HOUDINI FOUNDATIONS

WELCOME TO HOUDINI

In this lesson, you will take your first steps into Houdini as you model a coffee cup then use dynamics to simulate a collection of gumballs falling into it. You will apply textures and materials, add lights and a camera then render out the finished sequence. By touching all aspects of this shot, you will begin learning how to navigate your way through Houdini and its node-based workflow.

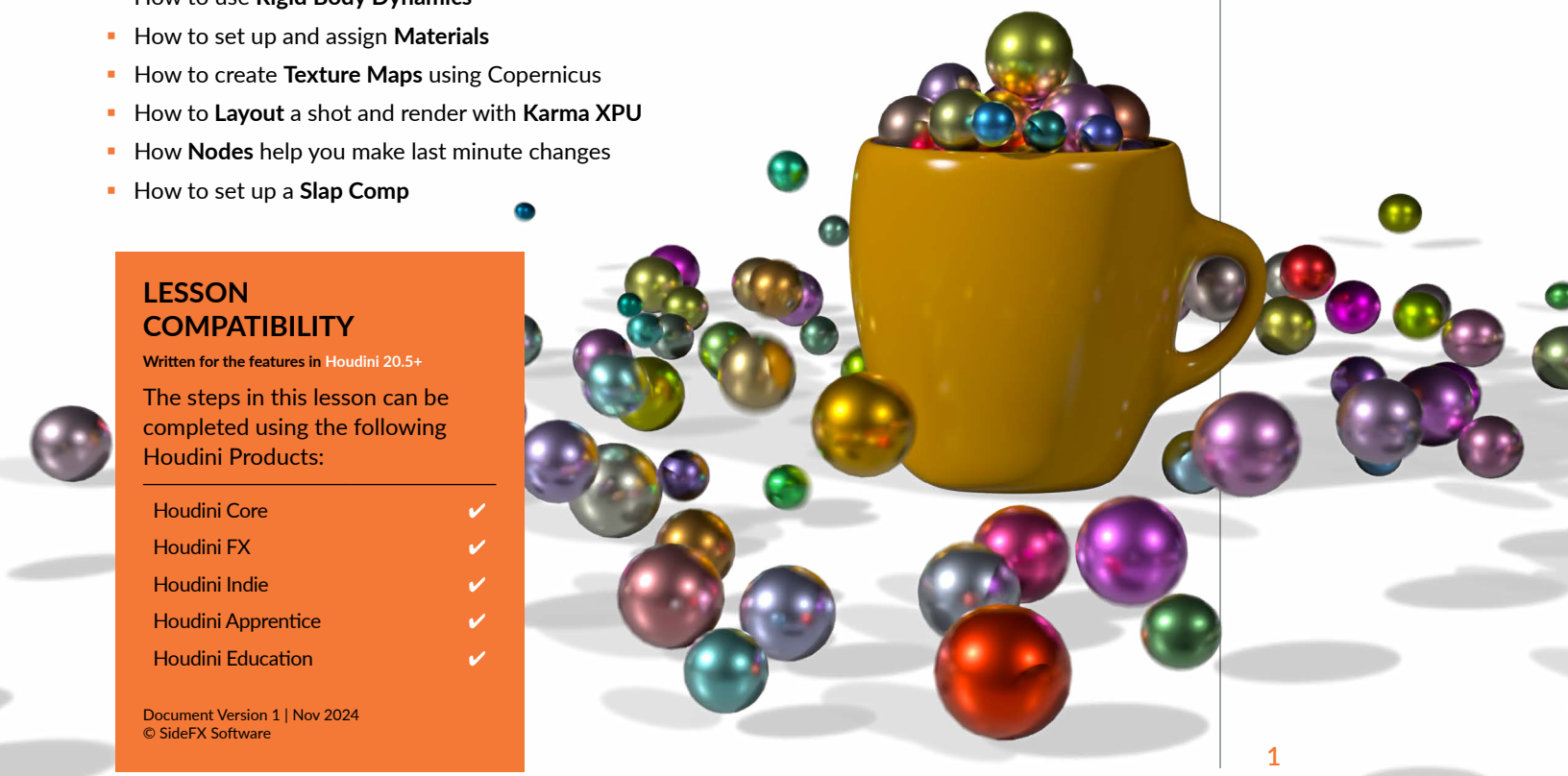
One of the main goals of this lesson is to explore the Houdini user interface and discover some of its most important tools. You will learn how to work interactively in the **Scene View** and how to use the **Network View** to manage your nodes as you refine your model and set up the **Rigid Body Simulation**. You will also set up materials and textures on the **Solaris Stage** then render using Houdini's built-in renderer **Karma XPU**. Along the way you will use Houdini's new image engine called **Copernicus** to create a **Texture map** and to add a **Slap Comp** to the final shot.

LESSON GOAL

Model, Render and Simulate gumballs falling into a cup using Houdini's procedural node-based workflow

WHAT YOU WILL LEARN

- How to work with the **View Tools**
- How to use **Shelves**, **Radial Menus** and the **Tab** key to access tools
- How to create a model using polygonal **Geometry**
- How to work with **Nodes and Networks**
- How to use **Rigid Body Dynamics**
- How to set up and assign **Materials**
- How to create **Texture Maps** using Copernicus
- How to **Layout** a shot and render with **Karma XPU**
- How **Nodes** help you make last minute changes
- How to set up a **Slap Comp**



LESSON COMPATIBILITY

Written for the features in Houdini 20.5+

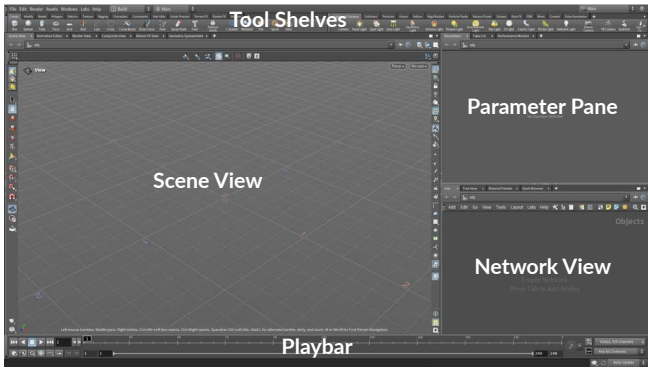
The steps in this lesson can be completed using the following Houdini Products:

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

Document Version 1 | Nov 2024

PART ONE
Model a Cup

To get started, it is important to learn how to explore the Houdini workspace with a focus on the panes you will use on a regular basis. The **Scene View** panel lets you create objects interactively, while the **Parameter** pane lets you edit node properties and the **Network Editor** lets you work directly with nodes. Learning how to work back and forth between these interface elements will be an important skill moving forward.



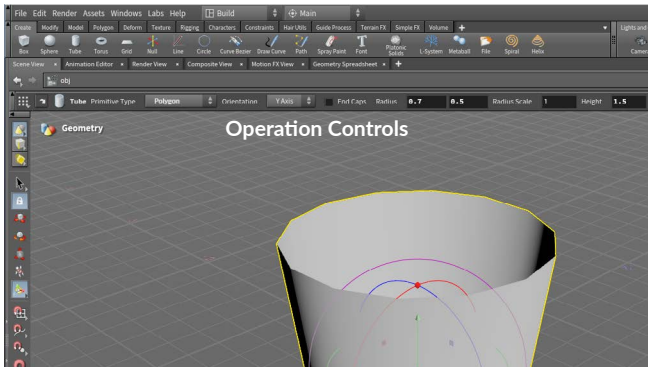
01

Select **File > New Project.** Change the **Project Name** to *overview_lesson* and press **Accept**. This creates a project directory with subfolders for all the files associated with this shot.

Select **File > Save As...** You are inside the *overview_lesson* directory. Set the file name to *gumballs_01.hip* and click **Accept** to save.

You now have an empty workspace with different panes. The main panes are the **Scene View**, the **Network View** and the **Parameter Pane**. At the top are **Tool Shelves** and at the bottom is the **Playbar.**

In the Scene View, **Press D** to open the **Display Options**. Click on the **Background** tab and set **Color Scheme** to **Dark Grey**.

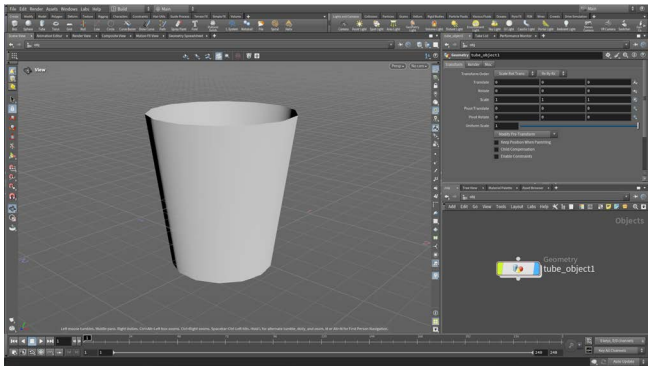


02

In the Scene view, **press c.** to bring up a radial menu. Choose **Create > Geometry > Tube**. Your cursor now shows the outline of a box waiting to be placed in the scene. **Press Enter** to place it at the origin.

From the **Operation Controls** bar at the top of the Scene View, set the following to shape the cup:

- **Radius** to **0.7, 0.5**
- **Height** to **1.5**
- **Rows** to **6**
- **Columns** to **14**



03

You can now explore the cup using the **View** tools. Press the following hotkeys:

Tumble	Spacebar or Alt[Opt] - LMB click-drag
Pan	Spacebar or Alt[Opt] - MMB click-drag
Dolly	Spacebar or Alt[Opt] - RMB click-drag

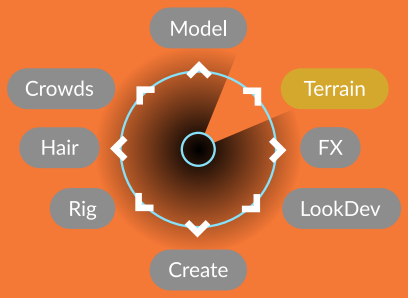
In some cases, you will want to home in to get your bearings. There are some hotkeys for that as well:

Home All	Spacebar - A
Home Selected	Spacebar - G
Home Grid [If Construction Plane is on]	Spacebar -H

RADIAL MENUS

One way to access tools in Houdini is radial menus which you can access using the **X**, **C** and **V** hotkeys. Each of these brings up a radial menu with lots of options for you to choose from. The main focus of each menu is as follows:

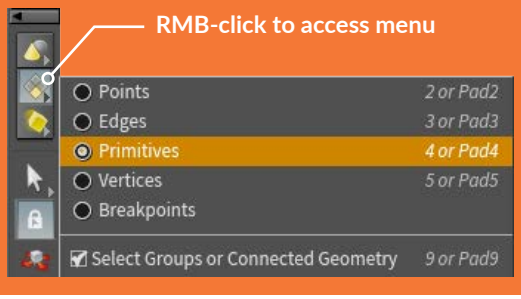
Snapping	**X**
Main (or Custom)	**C**
View	**V**

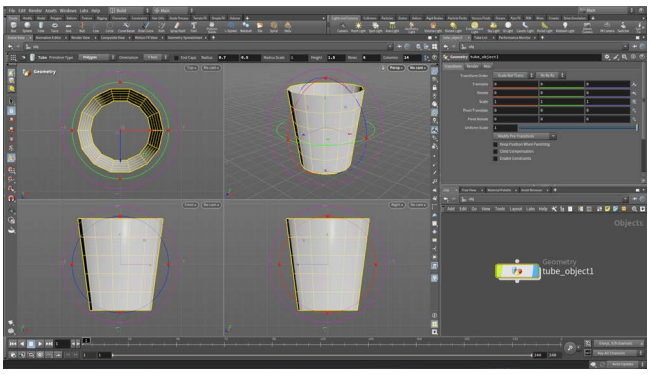


SELECTION HOTKEYS

If you are using the **Select, Move, Rotate, Scale** or **Handles** tools, the following hotkeys will determine your selection mode as well as which level you will be working at.

Objects	Object Level	1
Points	Geometry Level	2
Edges	Geometry Level	3
Primitives/Faces	Geometry Level	4
Vertices	Geometry Level	5



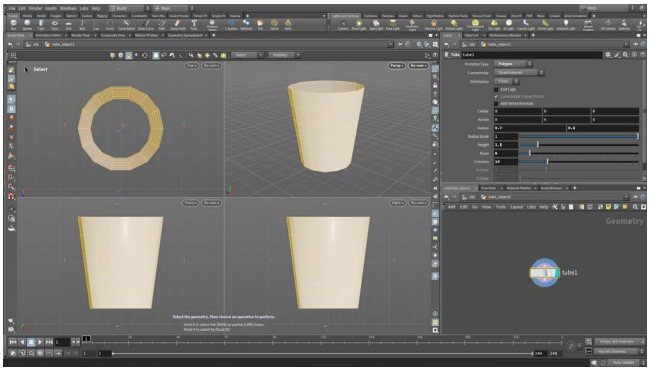


04

In the perspective view press **Spacebar - b** to change to a four view layout. Now you can see *Top*, *Front* and *Right* views along with the *Persp* view.

In the viewport, **press v** to bring up another radial menu. From this menu, choose **Shading >Smooth Wire Shaded**. Now you can see the topology of the surface which will assist when modeling the cup.

