171 - yours will probably be different.

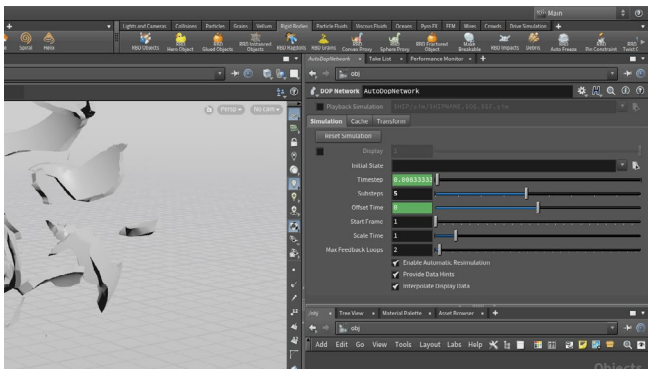
Add an **Attribute Create** node between the *create_packed_primitive* and *proxy_geo* nodes. Set the following:

- **Group** to **!171** (or whatever number your base is)
- **Name** to *active*
- **Value** to **1, 0, 0, 0**



07 Next, set the **display flag** on the *transform_hires* node and open up **Global Animation Options** and set **End** to **50.**

Now **play** back the sim. You can now see the source geometry being animated to match the proxies but the collision is as dramatic as it could be.



08 The Bullet sim defaults to **10 substeps** on the solver. This isn't enough to resolve collisions for the speed the of the bullet. Go up to the object level and on the *AutoDopNet* node set **Substeps** to **5**. This will add substeps on top of the solver setting. This may take longer to simulate but will increase accuracy and generally make the simulation more active.

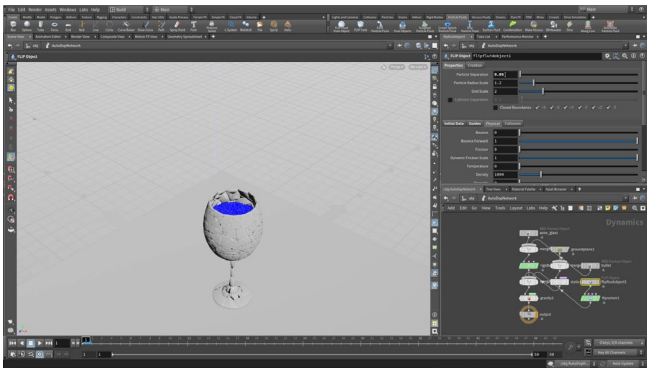
Play the simulation again to see that the collisions are looking much better. Go back and tweak settings if you want too change things. You can even go back and reposition some of the cracks.

Save your work.

PART FIVE

Add Fluids to the Simulation

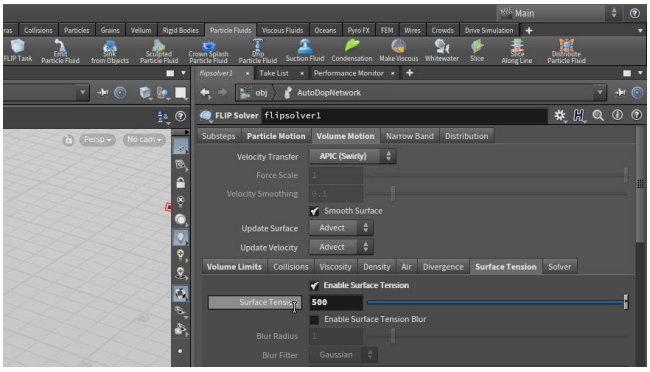
Now that the bullet is smashing the glass, it is time to convert the wine object into a fluid that will become part of the integrated simulation. This means that the RBD and Fluid simulations take place in the same DOP network and will work as one system. At first, the fluid will be represented by particles that can then be surfaced to visualize the fluid.



01

Go to **frame 1**. Select the *wine* object in the Network view and from the **Particle Fluids** shelf, click on the **FLIP Fluid from Object** tool.

This turns the fluid into a volume of fluid particles. In *AutoDopNet*, select the *flipfluidobject* node and set **Particle Separation** to **0.05**. This creates more particles which in turn adds more detail to the simulation.



02

Select the *flipsolver1* node and click on the **Particle Motion** tab, under **Behavior** set:

- **Add ID Attribute** to **ON**

Under **Reseeding** set:

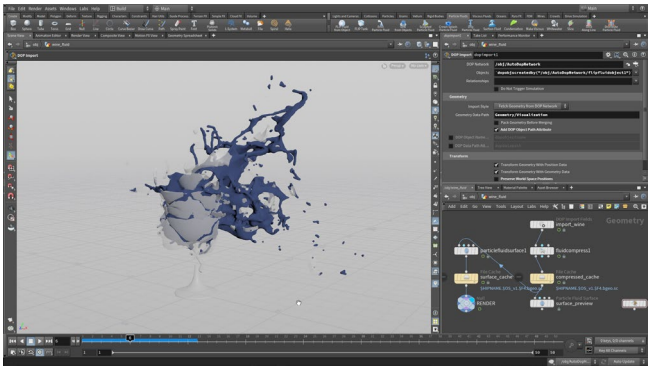
- **Reseed Particles** to **OFF**

In **Volume Motion**, set:

- **Velocity Transfer** to **(APIC) Swirly**

Under **Surface Tension**, set:

- **Enable Surface Tension** to **ON**
- **Surface Tension** to **500**



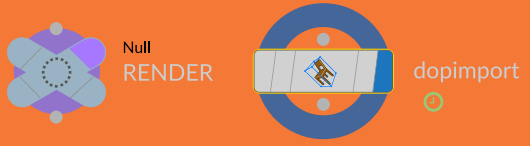
03

Press **Play** to run the simulation. With extra substeps it will take a little longer but will give you more accurate results. Simulate to just past **frame 10** and press **Escape** to stop the sim. Go to **frame 10** to preview the fluid so far.

