

HOUDINI FOUNDATIONS

MODEL, RENDER, ANIMATE

Welcome to Houdini. In this lesson you will start from scratch to model, render, animate, and simulate a soccer ball (also known as a football in many parts of the world). You will create a classic bouncing ball animation using the principles of squash and stretch, apply textures and materials, add lights and cameras, and explore the use of dynamics to simulate a group of soccer balls.

These tasks will introduce you to many different parts of Houdini as you create your first Houdini scene, explore the 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 build your animation rig. You will also set up materials and textures on the **Solaris Stage** then you will render using Houdini's built-in renderer **Karma**, and finally create a **Rigid Body Simulation**.

LESSON GOAL

Model, Render, Animate and Simulate a soccer ball 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
- How to create **Geometry**
- How to work with **Nodes and Networks**
- How to set up **Custom Attributes** and a **For-Each Loop**
- How to set up **Materials** and **Texture UVs**
- How to **Layout** a shot and render with **Karma**
- How to **Set Keyframes** and add **Motion FX**
- How to use **Rigid Body Dynamics**

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	✓

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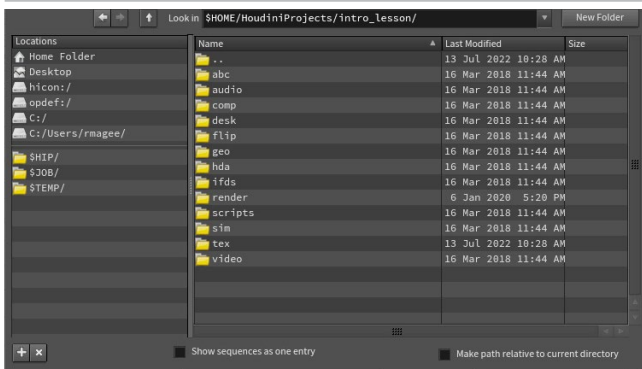


PART ONE: Explore the Houdini UI

To get started, it is important to learn how to work with the Houdini workspace and the three panes you will use the most. The Viewport lets you create objects interactively, the Parameter Pane lets you edit node properties and the Network Editor lets you work directly with the node networks.

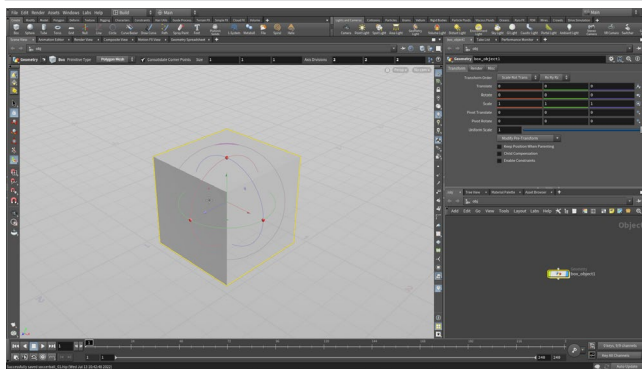
PROJECT FILES

Go to the **soccerball tutorial** page on **SideFX.com**, where you likely got this document, to download the *intro_lesson* directory. Put it into the **Houdini Projects** directory which you can find in either the **home** directory or the **documents** directory.



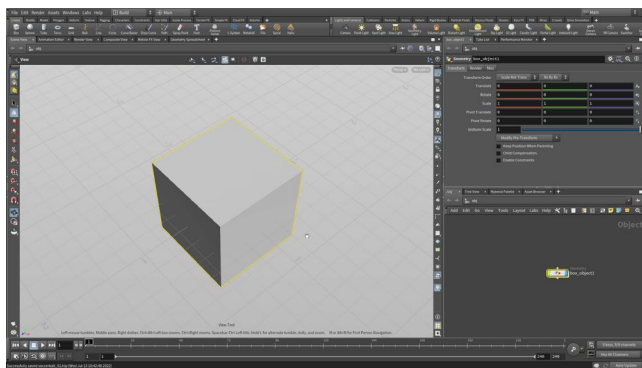
01 Select **File > Set Project**. Find the *intro_lesson* directory that you downloaded earlier and press **Accept**. This makes this project directory and its sub folders the place for all the files associated with this shot.