You can use your view tools in all four of these views. If you click on the **Viewport Layout** menu at the top right then you can set **Link Ortho Views** to **ON**. Now view changes are synced in these views.

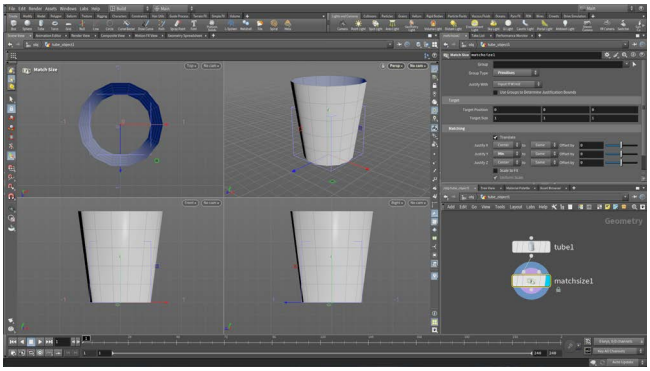


05

Press s to get the **Select** tool. You can also access this on the left side of the Scene view.

In the Scene view, click on the tube to select this object. **Press 4** to get **Primitive** selection which moves you from the Object level to the Geometry level. The tube appears unselected in this context. **Double-click** on the geometry to select all the primitives.

The Object level lets you work with the positioning of objects while the geometry level is where you define the shape of objects. The word **Geometry** is in the top corner of the Network view. The nodes in this context are called **Surface Operators** or **SOPS** for short.



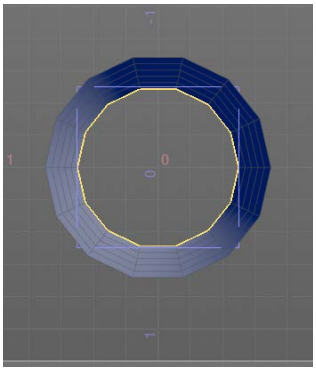
06

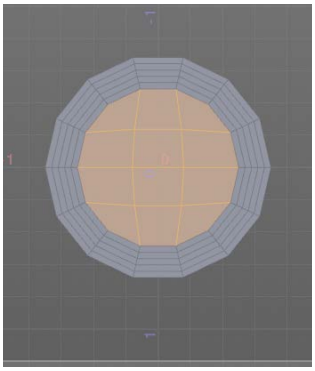
In the Scene view, **press Tab** and start typing out **Match Size**. Select it from the list and press **Enter**.

In the Parameter pane, set **Justify Y** to **Min** to **Same**. This lifts the cup up to sit on the ground.

The **Tab** menu is another way of accessing tools. As you become more familiar with tool names the tab menu will be easier to use.

Generally tools act on the selection you have in before you choose the tool. You can also use a tool without a selection in which case you follow the prompts at the bottom of the Scene View to make the necessary selections then press Enter.





07

Press s to get the **Select** tool. **Press 3** to get **Edge** selection then double click on the bottom edge of the tube. Go to the **Polygon** shelf and click on **Polyfill**. The shelf is another way of accessing tools.

In the Parameter pane, set the following

- **Fill Mode to Quadrilateral grid**
- **Corner offset -5**
- **Tangent Strength 0**

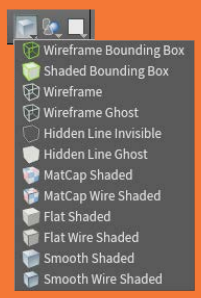
In the top view you can see the grid aligns with the Z axis.

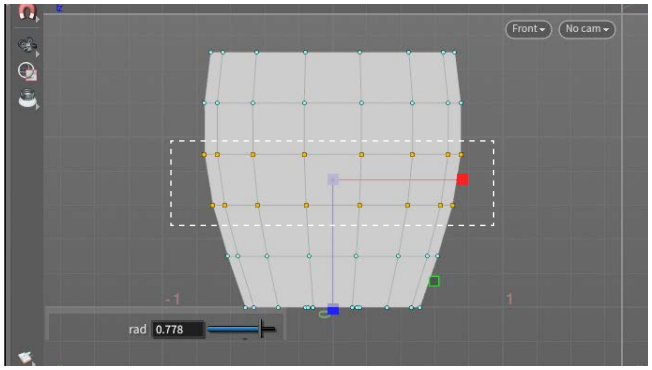
SHADING OPTIONS

There are a number of **Shading Options** available from either the **View** radial menu or the **Shading** menu in the top right of the Viewport.

For the shading of your objects, the lighting is determined by the **Display Options** on the right edge of the Viewport. You can choose from a headlight, normal lighting or high quality lighting with shadows.

To quickly toggle from your shaded view to wireframe press the **W** key.

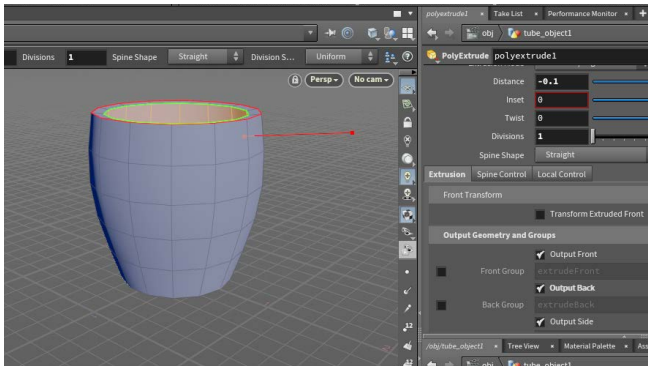




08 **Press s** to get the **Select** tool. **Press 2** to choose **Point** selection then in the Front view box select the middle two rows of points. Now press **tab > Soft Transform**. **Press E** to get a scale handle. In the top view click drag on the XY square to only scale in X and Y to puff out the middle of the cup.

Now drag on the **Rad** control in the bottom left corner to set the **Soft Radius** on this edit. Set it to around **0.75** to round out the shape. You can also access the parameter in the Parameter pane.

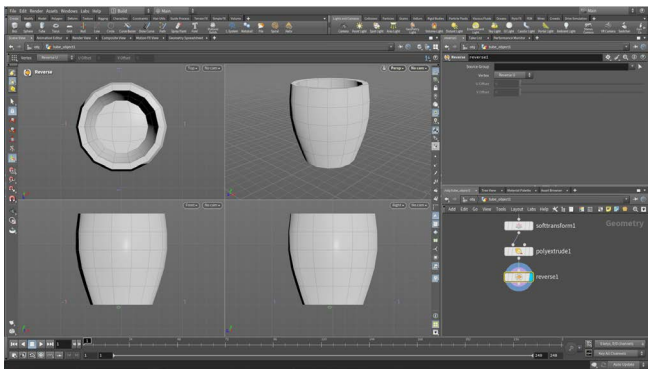
This action added an *edit* node to the network view.



09 **Press s** to get the **Select** tool. **Press 4** to go back to Primitive selection then **double-click** on the geometry to select all the primitives.

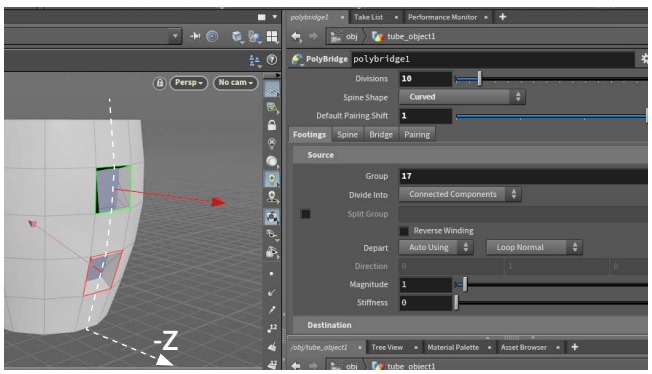
Press c and choose **Model > Polygons > PolyExtrude**. Drag on the handle to set the **Distance** on the geometry to around **-0.1**.

In the Parameter pane, go to the **Extrusion > Output Geometry and Groups** section and set **Output Back** to **ON**. This puts geometry on the inside and outside of the extrusion.



10 Right now the cup is a blueish color which means the surface normals are pointing the wrong way and the geometry is inside out. You can fix this easily.

Press s to get the **Select** tool. **Double click** on the geometry to select all the primitives. In the Scene view, press tab > **Reverse.** The normals are now corrected.

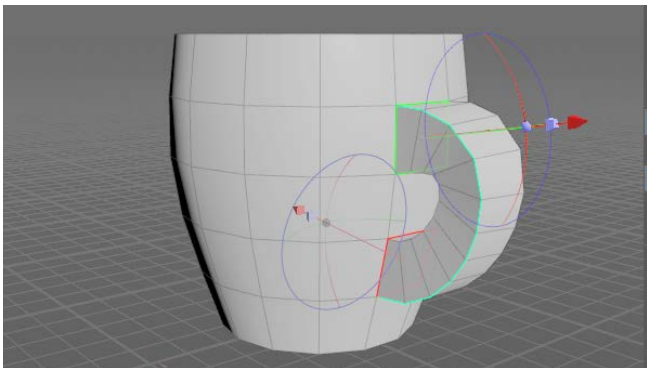


11 **Press s** to get the **Select** tool. Click in empty space to make sure that nothing is selected. **Press c** and choose **Model > Polygons > PolyBridge**.

Tumble around to find the side facing the -Z direction, select the primitive that is second from the top. Press **Enter**. Now select the primitive second from the bottom. Press **Enter**.

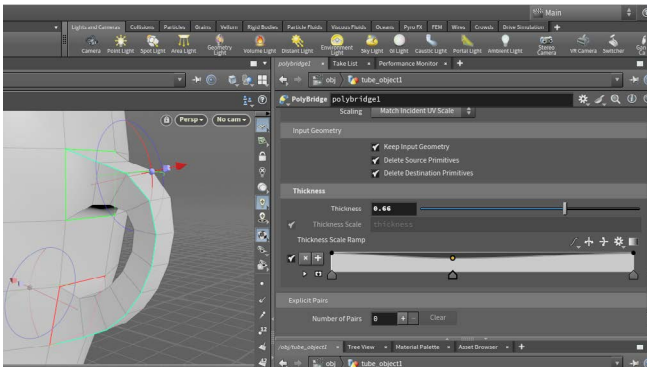
In the Parameter pane, set the following:

- **Divisions** to **10**
- **Spine Shape** to **Curved**
- **Default Paring Shift** to **1**

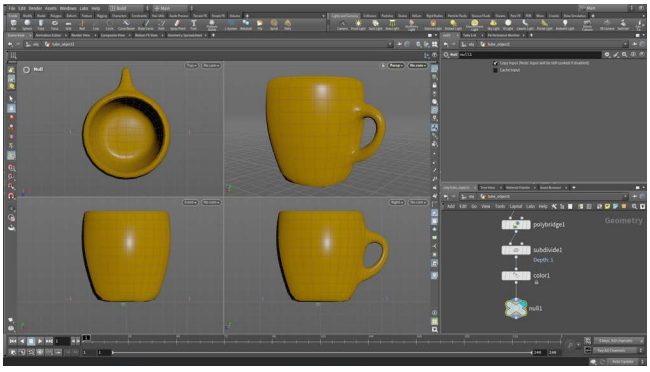


12 In the **Footings** section of the Parameter pane, go to the Destination section and set **Arrive to Along.** Now you can drag on the handles to play with the magnitude of the top and bottom. To match this image, set the **Source > Magnitude** to 3 and the **Destination > Magnitude** to **2.**

Under Source, set the Depart to **Auto Using > Explicit Direction**. This gives you a handle that you can rotate a bit to angle the handle up. Under **Destination** you can set **Arrive** to **Along > Explicit Direction**. Again this gives you the ability to shape the handle of the cup further.



13 Click on the **Bridge** tab and scroll down to the **Thickness** section. Set **Thickness** to around **0.66** then add a point to the middle of the **Thickness Scale Ramp** and push it down to thin out the handle in the middle.

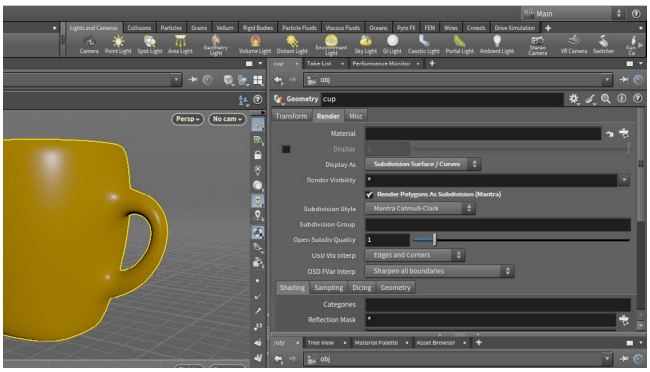


14 **Press s** to get the **Select** tool. **Press 4** to get Primitive selection, double click on the geometry then press **tab > Subdivide.** This adds more polygons to your model.

Press s to get the **Select** tool. Double click on the geometry then press **tab > Color.** in the Parameter pane, change the **Color** to an **Orange**.

In the Network view, **RMB-click** on the output knob of color and start typing **Null**. Select **Null** and place the node.

Hover over the node and click in the top right to set its Display flag. Rename the node to *CUP_OUT*.