To see it as a surface, go up to the object level and go into the *wine_fluid* object. Set the **display flag** on the *Render* null node to see the surfaced fluid. This will take longer to cook but will show you what the surface is going to look like at each frame.

DISPLAY AND RENDER FLAGS

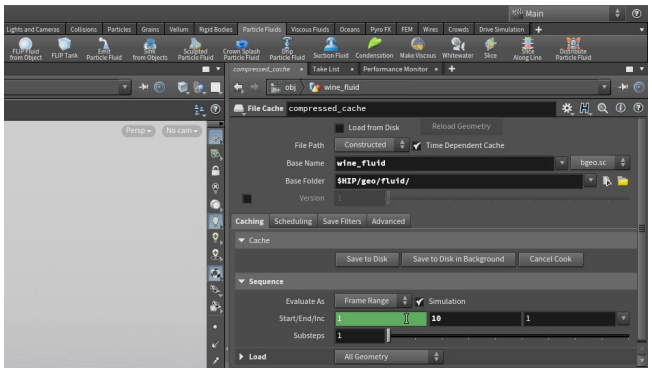
When the **wine_fluid** geometry network is first created, the **Display flag** is on the **dopimport** node which shows particles while the **Render flag** is on the null node which flows from a **particle surface** node. This set up is meant to give you fast performance in the viewport and if you render then you see the final surface. In this lesson, you will be caching out the surface therefore these nodes will not be used to render.



PART SIX

Cache and Retime the Simulations

For this shot, you only need to compute 10 frames of the simulation. You will save this to disk then use a retime node to create a longer shot where the fluid slows down then reverses in time. The retimed fluid particles will then be surfaced and output as a 50 frame sequence which will define the final shot for rendering. The wine glass and bullet will then be retimed to match.

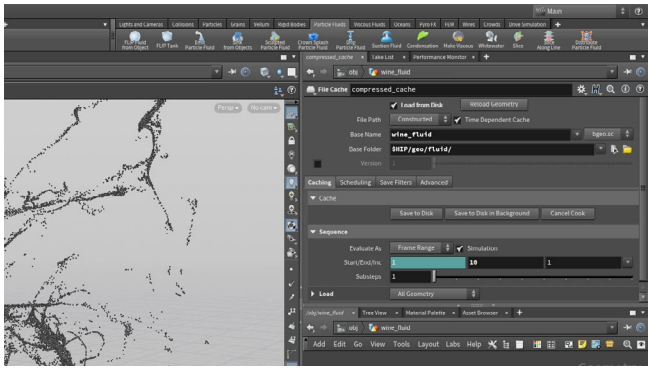


01 At the object level, **delete** the *wine_fluid_interior* node that the shelf tool created. Dive into the *wine_fluid* object. Delete all the nodes except the *import_wine*, *compressedcache* node and the *particlefluidsurface* nodes.

On *compressed_cache*, set the following:

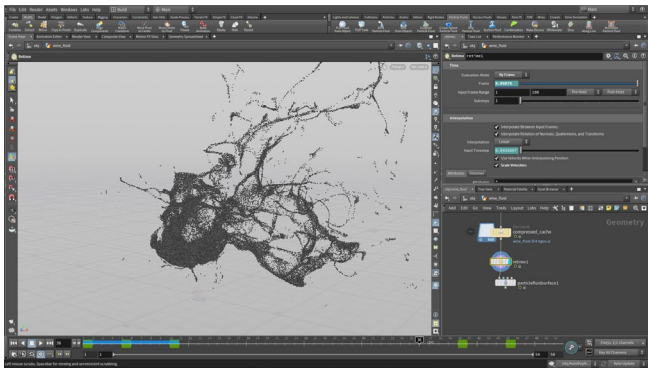
- **Base Name** to *wine_fluid*
- **Base Folder** to *$HIP/geo/fluid/*
- Turn **Off** the **Version** check box
- **End** to **10** (**RMB-click > Delete Channels** first)

Hit **Save to Disk.**



02 When it finishes, stay at the geometry level. From the **Visibility** menu in the top right of the Scene view, select **Hide Other Objects**.

Set **Load from Disk** to **On** and **Scrub** through the geo sequence. It will only play for 10 frames. You are now going to retime the sequence to stretch it out over 50 frames and slow down the effect.