Select **File > Save As...** You should be looking into the new *intro_lesson* directory. Set the file name to *soccerball_01.hip* (or *football_01.hip* if you would prefer) and click **Accept** to save.



02 In the viewport, **press c** to bring up a radial menu. From this menu, choose **Create > Geometry > Box**. Your cursor now shows the outline of a box waiting to be placed in the scene. **Press Enter** to place it at the origin.

This creates a box in the Scene view, adds a node in the Network editor and shows the object parameters in the Parameter pane. As you work through this project, you will touch on all of these interface elements.



03 You can now explore the **View** tool in Houdini. 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:

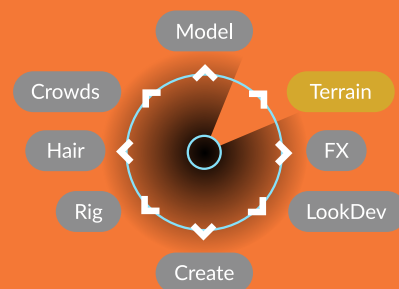
- **Home Grid** Spacebar - H
- **Home All** Spacebar - A
- **Home Selected** Spacebar - G



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 |

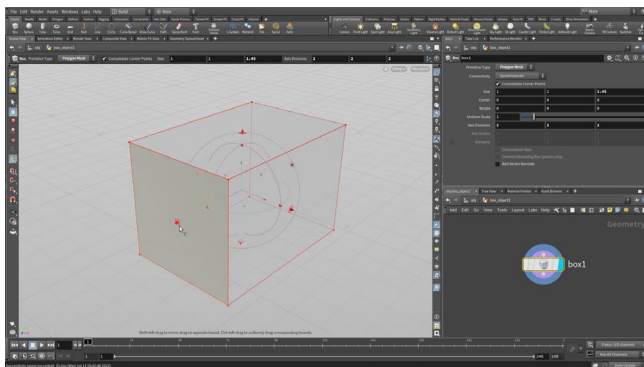
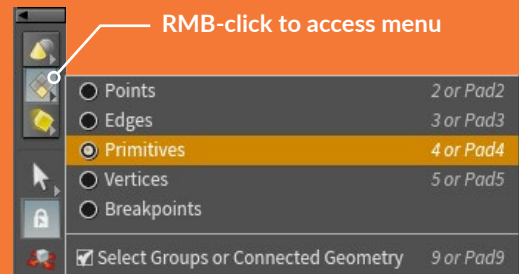




SELECTION HOTKEYS

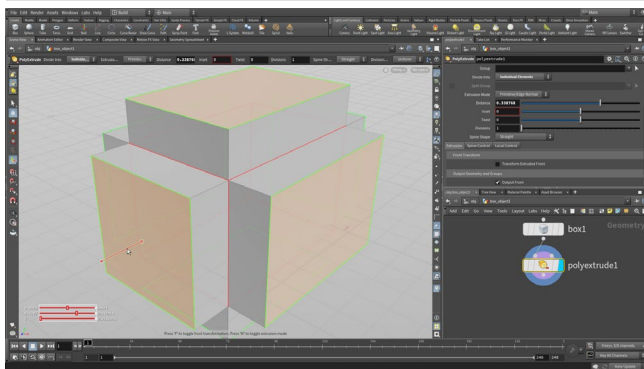
If you are using the **Select, Move, Rotate, Scale** or **Handles** tools, the following hotkeys will determine your selection mode as well as which level you will be working at.

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



04 With the object selected, **press i** to go to its geometry level. Use the **Shift** key to drag on handles to make it longer along z axis around the origin.