15 **Press v** to and choose **Shading > Smooth Shaded**. Press **Shift +** to turn on Subdivision display. This subdivides the model without adding any geometry.

Go up to the Object level and rename the object to *cup.*

In the Parameter pane, click on the **Render** tab. The **Display As** is set to **Subdivision Surface/Curves**. This affects viewport display but not rendering. Turn on **Render Polygons As Subdivision** so the model will render with subdivisions later in the lesson.

Press **Shift -** to turn off the Subdivision display. You can toggle it on at any point. **Press v** to and choose **Shading >Smooth Wire Shaded**.

SUBDIVISIONS

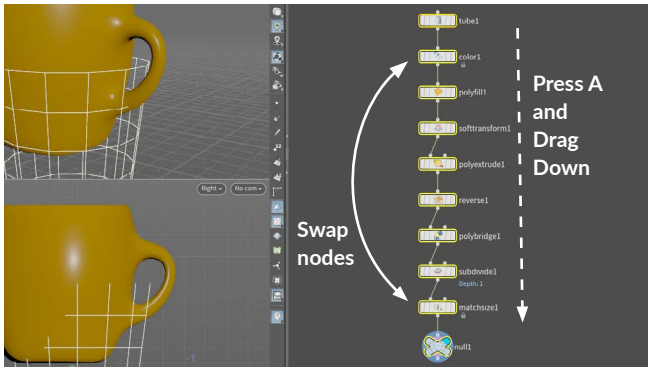
In this lesson you used a subdivide node to add geometry to your model that you may need for future modeling actions. The **Subdivision** display makes the display smoother without adding any geometry which keeps you model lighter to work with. Both are valid methods to subdivide your model while working in the Scene view.

When you render, you will want to turn on **Render Polygons as Subdivision** because this will render smoothly at the micropolygon level no matter how close you get to the model. This lets you avoid tessellation on the edges that breaks up the smoothness of the object.

PART TWO

Work with Nodes

Let's take a detour from modeling the cup to work with the nodes in the Network view. The nodes act as a recipe that describes the flow of data from the top to the bottom of the network. Keeping this view of your scene organized and easy to read is important for when you return to it later on in production or when you share your work with others and you want them to understand how you created the shot.

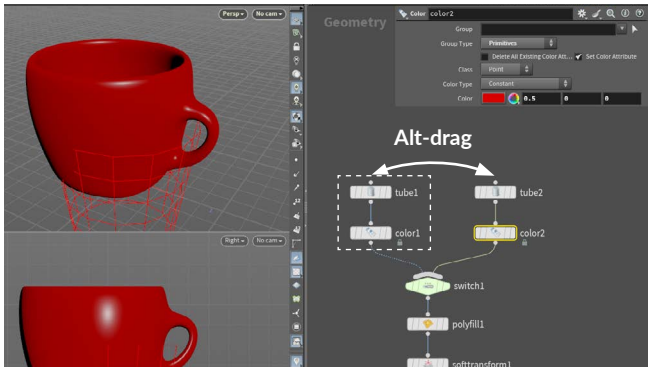


01

Press i to go back to the Geometry level. Click on the little up arrow in the divider between the Node view and the Parameter pane. This expands the Node view up. Use the RMB to zoom in and the MMB to track to see the whole network

Select the *matchsize* node. **Wiggle** your mouse to break it away from the node network. Move it down and place it on the line between *color* and *CUP_OUT*. Use the same method to move the *color* node from the bottom to just under the *tube* node.

Select all of the nodes. **Press A** then drag down from the first node in the network to straighten the nodes and distribute them evenly.



02

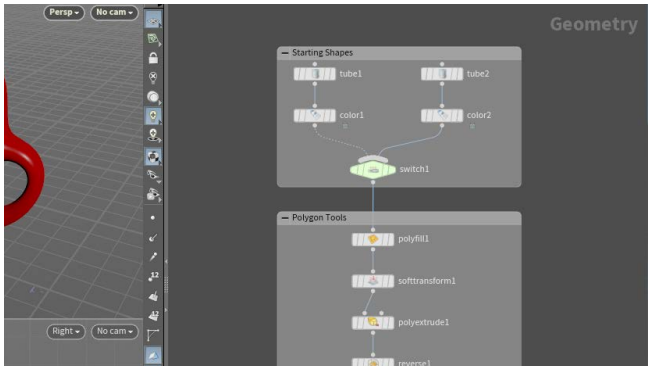
In the Network view, select the tube and color nodes and **Alt drag** to create copies. Press **tab > Switch** and place the node in between the original *color* and the *polyfill*. Wire the second *color* node into the *switch*.

Press p to bring up a Parameter pane inside the Network view. Set **Select input** to **1**.

Select the second *tube* node**.** Change the **Height** to **1.2.**

Select the *color* node and change the second *color* to **red.**

Press p to turn off the Parameter pane.



03

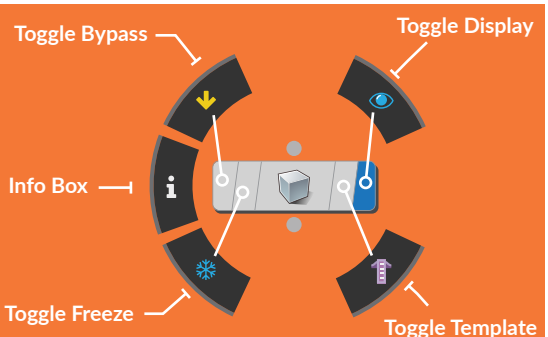
Box select both *tube* nodes, both *color* nodes and the *switch* node. Press **Shift - O** to add a network box with these nodes inside it. **Double-click** in the titlebar and name this *Starting Shapes.*

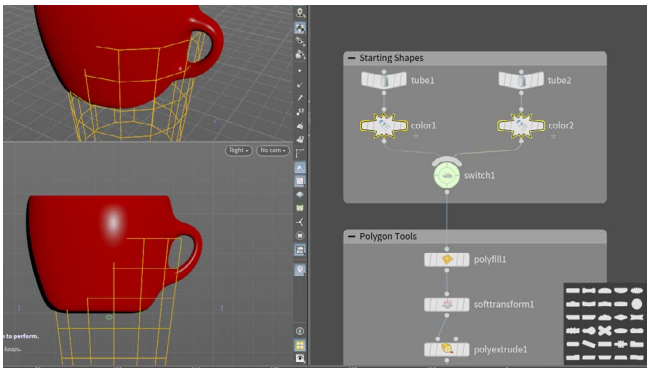
Now select the nodes from polyfill to subdivide. Press **Shift - O** to add a network box with these nodes inside it. **Double-click** in the titlebar and name this *Polygon Tools.*

You can move around the boxes to or move the nodes inside the boxes. You can also click on the top left corner to collapse the network box if you want to reduce clutter.

NODE FLAGS

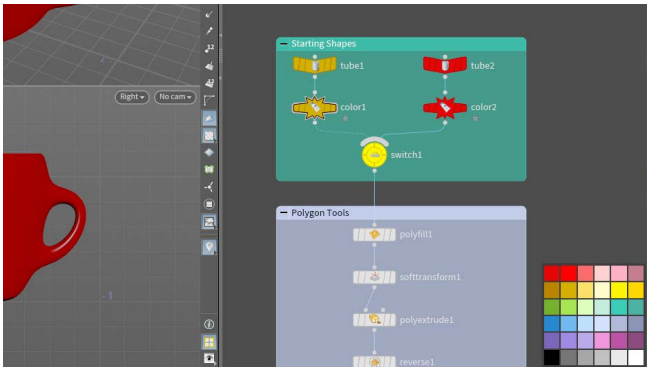
When you mouse over a node, this radial menu lets you toggle on and off several flags. The **Display flag** sets this node as the node you can see in the Scene view. The **Bypass flag** turns off a node to see how the network functions without it. The Template flag lets you see a node in wireframe while working with other nodes. The Freeze node blocks changes from the node and nodes up the chain from the frozen node from working.





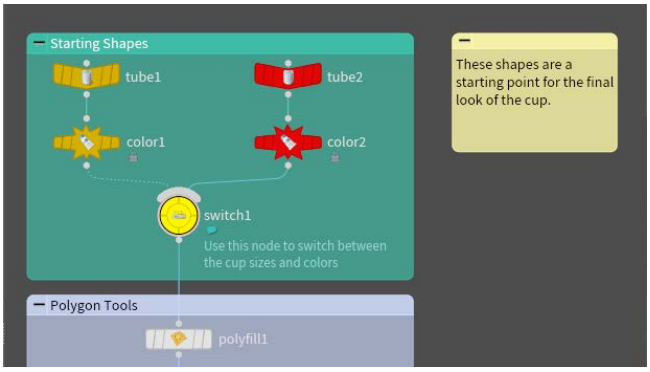
04 In the Node view, **Press Z** to bring up the Shape Palette. Select the *switch* node and change it to a **circle**. Change the *tube* and *color* nodes to distinguish them.

Some nodes have shapes when they are first built. You have the ability to change the shapes to help the readability of your network.



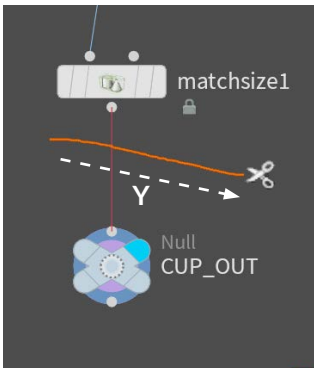
05 In the Node view, **Press C** to bring up the Color Palette. Select the *switch* node and change it to **yellow**. Change the *tube* and *color* nodes on the left to **orange** and the ones on the right to **red**. You can also select and add color to the Network boxes.

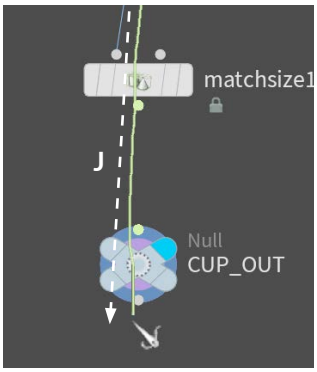
Again this will help you organize your network and find these nodes later on.



06 In the Node view, **Press Shift-P** to add a sticky note to the network. You can use this to annotate a part o your network.

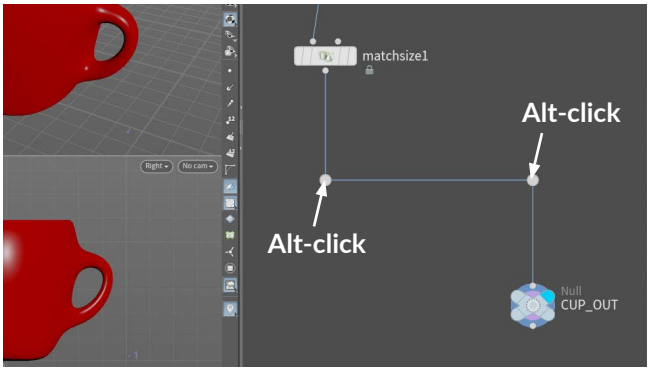
Another way to annotate a specific node is to use the Node flag menu to bring up the **Info box**. Near the bottom is a comment field. Fill that in then turn ON the **Show Comment in Network** button. Now you have more information for other artists exploring your network.





07 Move down to the bottom of the network. **Press Y** and drag over the line connecting *matchsize* and *CUP_OUT*. This breaks their connection.

Press J and drag down from *matchsize* to *CUP_OUT*. This reconnects the nodes. You can use this with multiple nodes if needed.



08 Move the CUP_OUT node down and to the right. Press **Alt** and **click** on the line to add a dot to the line. Add a second one then move the dots to create two right angles. Network dots are useful organizing tools that you can use to make your network more readable.

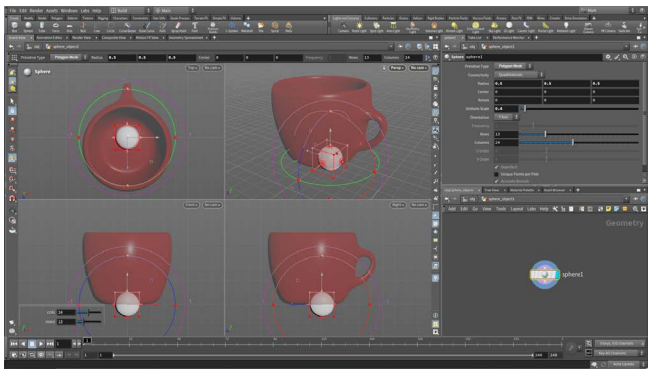
Most of these steps don't have any affect on what happens in the Scene View. But they are very important to help you manage the nodes that created as you work in Houdini.

Now back to creating 3D stuff!

PART THREE

Create a Gumball Simulation

In this shot, you are going to drop gumballs into the cup you just modeled. To do this, you want to place gumballs above the cup. Using a box and then scattering points onto the box, you can get a nice collection of gumballs. You also leave yourself the chance to change the number of gumballs at any point. You will also use attributes such as color and pscale to add some variety to the gumballs. The key is that you leave yourself open to the possibility of changes down the line.