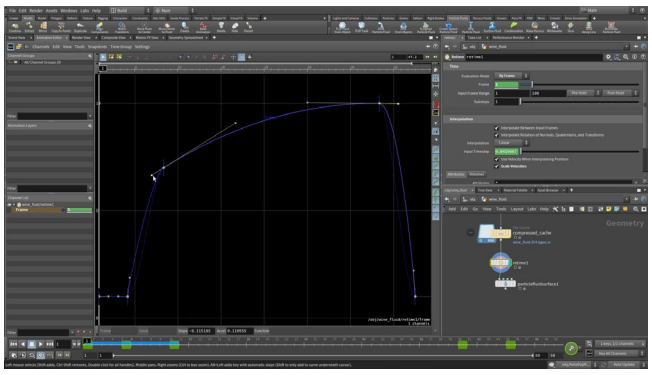


03 Add a **Retime** node after the *compressed_cache* node and set its **Display flag**. Set the following:

- **Evaluation Mode** to **By Frame**.
- Turn **ON** the **Scale Velocities** option

RMB-click on the **Frame** field and choose **Delete channels**.

- At **frame 1**: set **Frame** to **1** and **Alt-click** to keyframe
- At **frame 5**: set **Frame** to **1** and keyframe
- At **frame 10**: set **Frame** to **7** and keyframe
- At **frame 40**: set **Frame** to **10** and keyframe
- At **frame 45**: set **Frame** to **1** and keyframe



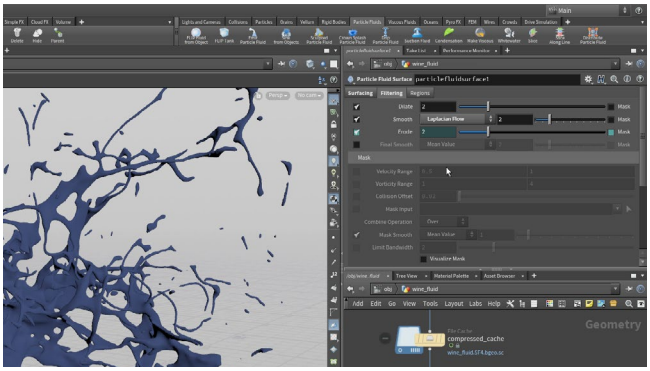
04 Click on the **Animation Editor** pane to see the animation curve you just created. **Press h** over the graph to home the view and then **RMB-click-drag** to zoom out a bit.

Click and drag on the curve handles to get a shape similar to what you see here. If you need to break tangents on a curve, select the key and **press T** to untie the tangents. Then select and drag on each end individually. The goal here is to have the liquid splash out quickly then slow down until is freezes for a short time then speed out into a fast reconstruction back to its original shape.

RETIME

The most interesting part of the smashing wine glass is the first 10 seconds. To emphasize this part of the simulation, you are going to save out the fluid particles for the 10 frames then uses the **retime** node to stretch out the sequence in a sort of "bullet-time" effect that snaps back to the original wine glass by reversing time.

Once you have this set up for the fluid, you can surface the points and save out a longer sequence. The same retime node can then be copied and pasted to be used on the smashing glass and the bullet.



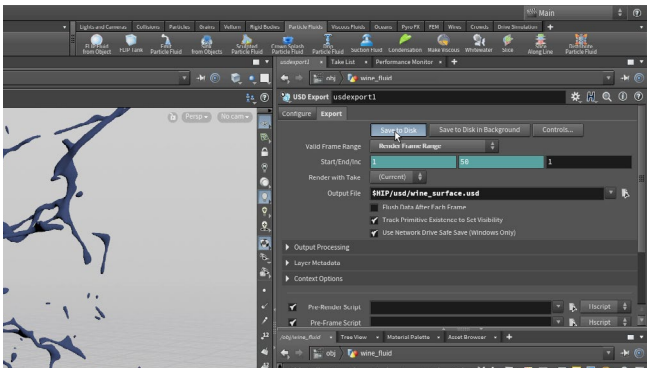
05

Make sure that the *retime* node is wired into the *particlefluidsurface* node then set it's display flag. This will give you your final fluid based on the retiming. Select the *particlefluidsurface* node and keep:

- **Method** set to **Average Position**
- Set **Union Compressed Fluid Surface** to **Off**.

In the **Filtering** tab turn:

- **Dilate** to **ON** and set it to **2**.
- **Smooth** to **ON** and set it to **Laplacian Flow**

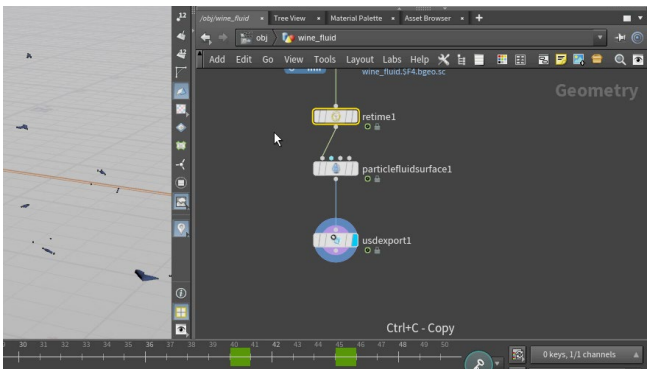


06

Add a **USD Export** node to the end of the chain. **Rename** it *wine_surface*. Set the following

- **Valid Frame Range** to **Render Frame Range**
- **Output File** to *$HIP/usd/wine_surface.usd*