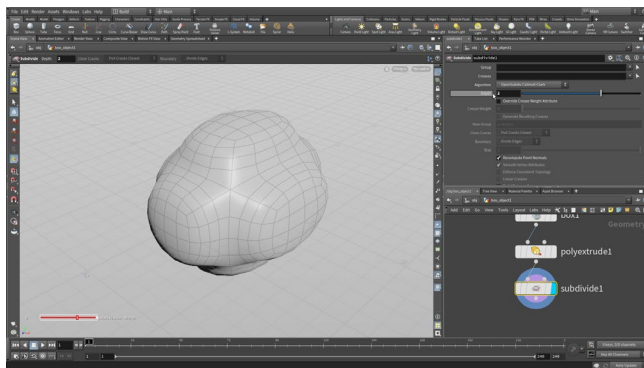
When an object is created in Houdini, there is an **Object level** which is where you manage the transformations of the object and a **Geometry level** where you define its shape. Pressing **i** brought you down into the geometry level of this object. You can also get there by double-clicking on the object node in the Network editor. Later, to get back to the Object level, you will **press U**.



05 Press **S** to go to the **Select tool** then **4** to access Primitive selection. Press **n** to select all then **press c** to bring up the radial menu and choose **Model > Polygons > Poly Extrude**.

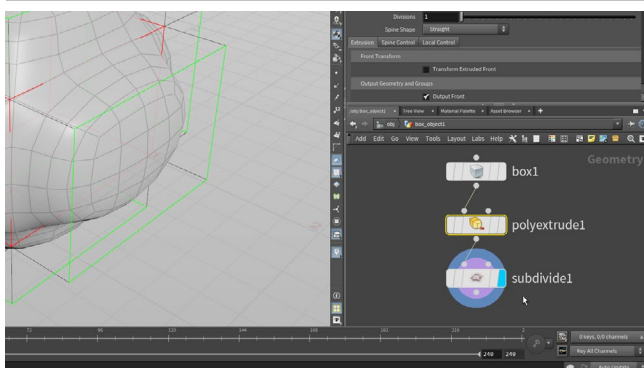
In the either the **Operation Control Bar** at the top of the Scene view or the **Parameters** pane, set **Divide Into** to **Individual Elements** and use the handle to set the **Distance** to around **0.4**. This extrudes the faces along the normals of each primitive.

You can see that there are now two nodes in the Network view. Each step you take in Houdini creates a node that you can work with to refine your scene.



06 Press **n** to select all of the new faces and press **Tab** and begin typing **sub...** then select **Subdivide** from the list. The **Tab** key is another way to access tools in Houdini. Typing the tool name lets you focus the list making it easier to find what you want without navigating the submenus.

In the Parameter pane, set **Depth** to **2**. This subdivides the geometry to create more polygons. Houdini also has a subdivision display option at the Object level which you can use to see subdivisions without actually adding any geometry, but in this case you do want to create more polygons.

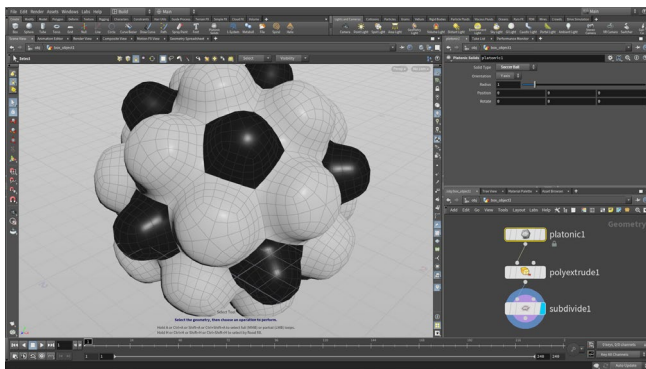


07 Select the different nodes in the chain. The handles for each of the nodes appear as you select them but the display remains on the final shape. Set the **Display Flag** on each of the nodes to change which node is the display node. You can also try some of the other flags such as **Bypass** or **Template**. **Wiggle** the **polyextrude** node out of the network then drop it back in.