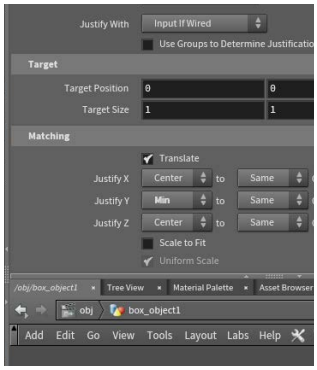
01

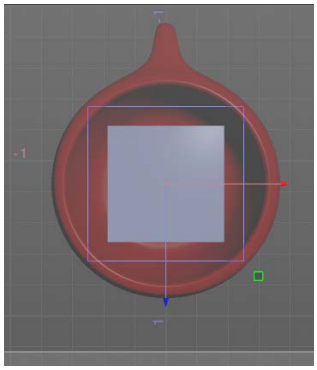
In the Scene view, **press c** to bring up a radial menu. From this menu, choose **Create > Geometry > Sphere**. **Press Enter** to place it at the origin. This creates a new *sphere* object

Press i to dive down into the sphere object. You can still see the cup as a ghosted shape. You will use the cup as a guide.

On the *sphere* node, set the following:

- **Uniform Scale** to **0.4**



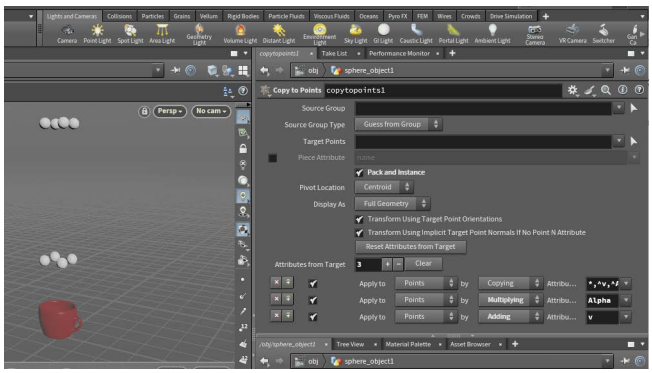


02

Press c and choose **Create > Geometry > Box**. **Press Enter** to place it at the origin. Double click on the *box* node to dive down into this object, Set the following:

- **Size** to **0.75, 5, 0.75**

In the Scene view, select the box geometry then press **tab** > **Match Size**. Set **Justify Y** to **Min to Same** and **Offset by** to **3.** This lifts the box up above the cup. In the Top view use the handle to center the box over the middle of the cup.



03

Navigate back to the Object level. Make sure nothing is selected. On the **Modify** shelf, click on **Copy to Points**. Select the *sphere* and press **Enter** then select the *box* and press **Enter**. **Press 4** to go to primitive selection mode so you aren't visualizing points anymore.

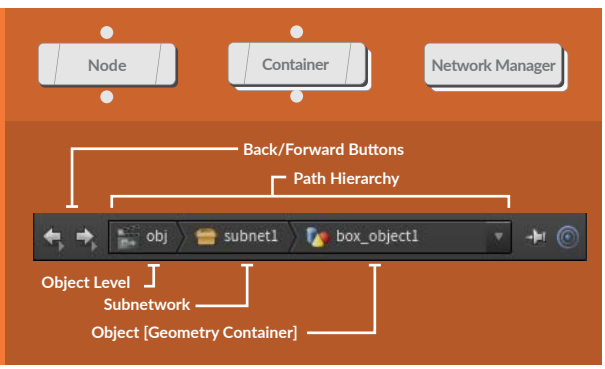
There is now one sphere attached to every corner point. The nodes from the two objects have been merged into one object.

On the *copytopoints* node set **Pack and Instance** to **ON**. Select the **Target Points text** and remove it. This text could limit the number of copied spheres. An empty field lets you copy to all points.

NAVIGATING NETWORKS

Nodes can be nested in other nodes, network managers or subnetworks. These container nodes have a white drop shadow. Double-click on node containers to jump in, press u to jump up.

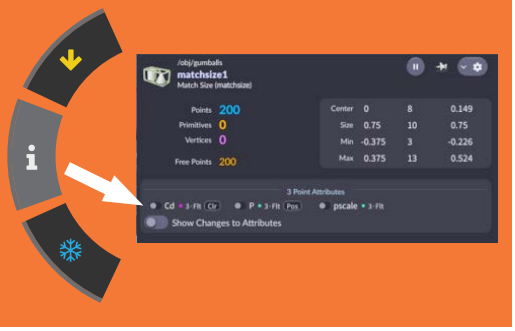
You can also use the browser-like path at the top of most panes to navigate these hierarchies. Click on this path to jump up and down the hierarchy or to go to other networks. You can also use the **Back and Forward** Buttons to navigate.

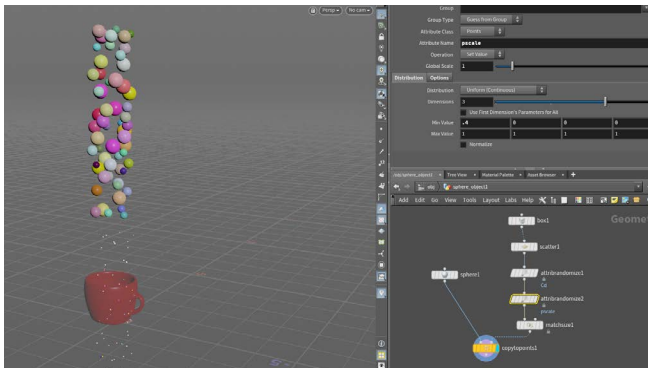


WORKING WITH ATTRIBUTES

Attributes can be assigned to Points, Primitives or Vertices. Some typical types of attributes include **color (Cd)** or **UVs**. You can see the attributes at any point in your chain by mousing over a node and choosing the **i** from the radial menu. You can also review the attribute values in the **Geometry Spreadsheet** panel.

In this lesson, you will be adding **color** and **pscale** attributes that are passed down from the points to the copied spheres.





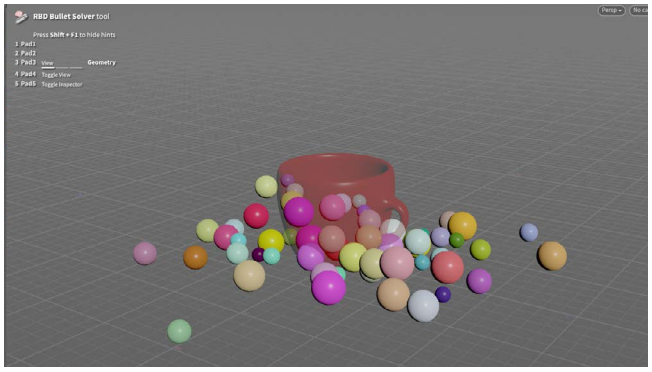
04

In the Network view, press **tab > Scatter**. Place the node down on its own. Set **Force Total Count** to **60**. Move this node between *box* and *copytopoints*. It will snap onto the wire line.

Press tab > Attribute Randomize. Place the node between *scatter* and *copytopoints*. You have 60 colored gumballs above the cup.

Press tab > Attribute Randomize. Place the node between *attributerandomize* and *copytopoints*. Set the **Attribute Name** to *pscale* and **Min Value** to **0.4**.

Now the gumballs come in different colors and sizes. These attributes are passing their information to the *copytopoints* node.

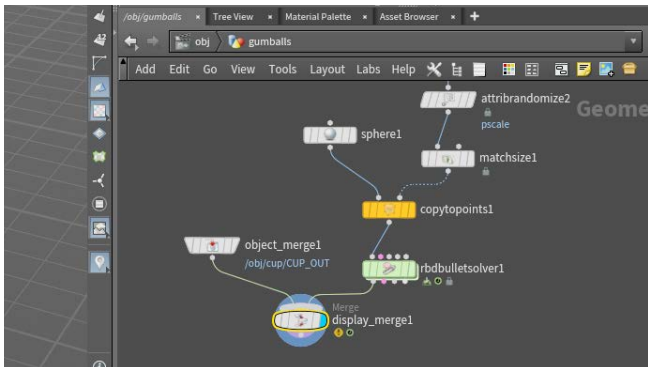


05

Make sure your timeline is at **Frame 1**. Press **tab >RBD Bullet Solver.** Place this node at the end of the chain and wire the *copytopoints* output into it. Set its Display flag.

In the Parameter pane, click on the **Collision** tab and under **Ground Collision** set **Ground Type** to **Ground Plane**. On the **Visualization** tab turn **OFF** the **Ground** display.

Press Play to simulate the gumballs. They fall to the ground but ignore the cup. This is because it isn't part of this network yet. You are seeing it ghosted from the cup network. Stop playback.

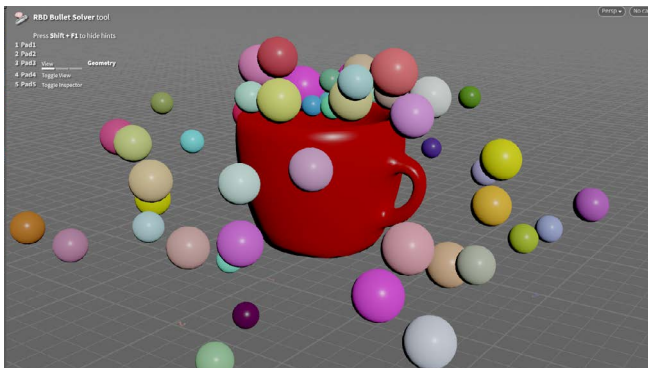


06

Return to **Frame 1**. Go to the Object level. Select the *cup* object in the Scene view and from the **Modify** shelf, click on the **Extract** tool. This merges the cup into different network.

Go back to the Object level. In the Network view, shift-select the *sphere* and then the *extract_object*. From the **Modify** shelf, click on the **Combine** tool.

Go back up to the Object level and rename the new combined network to *gumballs* then **press i** to dive back in.

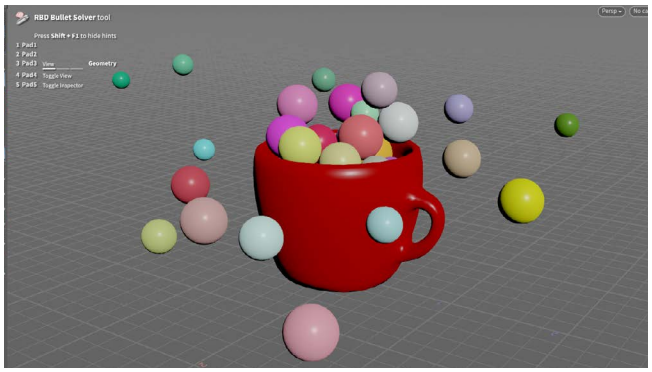


07

Select and delete the *display_merge* node. Move the *object_merge* node to the right side and wire its output into the fourth input on the *rbdbulletsolver* node. When you mouse over the inputs you will see a pop-up that says **Collision Geometry (input)**

At the bottom left edge of the **Timeline**, click on the **Global Animation Options** button. Set the *End* to **72** and click **Close**. This will set the timeline range to 72 frames.

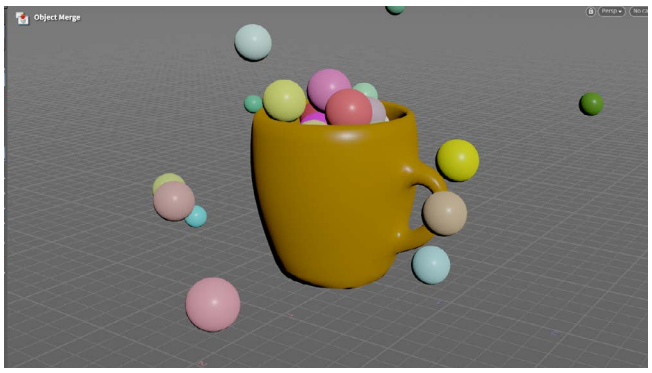
Press Play. The gumballs now fall on top of the cup but not into the cup. It seems like the cup is a solid shape. Stop playback.



08 Return to **Frame 1**. Select the *rbdbulletsolver* node. On the **Collision** tab, set **Collision Shape** to **Concave**. This will allow the inside of the cup to be taken into account. Click on the **Properties** tab and set **Bounce** to **0.8**.

Press Play. The gumballs now fall into the cup with some spilling to the ground. Stop playback

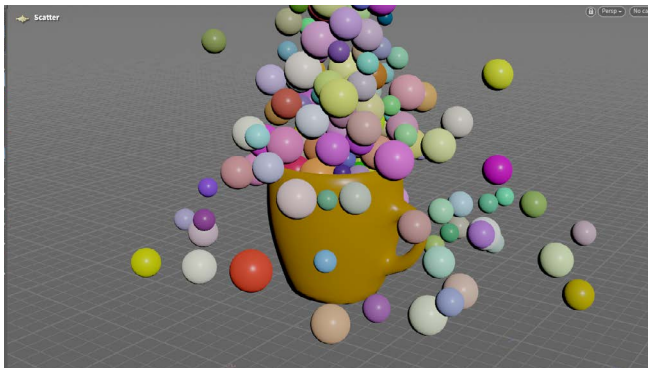
You can set **Bounce** and **Friction** on the *gumballs* using the **Properties** tab, the *cup* on the **Collision** tab and the *ground* using the **Ground Collision** section. Explore different settings to see how they affect the results.