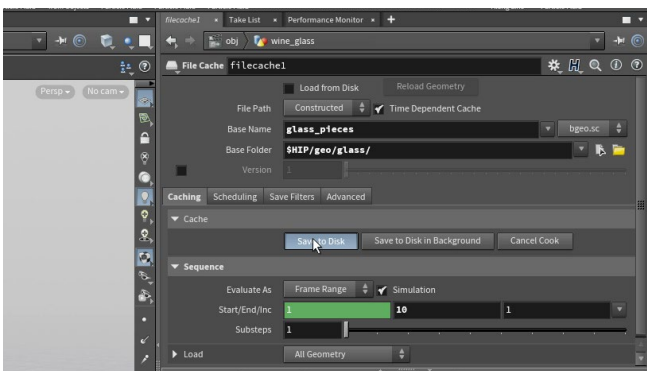
Hit **Save to Disk.**



07

Select the *retime* node and press **Ctrl-c** to copy it. You will paste this in another network to retime the shattering wine glass. This will ensure that the keyframes match in both of the networks.

Save your work.



08

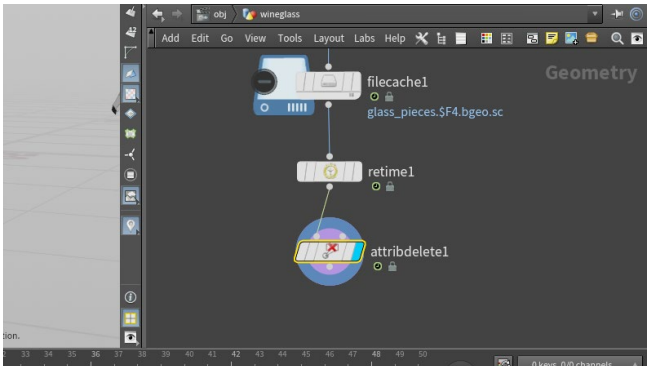
Go to frame 1 and navigate into the *wine_glass* network. Beneath the *transform_hires* node, wire in a **File Cache** node and set the following:

- **Base Name** to *glass_pieces*
- **Base Folder** to *$HIP/geo/*
- Turn **Off** the **Version** check box
- **End** to **10** (**RMB-click > Delete Channels** first)

Hit **Save to Disk**. Set **Load from Disk** to **On** and **Scrub** through frames 1 to 10 to make sure that it looks correct.

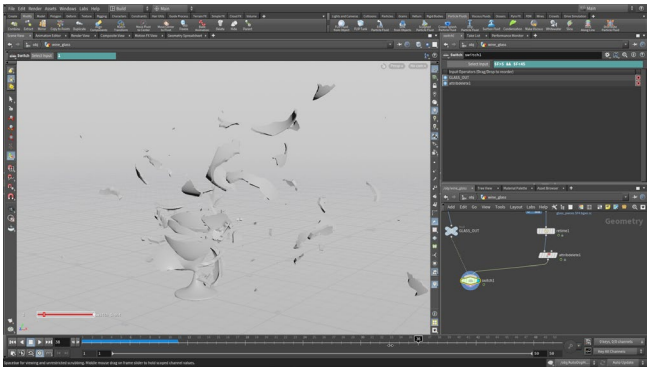
USD and SOLARIS

To support the look dev stage of this project, you are caching out the **fluid**, the **wine glass** and the **bullet** to USD. By doing this, you can focus on rendering without worrying about simulations being recalculated. Here you will display the caches in the same scene file as the simulations but another option would be to start a new scene file and import the caches into that file. This would let you focus on lighting and rendering your shot but would make it harder to go back and tweak the sim.



09 **Press Ctrl-v** to paste in the *retime* node and place it after the *filecache* node and set its **Display flag**. Now you have the same timing on the glass that you have on the fluid. You can scrub through the timeline to watch the timing of the pieces.

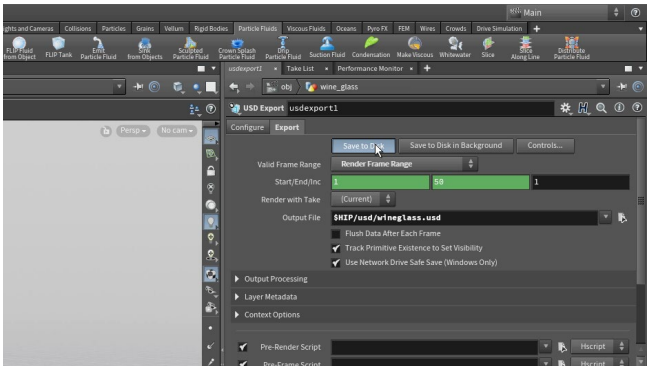
After the *retime* node, add an **Attribute Delete**. From the arrow next to **Primitive Attributes**, select *name* to remove this attribute from the geometry.



10 Add a **switch** node into the network. Feed the *GLASS_OUT* into it first and *attribdelete* node into it second.

Set **Select Input** to *$F>5 && $F<45*. Scrub in the timeline to see how this works. This expression makes the switch from the unbroken glass to the broken glass at frame 5 and then back at frame 45.