At the end, return everything to normal and set the **Display flag** on the **subdivide** node. This is very important. The Display flag determines what you will see at the object level. **Always check to make sure you have the right display flag set!**

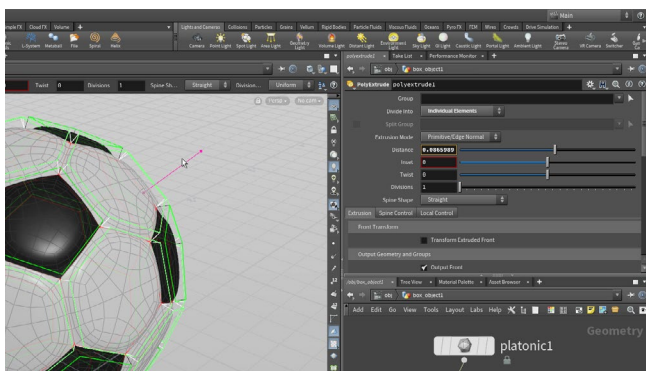
PART TWO: Create a Soccerball

You are now going to replace the box with a soccerball shaped platonic shape. Using Houdini's procedural approach, you can replace the box node with a platonic solid node. From there you will adjust the other nodes to make it look like a soccerball. This ability to swap out input nodes lets you prototype networks with simple geometry for added flexibility.



01 In the **Network editor**, use the **Tab** key to add a **Platonic Solids** node to the network. Click to place it down near the top of the chain. Wire the *platonic* node into the *polyextrude* node. In the parameter pane, set **Solid Type** to **Soccer Ball**. Select and delete the *box* node.

Because of Houdini's procedural nature, it is often possible to replace an input node and have the whole network function properly. This gives you flexibility as you work and if you don't like the results after the change then you can always wire back the original shape.



02 Select the *polyextrude* node. Make sure the **Handle** tool is active then use the handle in the viewport to set a smaller **Distance**. You can also set the parameter value in the Parameter pane. This creates a better look for the soccerball. Remember that even though you are viewing the *subdivide* node, selecting the *polyextrude* node gives you access to its handles and parameters.

You might think that with this primitive type you are all set but it is really just a truncated icosahedron with flat faces. You need a round soccerball so you will have to put a little more work into it.



03 Press **V** in the viewport and from the **Radial Menu**, select **Shading > Smooth Shaded**. You can also use the menu in the top right of the viewport to change your shading.

This soccerball looks like a cheap plastic ball rather than a proper leathery soccerball. You are now going to branch off and add more nodes to get a better look.

After analyzing it, set the shading back to **Smooth Wire Shaded**.

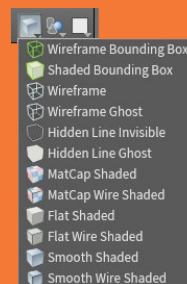


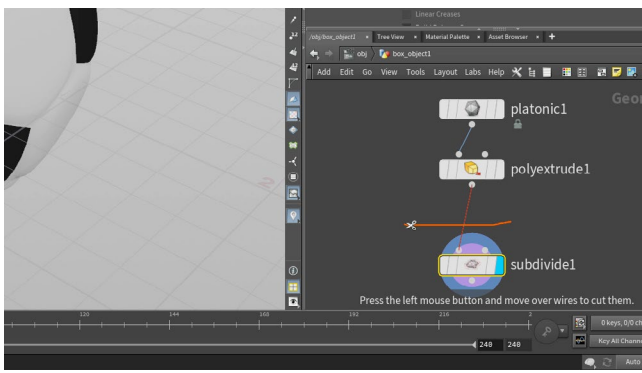
SHADING OPTIONS

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.

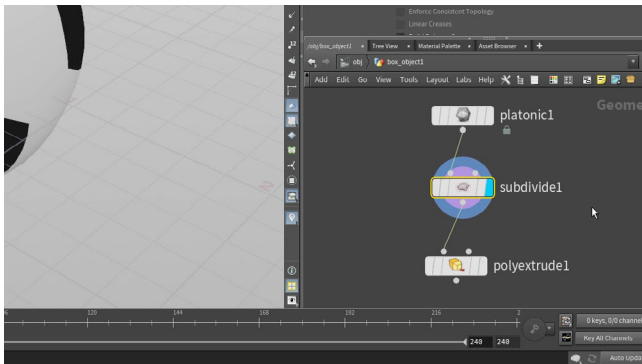
For the shading of your objects, the lighting is determined by the **Display Options** on the right edge of the Viewport. You can choose from a headlight, normal lighting or high quality lighting with shadows.