09 Return to **Frame 1**. Click on the *object_merge* node and press the **Jump to Operator** button to navigate back to the *cup* network. Select the *switch* node and change the **Select Input** to **0** to go back to the first cup design.

Press the **Jump Back** button on the Network view to go back to the *gumballs* network.

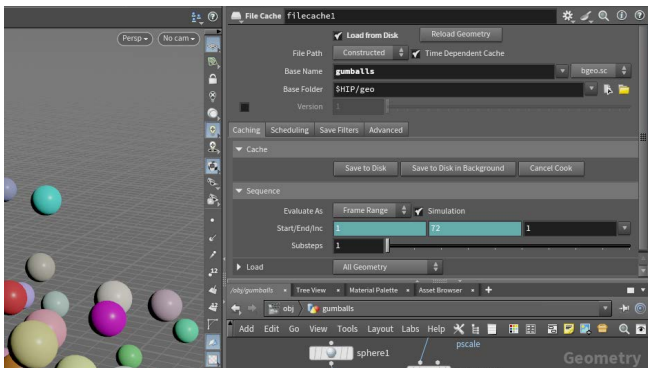
Press Play. The gumballs now fall into the bigger cup with only a few spilling to the ground. Stop playback.



10 Return to **Frame 1**. Select the box node and change its **Size Y** to **10.** Now select the *scatter* node and change the **Force Total Count** to **200**.

Press Play. A lot more gumballs fall into the cup with a lot of them spilling to the ground. Stop playback and return to **Frame 1**.

Houdini's node-based workflow allows you to explore options and create multiple iterations as you art direct your shot. This flexible workflow supports the creative process and is a part of all aspects of Houdini.



11 In the Network view, **RMB-click** on the first output of the *rbdbulletsolver* node and choose **File Cache**. Place the node down and set its Display flag. Set the **Base Name** to *gumballs* and turn **OFF** the **Version**.

Press **Save to Disk**. This runs through the simulation which should be fast because the sequence was cached on playback. At the end, the **Load From Disk** option is turned on and now you can scrub freely without the simulation slowing things down.

If you later want to tweak the simulation then you just need to press the **Save to Disk** button to capture your changes.

NODE TYPE | LOPS

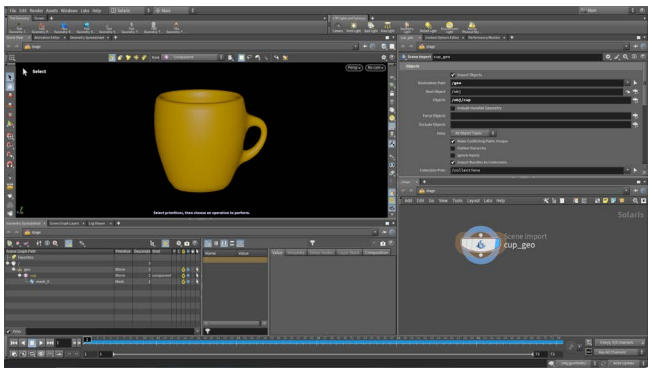
You have used object nodes and dived into them to create geometry using Surface Operators or SOPS. You are now going to move your work to Solaris which is the Lighting Operator or LOP context in Houdini. The Solaris environment can be found in the `/stage` network.

Here you will place nodes for bringing in geometry, assigning materials and adding lights and cameras. The Solaris environment converts everything into USD [**Universal Scene Description**] which is an open source format created by PIXAR. The Solaris/LOPS context allows you to work with USD which is needed to render to the Karma XPU renderer.

PART FOUR

Layout, Lookdev & Lighting

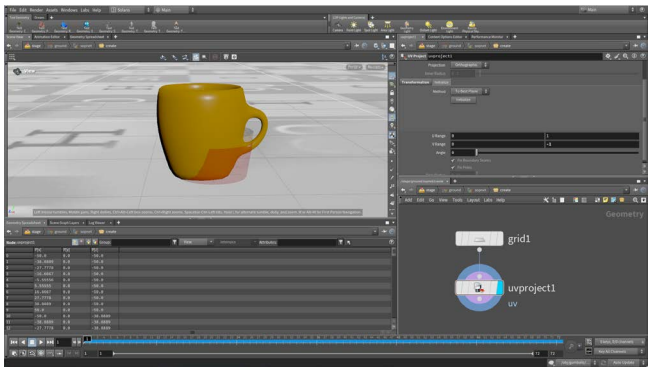
To create a scene for rendering, you are going to bring the geometry into the Solaris or LOPS context of Houdini. LOPS are used to prepare the scene for rendering. For studios building more complex lighting pipelines Solaris offers a wide range of scene management tools. For an artist creating a single shot like the gumball scene, the setup is much simpler and even though you are using USD you will barely notice it.



01 Change the desktop to **Solaris**. Make sure you are looking at the **Stage** in the path bar. Turn off the grid in the top right on the **Display Options**. **Press D** to open, click on the **Background** tab and set **Color Scheme** to **Dark**.

In the Network view, press **tab > Scene Import** and click to place the node down. Name this node *cup_geo*. Set the **Destination Path** to */geo*. Next to the **Objects** field, click on the **node selector** button and from the pop up window, select the *cup* object.

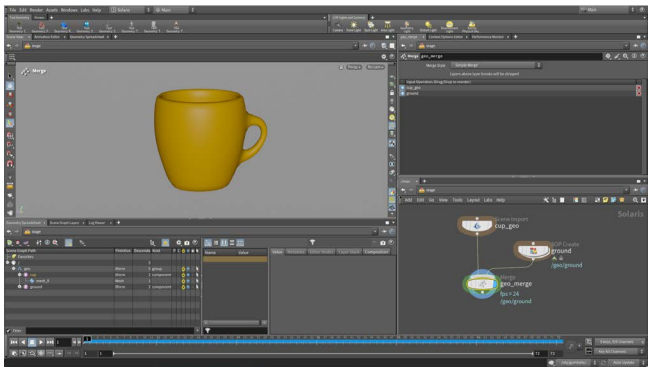
Click **Accept Pattern**. In the **Scene Graph** in the lower left you will see **geo**. Click on the **+ sign** to open it up to see *cup*.



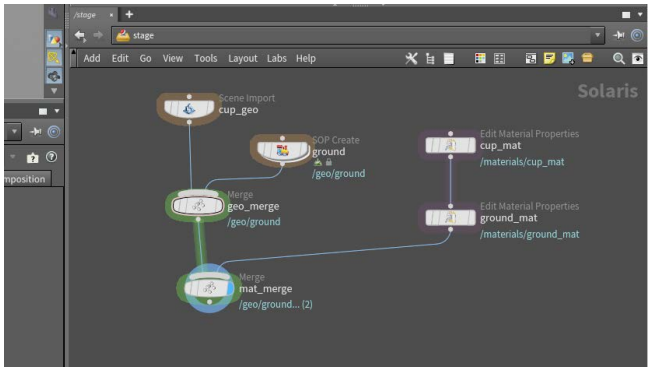
02 In the Network view, press **tab** > **Grid**. Place down the node and rename it *ground*. Set **Import Path Prefix** to */geo/$OS*. This will use the name of the node and place it in */geo*. You can see this in the scene graph.

Double-click on the *ground* node to dive down to the geometry level. Select the *grid* node and set the size to **100, 100**.

RMB-click on the output on *grid* and choose **UV Project**. Place the node down and set its Display flag. Click on the **Initialize** tab and click the **Initialize** button. Go back to the **Transformation** tab and set **V Range** to **0, -1**. This will orient the UVs properly.



03 **Press u** to go back to the **Stage** level. Right now either the *grid* or the *cup* are not visible in the Scene view or in the Scene Graph. Press **tab > merge**. Place the node down and set its Display flag. Rename it to *geo_merge*. Wire the *ground* and *cup* nodes into *geo_merge*. Both are now visible.



04 Press **tab > Quick Surface Material** and place the node off to the side. Rename this node to *cup_mat*.

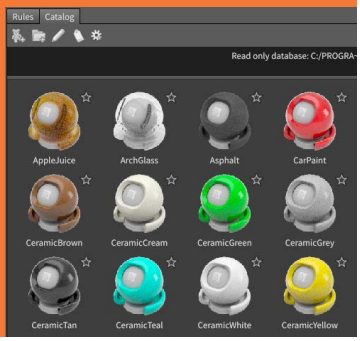
Alt-drag on that node to create a second **Quick Surface Material**. Rename this node to *ground_mat*. Change its **Base Color** to grey.

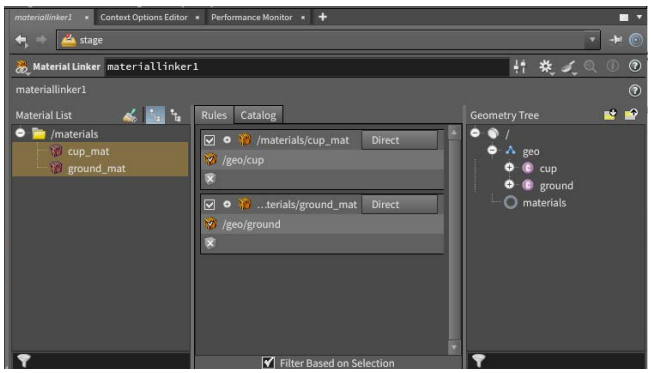
Press **tab > merge**. Wire the node after the *geo_merge* node and set its Display flag. Rename it to *mat_merge*. Wire *cup_mat* into *ground_mat* and then *ground_mat* into *mat_merge*.

MATERIALS IN SOLARIS

The **Quick Surface Material LOP** gives you access to a shader that has been pre-built using **Material X** then stored in the **USD** format. A **Quick Surface Material** is actually an **Edit Material Properties** node that loads this USD file. You can then rename it and edit its properties for use in your scene.

You can also build materials using a **Material Library** node and a **Karma Material builder** but the **Quick Surface Material** will meet your needs in many situations. You can also access a **Catalog** of materials on the **Material Linker** node.



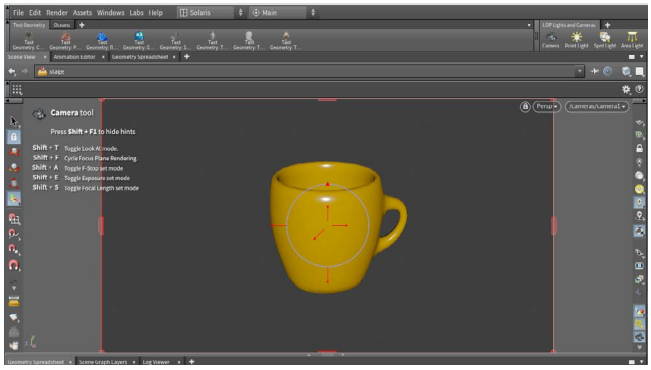


05 Nothing changes in the Scene view because these materials haven't been assigned yet. For this you need the **Material Linker** node.

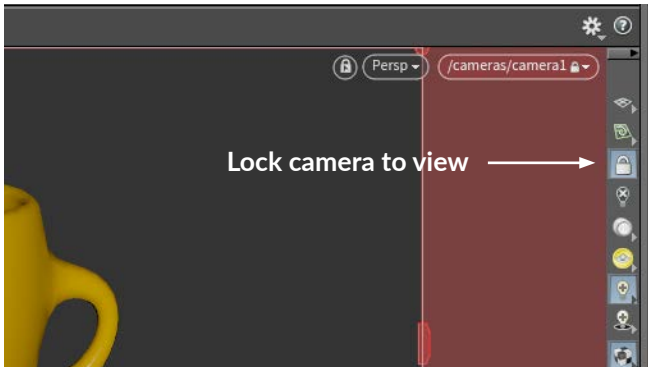
Press **tab > Material Linker** and place the node at the end of the chain then set its **Display Flag**.

In the Parameter pane, drag the *cup_mat* from the **Material List** to the **Rules** section. Open up the geo folder under **Geometry Tree** and drag *cup* to the shader part of the rule. The cup still looks orange because its color is being multiplied with the material color.

Repeat these steps for the *ground_mat* and the *ground* geometry.

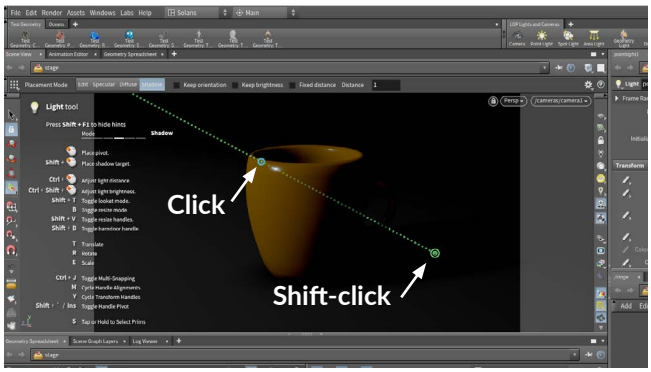


06 In the Scene View, use your view tools to get a good look at the cup. From the **LOP Lights and Camera** shelf, click on the **Camera** tool. This adds a camera node to the chain that matches the view you set up. In the top right of the **Scene View**, you can see that you are looking through *camera1*.



07 You can use the *camera* handles in the center of the view to adjust the view. Or you can go to the right side of the Scene View, click on the **Lock camera to view** button. Now use the **View tools [Spacebar-LMB/MMB/RMB]** to tweak the position the camera.