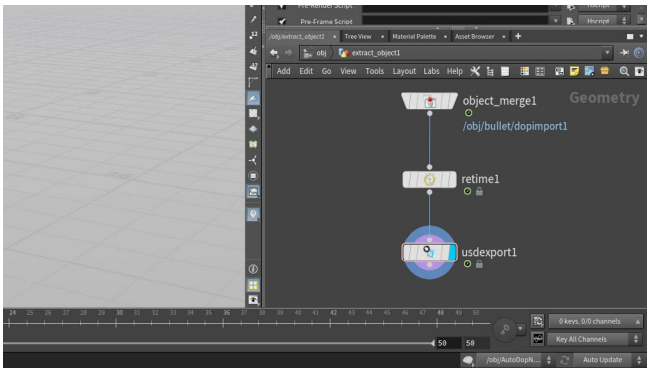
You are putting these shapes together so that the glass is unbroken before and after impact in the wineglass USD file.



11 Add a **USD Export** node to the end of the chain. Set the following

- **Valid Frame Range** to **Render Frame Range**
- **Output File** to *$HIP/usd/wineglass.usd*

Hit **Save to Disk.**



12 Go to **frame 1** and select the *bullet* object. From the **Modify** menu, select **Extract**. This gives us the world space position of the geometry. Dive into *extract_object* and, **Paste** the *retime* node beneath the *object_merge* node then connect them.

Add a **USD Export** node to the end of the chain. **Rename** it *bullet*. Set the following

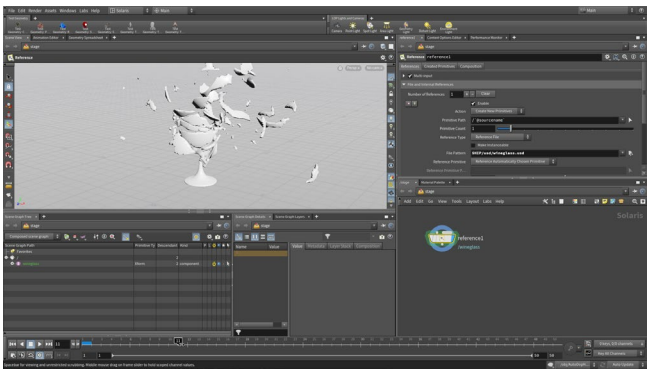
- **Valid Frame Range** to **Render Frame Range**
- **Output File** to *$HIP/usd/bullet.usd*

Hit **Save to Disk.**

PART SEVEN

Set up and Render the Shot

To render the shot, you will reference the USD files into the Solaris Stage then add a backdrop. Solaris is the context of Houdini that uses LOP nodes to set up the USD Scene Graph. Next, you will add and position a camera and then an environment light. The Karma renderer will then be invoked in the viewport to create a preview render of the shot.

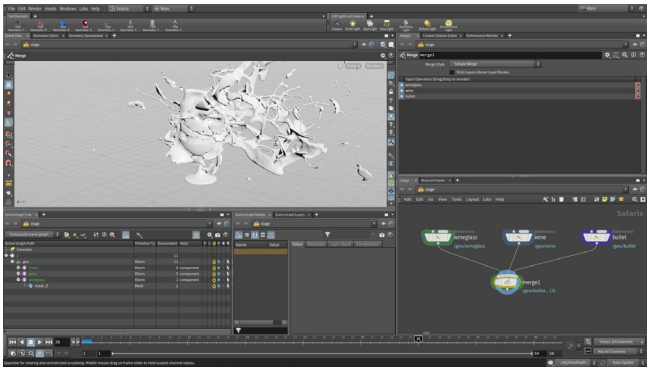


01

Change the desktop to **Solaris**. Choose **Stage** from the path bar.

In the Network View press **tab > Reference** then click to add a **Reference** node. Next to **Reference File**, click on the **File Chooser** and find the *wineglass.usd* file. Rename the node to *wineglass*. Set the **Primitive Path** to */geo/$OS* - this will use the node name and place it into a group called *geo*.

In the Scene View, use your view tools such as **spacebar-h** for homing the view to get a better look at the wine glass.



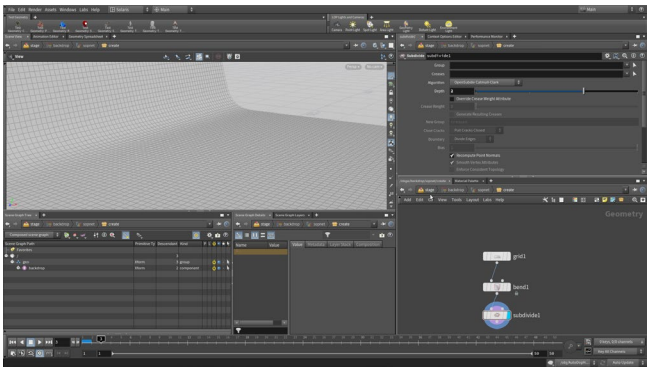
02

Alt-drag on this node to make a copy and again to make a second copy. For the first copy, click on the **File Chooser** and find the *wine_surface.usd* file. Rename the node to *wine*.

Repeat to make another copy, find the *bullet.usd* file. Rename the node to *bullet*.

Add a **Merge** node to the network and wire all three reference nodes into it. Set its **display flag** then scrub to see the results.