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

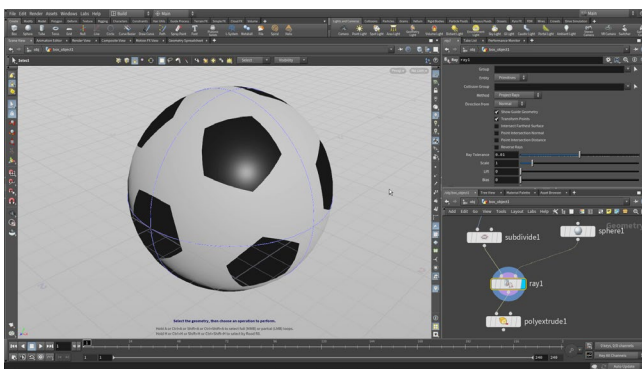




04 In the Network view, **press Y** and drag across the line connecting the *subdivide* node and the *polyextrude* node to break the connection. You are now going to move the subdivide in between the other two nodes so that you get a rounder soccerball.

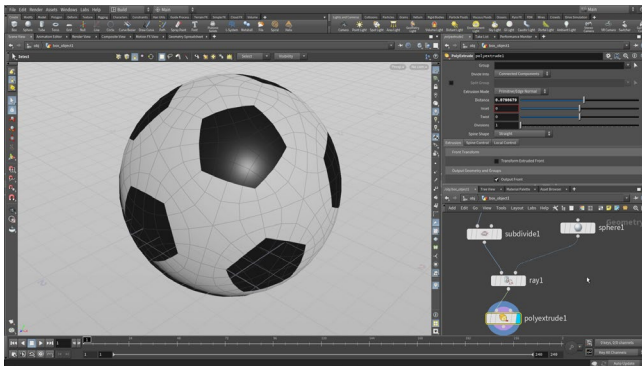


05 Drag the *subdivide* node in between the *platonic* solid node and the *polyextrude* node. You can drop it on the connecting wire and it will insert itself in automatically. If not then jiggle it a little until it finds the connection. This will give more detail to the sphere before it is extruded.



06 Use the **tab** key in the network editor to add a **Ray** node and wire it in after the *subdivide*. Now add a **sphere** node to the network and set its **Radius** to **1, 1, 1** and the **Primitive Type** to **Primitive**. Now wire the sphere into the second input on the *ray* node. This will project the subdivided ball onto a perfect sphere.

This is a very powerful node in Houdini that lets you project points from one piece of geometry onto another. It is the perfect solution to our problem of a subdivided soccer ball that wasn't truly round.



07 Set the **Display** flag back on the *polyextrude* node. With **Divide Into** set to **Individual Elements** all the small polygons are extruded but you don't want that. Set it to **Connected Components** then all the polygons are extruded.

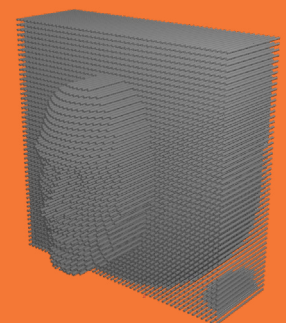
You need a way for this network to extrude the original patches of the soccer ball but after the ball has been subdivided. You can do this using the primitive numbers on the original geometry.



THE RAY NODE

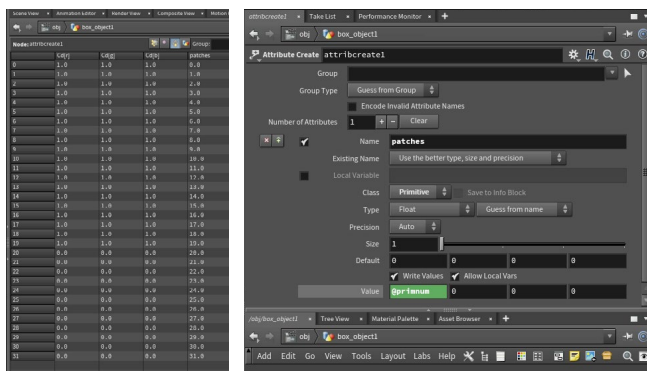
The ray node is a tool that projects points out to another piece of geometry. This is similar to the pinboard toy you played with as a kid. In fact, this is the node you would use to set up a pinboard in Houdini.