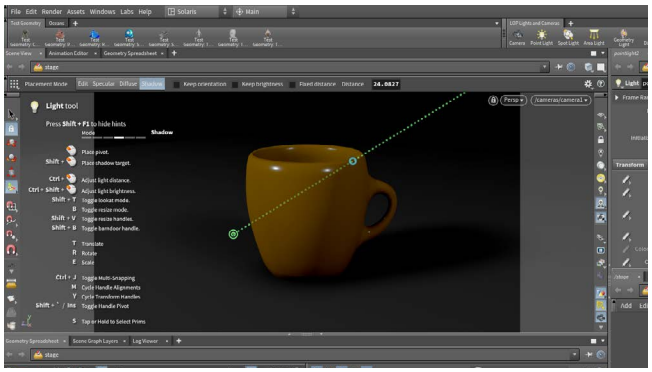
IMPORTANT: When you finish, toggle off the **Lock Camera** button in order to avoid accidentally losing your chosen camera view. If this button is off then you will lose the camera but it is easy to get it back by rechoosing it from the menu.



08 From the **LOP Lights and Camera** shelf, **click** on the **Point Light** tool then press **Enter** to place it so you are looking through it. Change back to *camera1*.

With the node active, press **Shift-F** to turn on the **Shadow** mode. You can also click on it in the **Operation Control** bar. Now **click** on the top of the cup to set a pivot point then **Shift-click** to place a target on the ground.

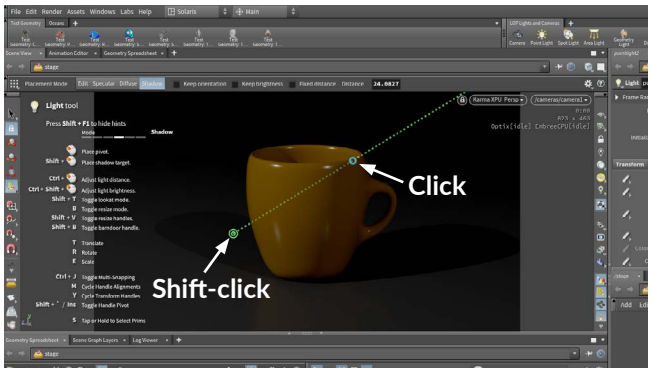
Ctrl-Drag to set the light distance. **Ctrl-Shift-drag** to change the intensity of the light. You may need to set it quite high to see some impact on the look of the cup.



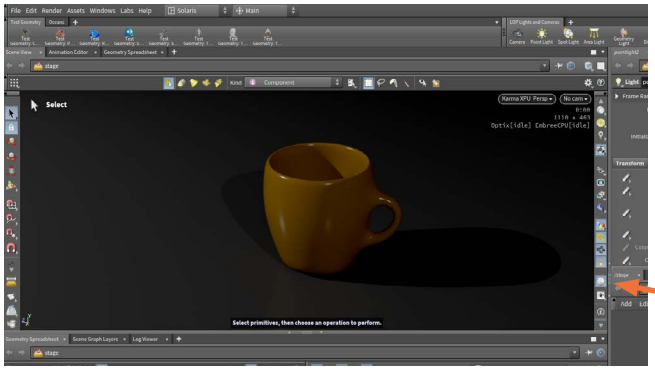
09 From the **LOP Lights and Camera** shelf, **click** on the **Point Light** tool then press **Enter** to place it so you are looking through it. Change back to *camera1*.

With the node active, press **Shift-F** to turn on the **Shadow** mode. You can also click on it in the **Operation Control** bar. Now **click** on the top of the cup on the other side to set a pivot point then **Shift-click** to place a target on the ground.

Ctrl-Drag to set the light distance. **Ctrl-Shift-drag** to change the intensity of the light. This light is your secondary light so it can be a little less intense.

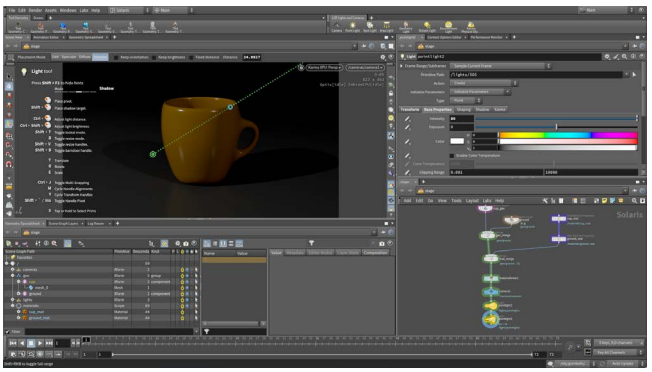


10 Click on the menu just to the left of the camera menu, and set it to **Karma XPU**. Now you are using the Karma renderer in the viewport.



11 Tumble around - go back to camera1.

If you have an Nvidia graphics card with the latest drivers installed, you can turn on the Optix Denoiser to resolve the image more quickly. Turn it on in the **Display Options** bar or **press d** and set **Enable Denoising** in the **Render Display Options**.



12 Return the view to looking through the *camera*. If you want to tweak the two lights then select them and adjust their angle, intensity or position.

Or you can wait until after the materials are in place. At that point you will learn how to use a Light Mixer node.

Save your work.

INTERACTIVE LIGHTING TOOLS

The light tools provides a number of interactive tools that let you make lighting decisions from the camera's point of view.

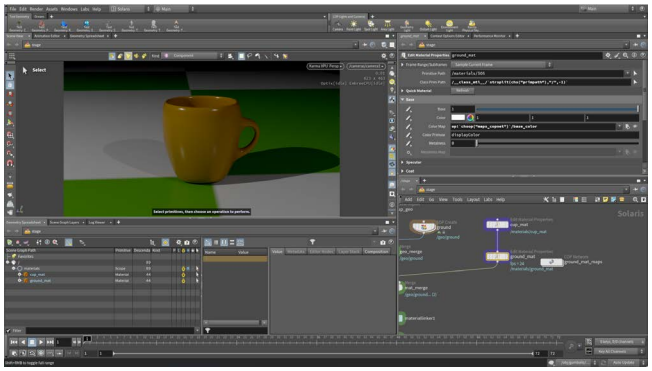
Instead of zooming out, adjusting the light handles then looking through the camera and back and forth, you can use these handles to make decisions from the best vantage point.

Use the hints to help determine some of the shortcuts and use the **Operation Control** bar to change modes.

PART FIVE

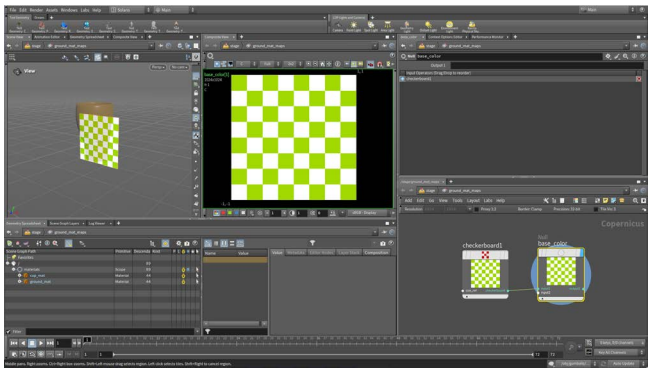
Texture the Ground

To add texture to the ground, you will use the COP or Copernicus context to work with procedural images. You can start this using a button on the Quick Surface Material and then build up your network from there. You can set up nodes that feed into color, specular and normal maps but use the same image nodes to feed all three. This gives you the flexibility inside Houdini to explore the right look for your surface without going out to a separate image processing application.



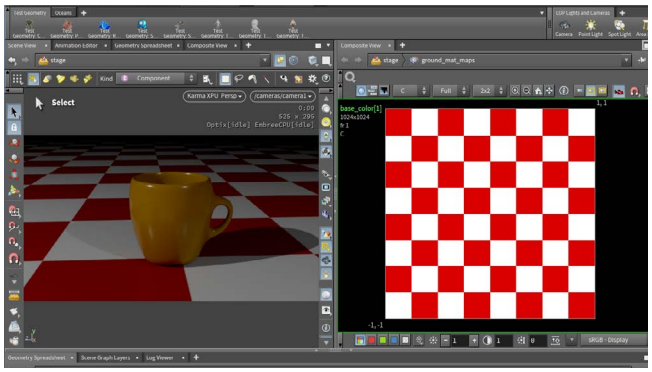
01 Select the ground_mat node. Set **Base > Color** back to **white**. Click on the circle on the left side of the **Color Map** parameter and choose **Set or Create**. This displays a UV grid on the ground surface.

On the far right of the parameter, click on the **Create COP texture for this map** button. Now there is a green and white checkerboard texture on the ground.



02 **Double-click** on the *ground_map_mats* node to dive into the network. In the Scene view you can now see the map on a 3D grid. Another way to see it is to click on the plus sign in the tab section and choose **New Pane Tab Type > Viewers > Composite View**.

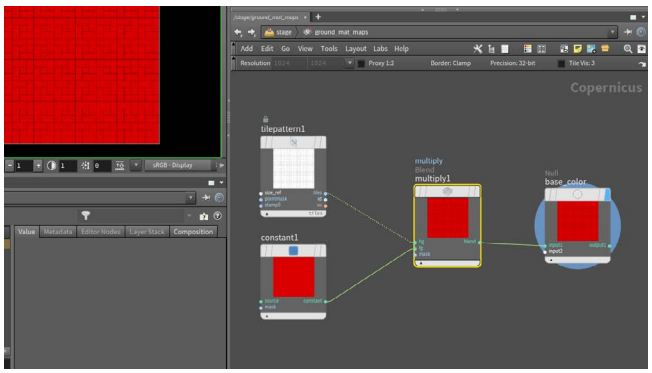
In this view, click on the arrow in the top right and choose **Split Pane Left/Right**. In the section on the left, click on Scene View. Now you can see both displays.



03 In the Scene View, click on the **Pin** icon to lock the view to its path. Now click on *stage* to navigate back up to see the Karma XPU rendering of the shot. Now **double-click** on the *ground_map_mats* node to dive back into the cop network.

Select the *checkerboard* node and change the **Odd Color** to **Red**. You can see the texture update in both the Scene view and the Composite view.

Go up to the Stage level and select the *ground_mat* node. Scroll down in the Parameter pane to the Maps section and open it. Set **UV Scale** to **5, 5**. This will repeat the checkerboard several times.



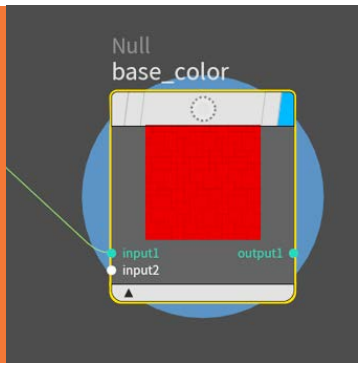
04 Go back into the *ground_map_mats* node. Select and delete the *checkerboard* node. Press **tab > Tile Pattern** and place down the node. Wire the *tiles* output into *input1* on the *base_color* node. Change **Pattern Type** to **Windmill**.

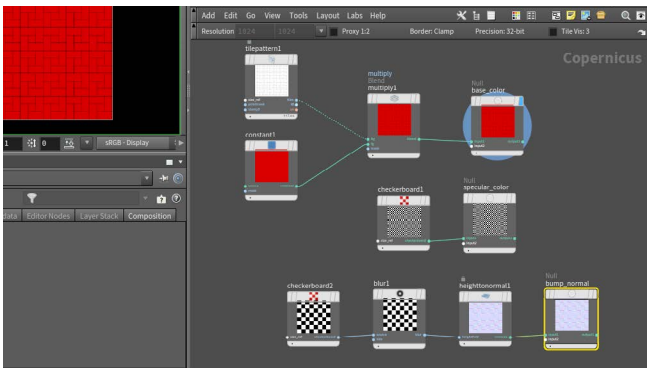
Now press **tab > Constant** and place the node under the *tilepattern* node. In the Parameter pane, set signature to RGB and make the color Red. Now add a Multiply node and insert it between *tilepattern* and *base_color*. Wire the *constant* node into the *fg* input. Now you have red Tiles with black grout.

NODE TYPE | COPS

For working with 2D images for either the creation of texture maps or slap comps, the Copernicus context is where you will find COP nodes. These nodes can be viewed in a 3D or a 2D view and you can hook them onto materials to render with Karma XPU. The Quick Surface Material makes it very easy to set these up.

Note: *This context is in beta with Houdini 20.5. Its purpose in this lesson is for you to see its potential. Please test it out and provide feedback to SideFX.*

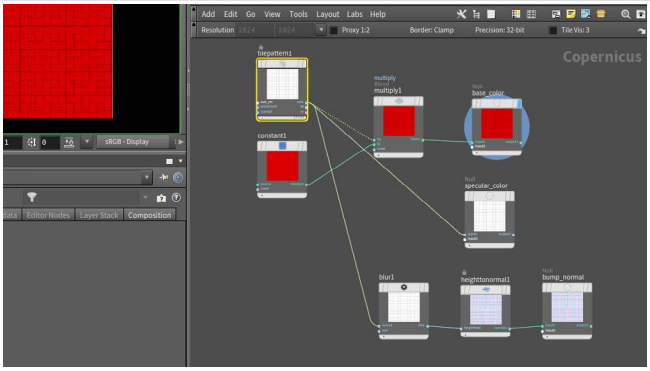




05 Go up to the Stage level and select the *ground_mat* node. In the Specular section, click on the circle on the left side of the **Color Map** parameter and choose **Set or Create** then click on the **Create COP texture for this map** button.