In the **Scene Graph**, you can see a *geo* entry and underneath that you will find the three referenced USD files.



03

In the Network view, press **tab** and type out **Grid**. Click to place down the node, rename it *backdrop* and wire it into the *merge* node. Set **Import Path Prefix** to */geo/$OS*. **Double-click** on the *backdrop* node to dive down to the geometry level.

Select the *Grid* node and set the **Size** to **200, 200** and **Rows** and **Columns** to **20**. **RMB-click** on the *grid* node's output and type **Bend**. Click to place a bend node and set its **Display Flag** then set: **Bend** to **75, Capture Origin** to **-40, 0, 0, Capture Direction** to **-1, 0, 0,** and **Capture Length** to **20. RMB-click** on the *grid* node's output and type **Subdivide.** Set its **Display Flag** then set **Depth** to **2.**

CACHING OUT SIMULATIONS

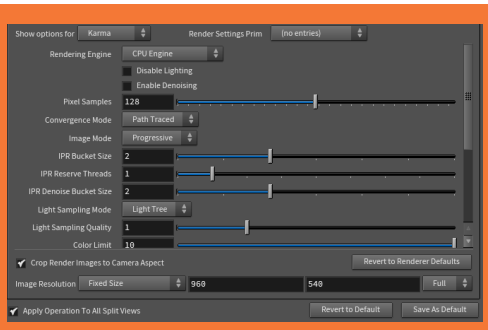
To support the look dev stage of this project, you cached out the **fluid**, the **wine glass** and the **bullet** to geometry (USD) sequences. By doing this, you can focus on rendering without worrying about simulations being recalculated.

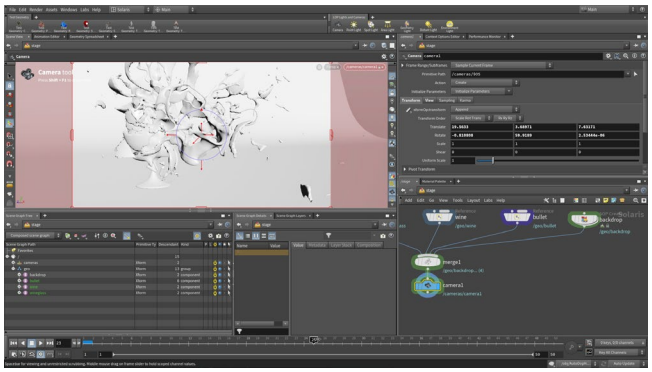
This is a typical workflow when working on VFX shots that can consume **LOTS OF HARD DRIVE SPACE**. You should be aware of this before sending off huge simulations with lots of particles - make sure you have somewhere to store the various intermediate stages.

VIEWPORT RENDERING

You are now going to render the sequence using Houdini's renderer Karma. At first this will render using settings you can find in the Display options. Press **d** in the Scene View to bring it up. You can turn on the denoiser here, set Pixel Samples and the Image Resolution.

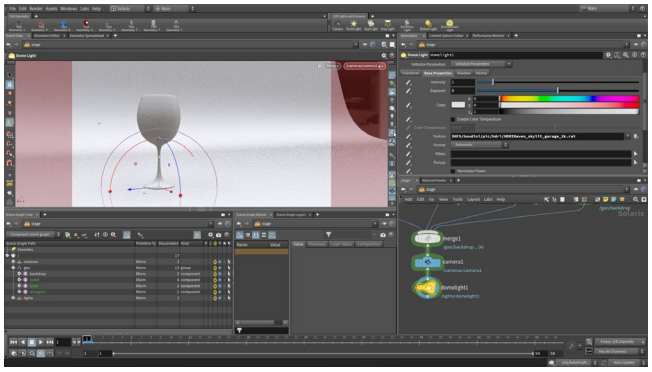
Later when you set up a **Karma LOP**, there will be render settings on that node which will be used to create the final output.





04 Use your view tools to look at the *wineglass* from the front. From the **LOP Lights and Camera** shelf, **Ctrl-click** on the **Camera** tool. This adds a camera node into the network and you are now looking through the camera in the viewport.

Press the **Lock Camera/Light to View** button so that view changes can be used to reposition the camera. Now **Tumble**, **Pan** and **Dolly** in the viewport to reposition the camera so the wineglass is on the left and the splash moves to the right. Scrub the timeline to make sure the camera works for the whole sequence.



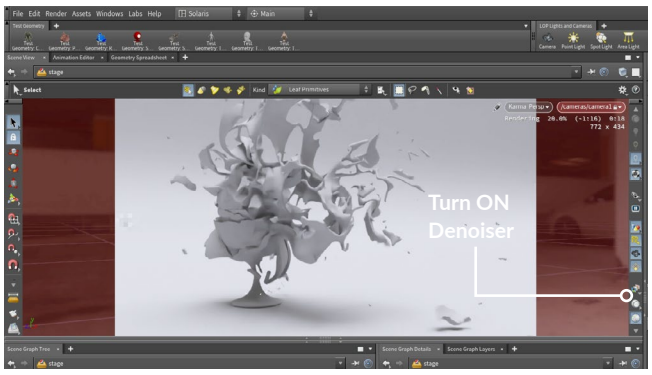
05 From the LOP **Lights and Camera** shelf, **Ctrl-click** on the **Environment Light** tool. This adds a *domelight* node to the end of the chain.