GETTING HELP | To learn more about each node, you can click on the **?** help button in the top right of the Parameter pane to open up the node's online documentation. You can also hover over the tool in the shelf and **press F1**. In many cases, there are sample files that you can open in Houdini to learn what the node can do.



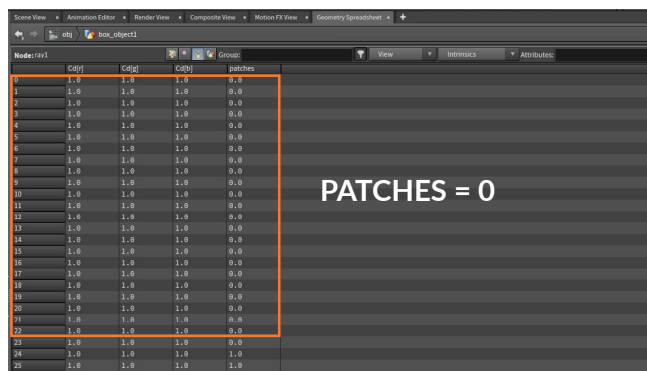
PART THREE: The For-Each Node

Now you get to see the magic, as the attributes you just created in the last part are fed into a for-each loop where the original patches are extruded even though each contains many polygons. This will provide a more leathery look for the soccerball once you subdivide it once more time after the poly extrudes.



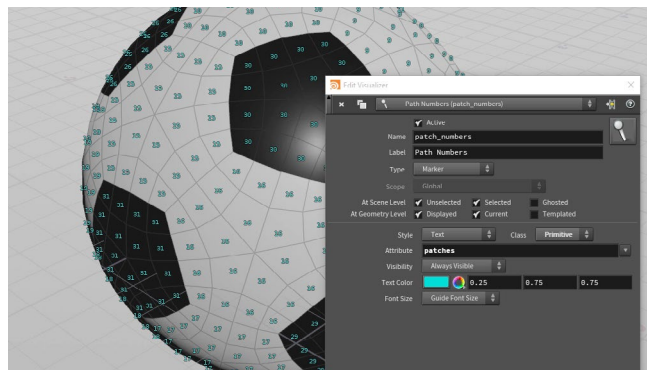
01 Add an **AttributeCreate** node after the *platoic* node. – Set its **Name** to *patches* and its **Class** to **Primitive**. Now set the first of the **Value** fields to **@primnum**.

This expression takes the primitive number attribute and turns it into a new attribute called *patches*.



02 With the *attributecreate* node selected, click on the **Geometry Spreadsheet** tab next to the main viewport. Click on the **Primitive** button and you can see the primitive numbers on the left, three color attributes which show the color of the patches and the *patches* attribute which matches the primitive numbers.

Click on the *ray* node. This attribute will be carried forward when the shape is subdivided. You can now see there are a lot more primitives but the *patches* attribute only goes as high as 31 and then it goes back to 0.



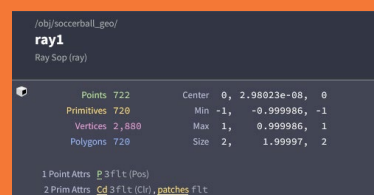
03 Go back to the **Scene View** tab, RMB-click on the **Visualizer display** button on the **Display Options** bar and click on the **+** Plus sign next to **Scene** and choose **Marker**. In the **Edit Visualizer** panel, set **Name** and **Label** to *Patch_Numbers*, set **Type** to **Marker**, **Class** to **Primitive** and **Attribute** to *patches*.