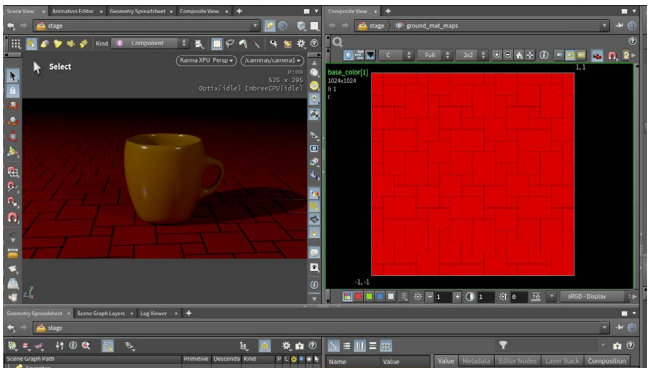
Scroll down to the **Bump** section and set **Bump Style** to **Normal**. Click on the circle on the left side of the **Bump Normal Map** parameter and choose **Set or Create** then click on the **Create COP texture for this map** button.

Go back into the *ground_map_mats* node to see the new nodes that have checkerboard nodes feeding into them.



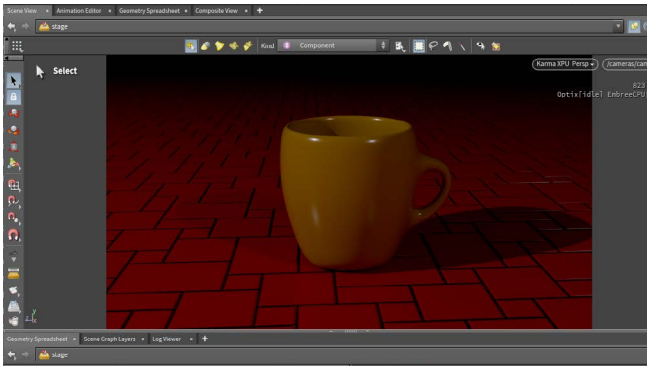
06 Select and delete the two new *checkerboard* nodes. Wire the *tiles* output on the *tilepattern* node to the *specular_color* input and the *blur* node's *source* input.

Right now the grout feels a little too thick. To fix this select the *tilepattern* node and change **Divisions** to **4** then go up to the Stage level and on the *ground_mat* node, set **UV Scale** to **15, 15**. This creates more tile and less grout.



07 Go back into the *ground_map_mats* node. Select and the *tilepattern* node and change **Pattern Type** to **French Pattern**. The viewport rendering may not update correctly.

Click on the **Karma XPU Persp** pulldown in the Scene View and choose **Restart Rendering**. Sometimes a kickstart is needed to handle some updates.



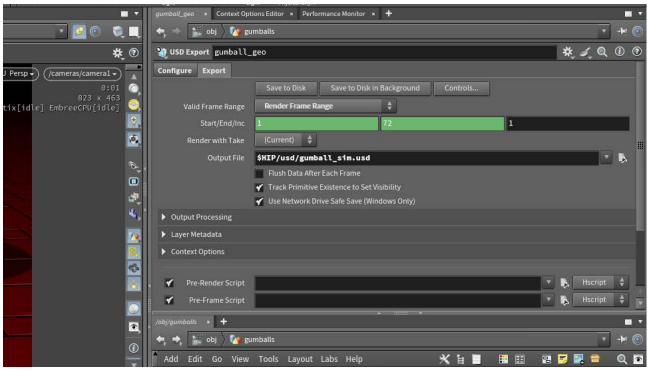
08 Go up to the Stage level. Click on the arrow pointing to the right on the divider between the Scene view and the Composite view. This will hide the Composite view but you will be able to bring it back if needed.

Save your work.

PART SIX

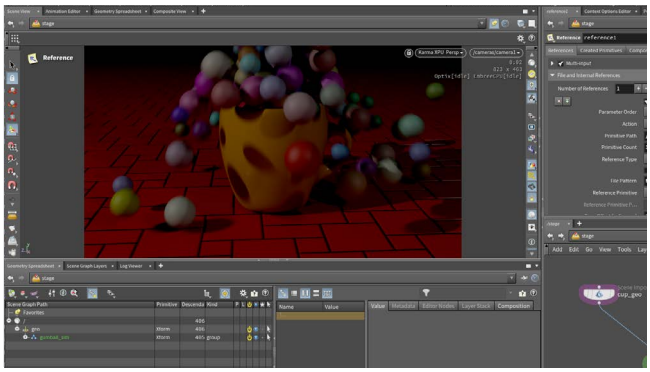
Render the Gumballs

The renderings so far have focused on the cup and the ground surface. It is time to add the gumballs to complete the shot. This time, you will export the geometry directly to a USD file then reference that back onto the stage. For animated pieces like the gumballs, this works better when rendering with motion blur since the motion is already cached. After the gumballs are in place you will need to set up and assign another material.



01 In one of the path widgets at the top of any pane, click on *stage* and from the menu choose *obj*. Double-click on the gumball object to dive into it. At the end of the chain, add a **USD Export** node, set its **Display flag. Rename** this node to *gumball_geo*. Set its **Relative Path Prefix** to */geo/$OS*.

Click on the **Export** tab then set **Valid Frame Range** to **Render Frame Range** and set **Output File** to *$HIP/usd/gumball_sim.usd*. Click the **Save to Disk** button.

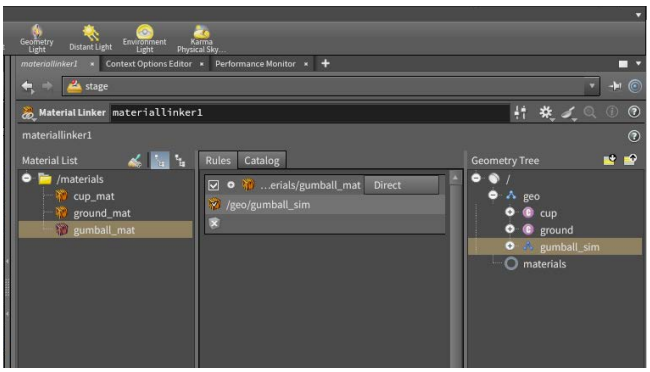


02 Click the **Jump Back** button twice on the Network view. This takes you back to the *stage* level. Press **tab > Reference** and place down the node.

Wire it into the *geo_merge* then in the Parameter pane, go to the **File Pattern** parameter and click on the **File chooser** button. Select **$HIP > usd > gumball_sim.usd** to get the cached simulation file.

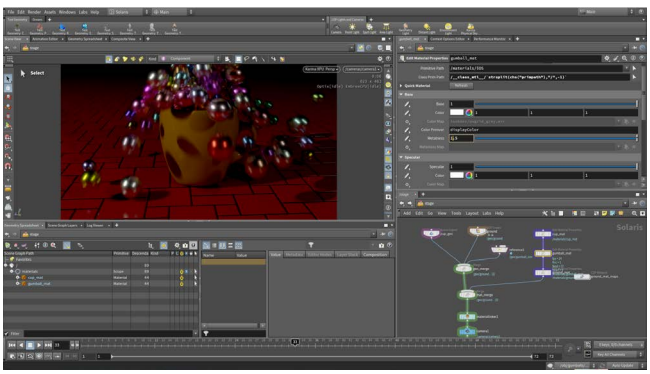
Set the **Primitive Path** to */geo/`@sourcename`* in order to set this up for the Scene Graph.

Go to **frame 33** to see the gumballs falling.



03 **Alt-drag** on the *cup_mat* node to create another **Quick Surface Material** and wire it between the *cup_mat* and *ground_mat* nodes. Rename this node to *gumball_mat*.

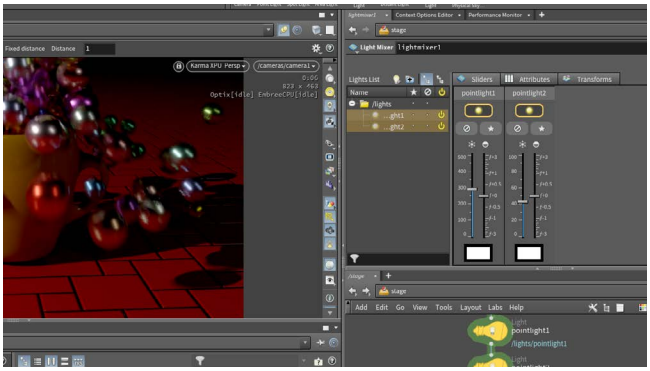
Select the *materiallinker node* and in the Parameter pane, drag the *gumball_mat* from the **Material List** to the **Rules** section. Open up the geo folder under **Geometry Tree** and drag *gumball_sim* to the shader part of the rule.



04 Select the gumball_mat node. You can now set some of its parameters to distinguish this material.

- Under **Base**, set **Metalness** to **0.8**
- Under **Specular**, set **Roughness** to **0.3**.

This provides a different and shinier look for the gumballs.

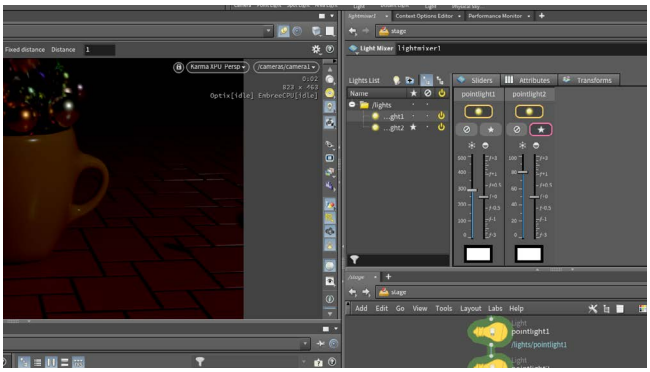


05

In the Network view, **RMB-click** on the last *pointlight* node's output and type **Light Mixer** then press **Enter** to place the node and set its **Display Flag**. This will create a panel in the Parameter pane which has a list of lights on the left side.

Drag the two lights from the list to the area on the right.

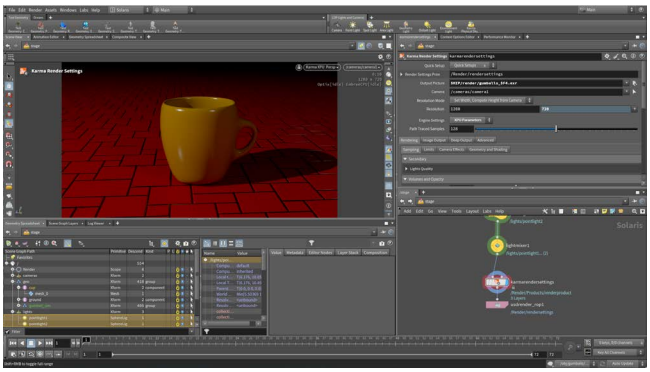
You can play with the intensity and exposure for the two lights here without making changes to the original lights. This way if you don't like your edits it is easy to go back to what you had or branch off and try a different setup with a different **Light Mixer** node.



06

Click on the **Star** icon to **Solo** each light to determine its contribution then tweak **Exposure** to adjust the lighting. Since the **intensities** are so high you can click on the icon above the intensity bar and from the pop-up set a **Max value** that works for your shot.

When you are finished be sure to **turn off** the **Solo** button to see all the lights.



07

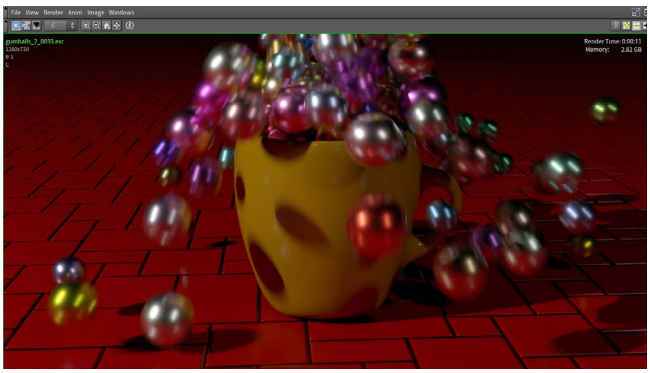
In the **Network View**, press **tab > Karma** to add a **Karma Render Settings** and **USD Render ROP** node.

Wire them into the end of the chain. Select the *karmarendersettings* node and set **Engine Settings** to **XPU parameters**.

On the **Image Output > Filters** tab set **Denoiser** to **nvidia Optix Denoiser** to turn the denoiser back on.

Set the **Output Picture** to *$HIP/render/gumballs_$F2.exr*. The *$F2* adds frame numbers to the renderings with a padding of two.

Save your work.



08

On the *usdrender_rop* node, set **Valid Frame Range** to **Render Frame Range** and turn on **Render All Frames With a Single Process**.

On the *usdrender_rop* node, make sure to set the Render Delegate to **Karma XPU** then click **Render to Disk**.