Select the *domelight* node and from the **Base Properties** tab, click on the **File Chooser** button next to **Texture**. Click on the *$HFS/houdini/pic/hdri* listing in the sidebar then select the *HDRIHaven_skylit_garage_2k.rat* file. Click **Accept**.

On the **Display Options** bar. Click on the **High Quality Lighting with Shadows** button.

06 From the *Persp* menu, choose **Karma** to render with Karma in the viewport. You can move to different frames in the timeline and the viewport will update quickly.

Karma is designed to work with USD which is why everything in the LOP context is converted to the USD scene graph. You can only use the Karma renderer from this part of Houdini.

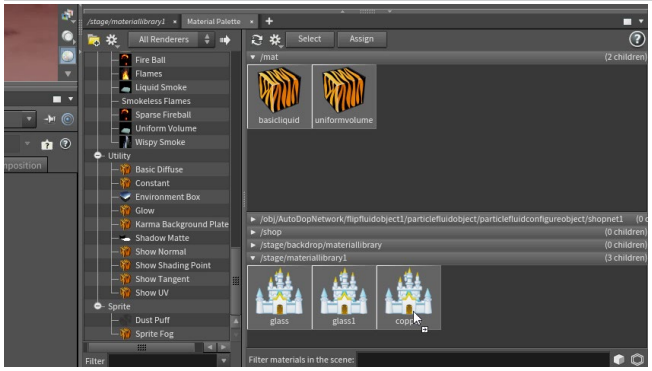


07 To get a cleaner image when you render, you can turn on **Denoiser** if you have an Nvidia graphics card and you have installed the latest drivers. You can turn it on in the **Display Options** bar.

PART EIGHT

Assign Materials and Render a Sequence

Now you can add materials to the wineglass, wine and bullet. These materials will become part of the USD Scene Graph and will get assigned to the geometry using a LOP node. You can then use a Karma LOP to prepare your render settings including the use of the Nvidia Optix Denoiser. After you render, you can load the sequence into Mplay to review the results.

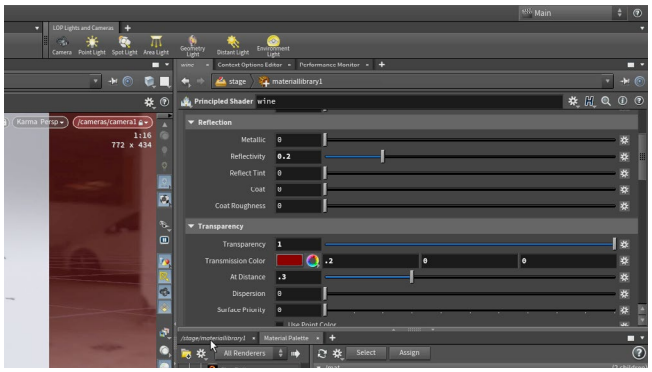


01

In the Network view, press **tab > Material Library. Wire** it into the end of the chain then set its **Display Flag.**

Go to the **Material Palette** pane. Click on the arrow next to */stage/materiallibrary* to open up this area. Scroll through the material gallery on the left of the palette and drag two **Glass** materials into the *materiallibrary* working area for the wineglass and wine.

Now find a **copper** material and drag it into the *materiallibrary* working area. You will use this for the bullet.

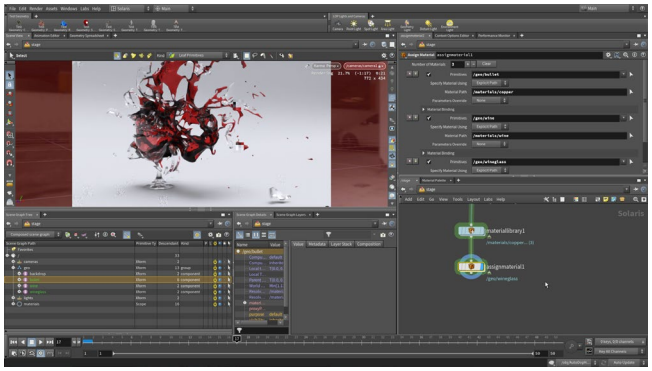


02

Select the second *glass* material and rename it to *wine*.

Set **Inside IOR** to **1.3443** which is an IOR for wine. Next, set **Reflectivity** to **0.2** to reduce how much the surroundings are reflected.

Set **Transmission Color** to **0.2, 0, 0** which will create a reddish wine look. Next set **At Distance** to **0.3.**



03

Go back to the **Stage** level. After the *Material Library* node, add an **Assign Materials** node.

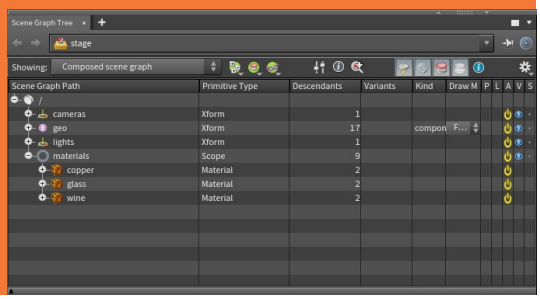
From the Scene Graph, drag the *wineglass* to the **Primitives** field then click on the arrow next to **Material Path** and choose the *glass* material for this primitive.