When the renderings are finished, choose **Render > Mplay > Load Disk Files** and open up the rendered images to review the shot.

If you want to create a movie, use the Mplay **File** menu and choose **Export > FFmpeg**. Set the **Output File** to **$HIP/gumball_sim.mp4** and press **Save**.

LIGHT MIXER NODE

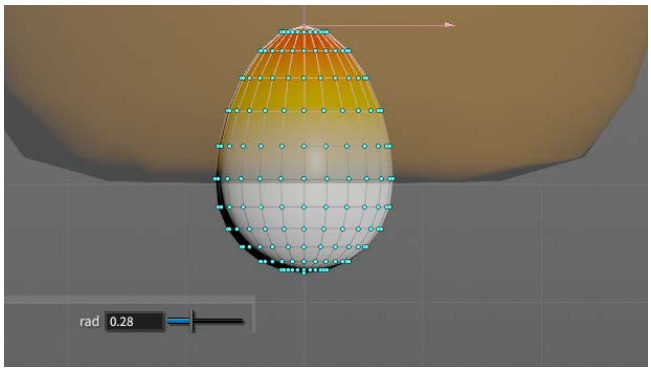
The **Light Mixer** node shows off some of the layering capabilities of Solaris. Instead of going back and adjusting the original light nodes, the **Light Mixer** node lets you layer changes on top of the original nodes.

In addition to the sliders, you can also go to the **Transforms** tab, select a light then use the viewport tools to adjust it. This gives you a great deal of flexibility to make final adjustments before rendering.

PART SEVEN

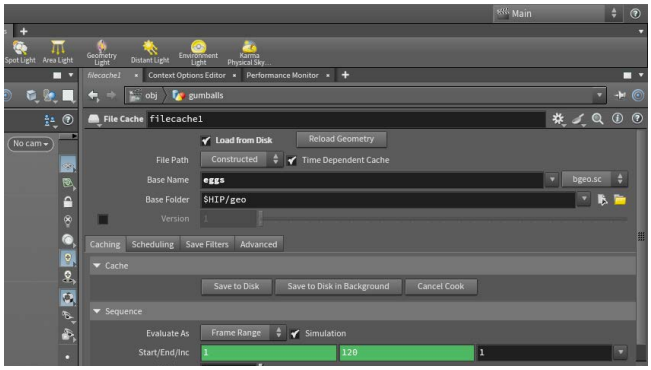
Last Minute Changes

The client calls after reviewing the shot and wants to change the gumballs to little candy eggs. The first step is to reshape the original sphere, then you will need to resimulate and recache the results. The client also proposes some compositing effects which you can add using a Slamp Comp created with Copernicus nodes. The compositing network can be applied onto your rendering right in the Scene view to make creative decisions for your final rendered sequence.



01 Go back to the object level and double-click on the gumball node. Set the Display flag on the sphere node then go to the Front view and press **Spacebar-g** to focus on the sphere. Zoom out just a little.

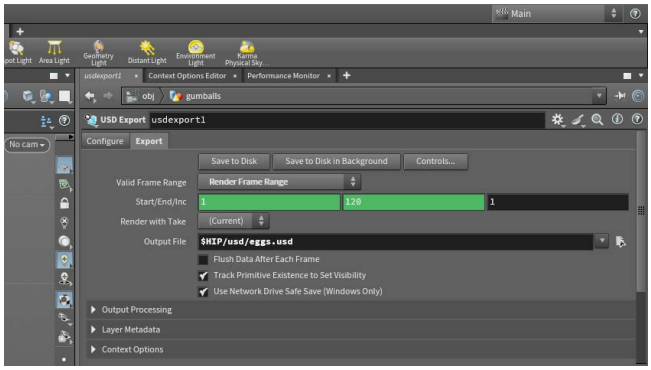
Get the **Select** tool and press 2 to get point selection then click on the point at the top of the sphere. **Press t** to get a translate handle and move the point up. Set the Soft Radius to smooth out the edit to create an egg shape. An *edit* node is added to your network to accept this change.



02 The client also wants the simulation to be a bit longer. At the bottom left edge of the **Timeline**, click on the **Global Animation Options** button. Set the *End* to 120 and click **Close**.

To see how this affects the simulation, you can Display the *rbdulletsolver* node and run the sim. You may want to adjust some parameters to get the look you want for this new shape.

When you are happy select the *filecache* node and change **Base Name** to *eggs*. Press the **Save to Disk** button to save out this new simulation The **Start** and **End** will now be **1, 120**.



03 Now go to the USD Export node and change the **Output File** to *$HIP/usd/egg_sim.usd*.The **Start** and **End** should also be **1, 120**. Click Save to Disk to save this new USD file.

If you replace the gumball USD file with this new one the names will be wrong and the materials will not get assigned properly. Lets layer the new simulation later on in the network.

04 Go back to the stage. Add a **Reference** node and place it in between the last *pointlight* and the *karmarendersettings* nodes.

Set **File Pattern** to *$HIP/usd/eggs*.usd. At first you see both the gumballs and the eggs. Change the **Primitive Path** to */geo/gumballs*.

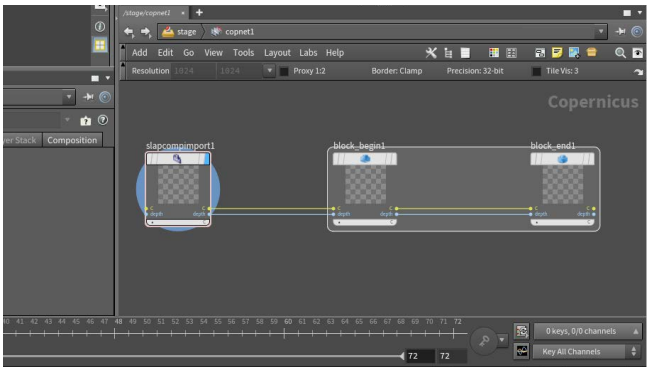
Now the egg simulation replaces the gumballs and the material is assigned properly. You are using the path to layer the new simulation on top of the old one. This is one of the abilities of the USD framework.

SLAP COMP

Slamp Comp using the Copernicus context to composite your rendering right in the Scene view then apply that to your final rendered sequence.

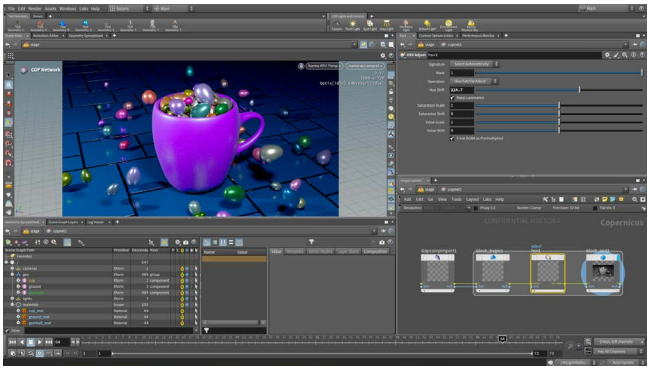
This workflow gives lighters the ability to explore ways make compositing a part of the rendering process. They can then send notes to the compositors down the production line to apply what is learned here.

Individual artists can use this to add effects such as glow at render time.



05 Go to **Frame 1**. In the Network view, press **tab > COP Network** then place the node. Make sure your Scene view is still pinned then **double-click** to dive into it.

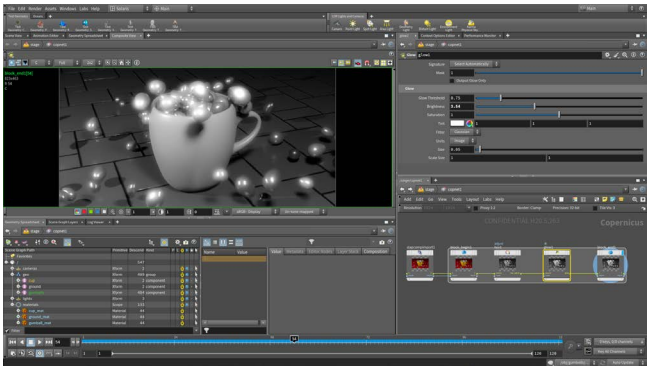
Press **tab > Slap Comp Block**. This adds three nodes to your network. This first imports in your Scene View image, while the second two define the slap comp.



06 Press **tab > HSV Adjust**. Place the node between the two block nodes. Now click on the **Control Slap Comp Settings** button on the **Display Options** bar.

On the *hsv* node, drag on the **Hue Shift** slider. You see the Scene view being affected by the adjustment.

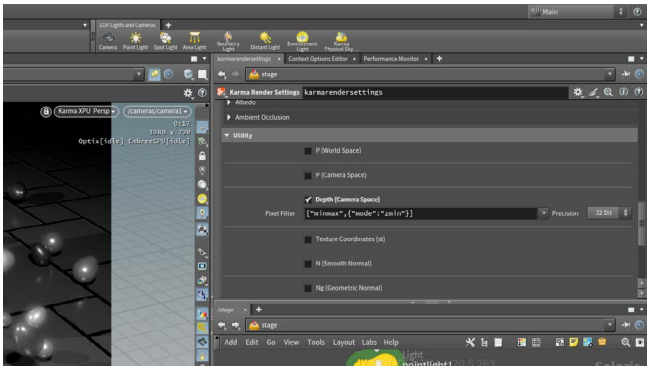
You could also bring up a **Composite view** pane and make these adjustments with that view in mind.



07 Go to another frame where you see the eggs. Drag the **Saturation Scale** to **0** make the image greyscale.

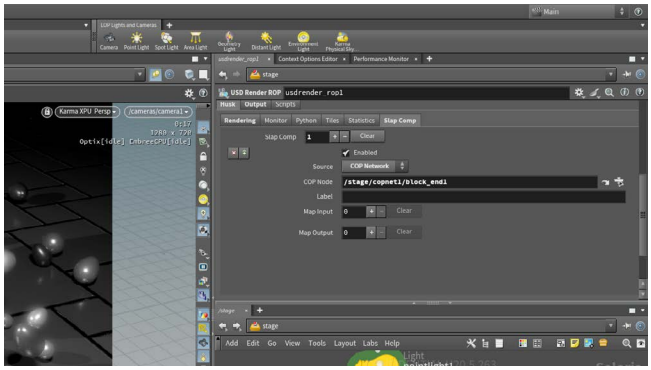
Press **tab > Glow**. Place the node between the *hsv* node and the *block_end*. Drag on the **Brightness** slider to add glow to the highlights.

You can turn on and off the **Control Slap Comp Settings** button to see your image with and without the Slap Comp adjustments.



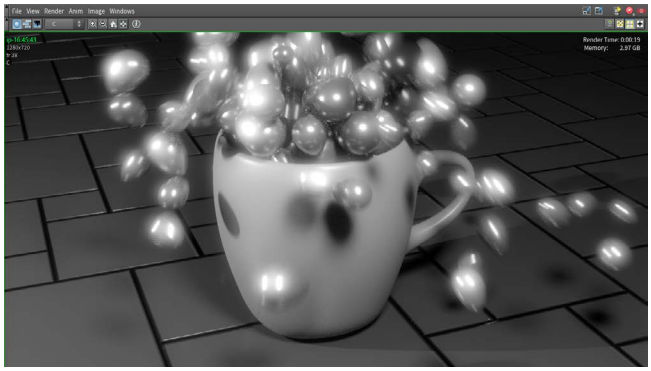
08 You can also render to disk using the Slap Comp. Go up one level to the stage. Select the *karmarendersettings* node and set the **Output Picture** to *$HIP/render/eggs_slapcomp_$F2.exr*.

Go to the **Image Output** tab and the **AOVs (Render Vars)** sub tab scroll down to the **Utility** section and open it. Check off the **Depth (Camera Space)** option to turn it ON. This is needed for the Slap Comp to work when rendering to disk.



09 On the *usdrender_rop* node, go to the **Husk** tab and then the **Slap Comp** tab. Click on the **plus sign** to get a Slap Comp. Set the **Source** to **COP Network** then use the file selector to find the *block_end* of the slap comp network.

Save your work.



10 On the *usdrender_rop* node, click **Render to Disk**.

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

If you want to create a movie, use the Mplay **File** menu and choose **Export > FFmpeg**. Set the **Output File** to **$HIP/eggs_sim.mp4** and press **Save**.

CONGRATULATIONS

You have now completed your first steps into the world of Houdini and its node-based workflow. You have used these nodes to **model**, **simulate**, **texture** and **render** a simple shot.

Along the way, you experienced the ability to make changes in support of your creative decisions. As you made those changes, they passed information down the node chain to update the results. Every part of Houdini uses nodes and as you complete more tutorials, you will see how easy it is to make changes and art direct your work.

You have also learned that different Houdini nodes work in their own context. You used **object [OBJ] nodes** to start your scene then built the cup using **Surface Operator [SOP] nodes**. You set up the lighting and lookdev of your shot using **Solaris [LOPS] nodes** and added textures using **Copernicus [COP] nodes**.

You have learned how nodes from each type can connect to and support other networks. You have also learned that different types of nodes can differ in how they are wired together and each have unique capabilities.

Learning these different node types is key to understanding Houdini. As you continue your work, you will learn how to use the “secret” language of SOP, LOP, COP etc. to talk about and explore Houdini.