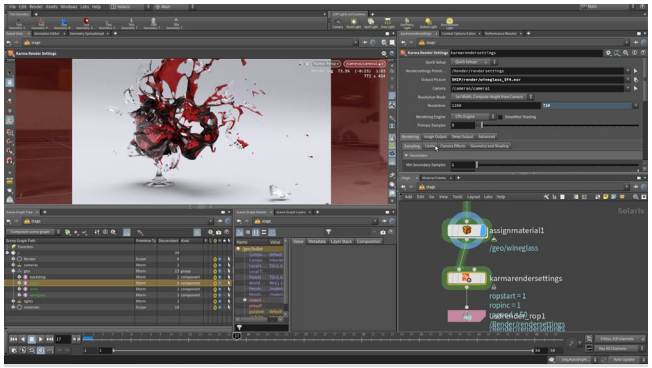
Now click the **Plus Sign** next to the check box twice to add two new entries. Use the same method to assign the *wine* material to the *wine* primitive and the *copper* material to the *bullet* primitive.

SCENE GRAPH

Just like the geometry and lights, the materials you add using LOP nodes are added to the **Scene Graph**. When you used the Material Library LOP, the default setting for the Material Path Prefix was **/materials/** and that is where they are placed in the graph. You could choose to organize them differently but this is the default.

This material path is the one you used in the **Assign Materials LOP** to place the materials onto the geometry.

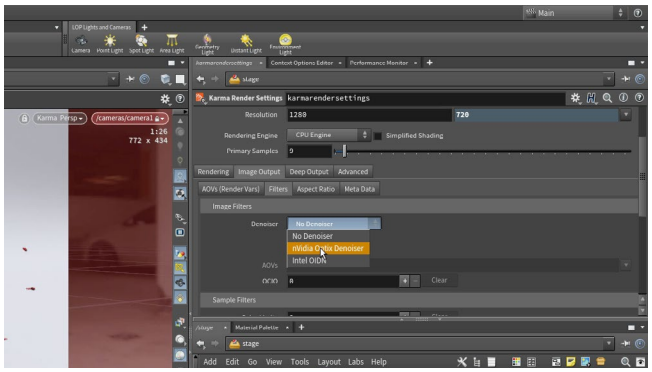




04

In the **Network View**, press **tab > Karma** to add a **Karma Render Settings** and **USD Render ROP** node. Wire them into the end of the chain. Select the *karmarendersettings* node and on the **Image Output > Filters** tab set **Denoiser** to **nvidia Optix Denoiser** to turn the denoiser back on.

Select the *usdrender_rop* node. Set **Valid Frame Range** to **Render Frame Range** and set the **Output Picture** to *$HIP/render/wineglass_$F4.exr*. The *$F* in the name is needed to add frame numbers to the renderings and the *4* is the padding of the frame number.

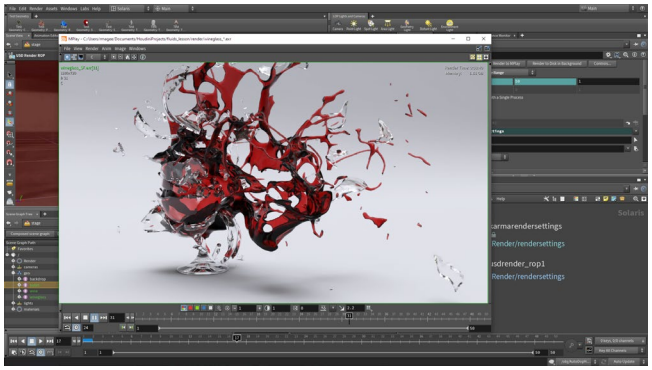


05

The denoiser from the viewport will not affect the output from this node therefore you much choose it explicitly. Select the *karmarendersettings* node and on the **Image Output > Filters** tab set **Denoiser** to **nvidia Optix Denoiser** to turn the denoiser back on.

The **nVidia Optix Denoiser** will match the one used in the viewport. There is also an **Intel OIDN** denoiser which is only available when rendering to disk.

Save your work. Select the *usdrender_rop* node and click on **Render to Disk**.



06

When you finish, choose **Render > Mplay > Load Disk Files** and open up the rendered images to review the final sequence.

Later you can branch off another **Karma** node to up the resolution and render settings for your final rendering. You can go back to **Convergence Mode** set to **Variance,** up the **sample** count and turn off the **denoiser**. It is always good to complete test renderings at a lower resolution first to make sure that everything is working the way you expect it to.

CONCLUSION

You have now created a complete VFX shot using the Bullet RBD and FLIP Fluid solvers to smash a wine glass. You used the retime node to slow down then reverse time so that the wine glass finished in the same position as it started then you cached out the results to USD files.

These were then used to set up and light your shot using the Solaris/LOPS context. Materials were created and assigned to the primitives get the right look for your shot.

This project shows how you can use Houdini's dynamic nodes and networks to integrate different kinds of effects while using geometry nodes to set up and output the simulations.

Now that you have an understanding of the nodes and networks used to create VFX shots. This will assist you as you dig deeper into Houdini to achieve your own effects.

Enjoy!