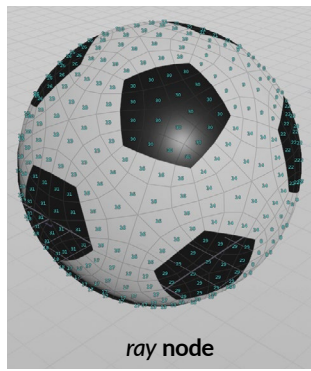
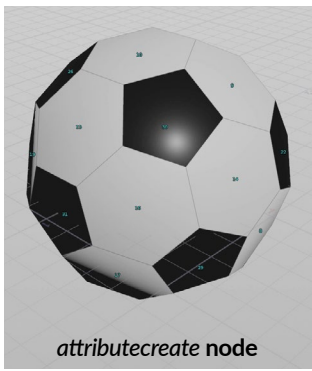


WORKING WITH ATTRIBUTES

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.

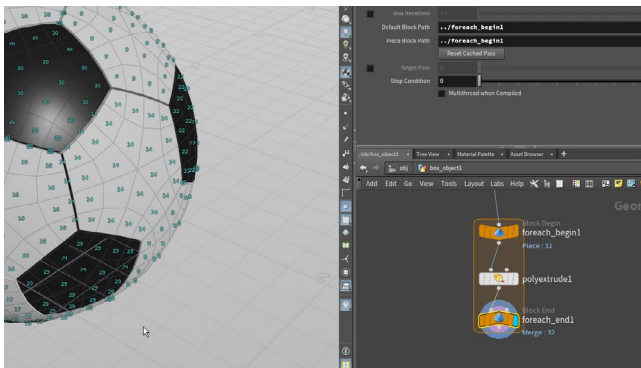
In this lesson, you will be creating a custom attribute called *patches* which will help you in the for-each loop.





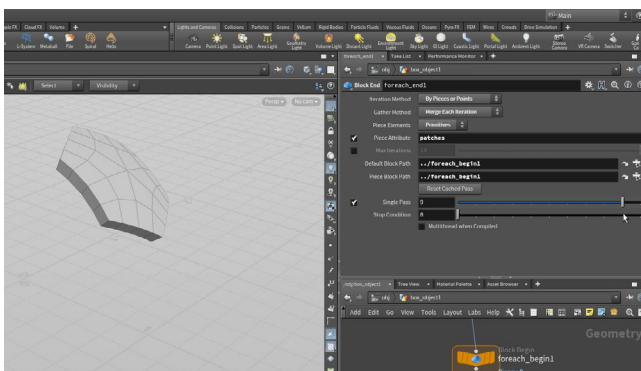
04 Now make sure the **Visualizer display** button is on and you will see the patch values on the soccerball in the viewport. You can see that the prim number from the original platonic solid have been transferred to the subdivided faces. Change the **display flag** to different nodes to see the relationship. This information will be used to polyextrude the patches properly using a for-each loop.

Turn **OFF** the Visualizer display and **save** your work. These steps have been a bit abstract and probably feel a bit too technical, but don't worry the payoff is coming.



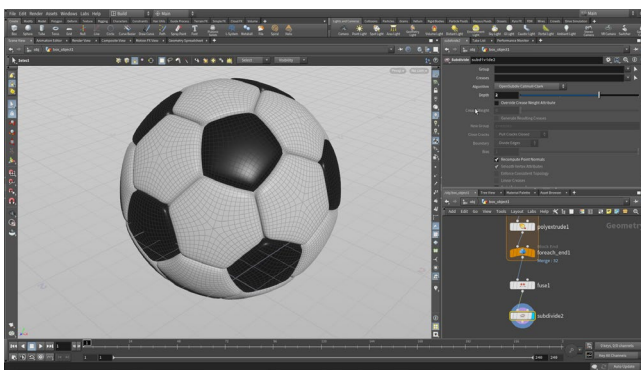
05 In the Network editor, press **tab** and start typing **For-each Named Primitive** to access two nodes that you can then place into the scene. Wire the *foreach_begin* between the *ray* node and the *polyextrude* node and then the *foreach_end* after the *polyextrude* node. Select the *foreach_end* node and in the parameter pane leave **Piece Elements** set to **Primitives** and set **Piece Attribute** to *patches*. Set display on the *foreach_end* node.

You should now see the original patches being extruded together based on the *patches* attribute. If they are not make sure **Divide** to is set to **Connected Components** on the *polyextrude* node.



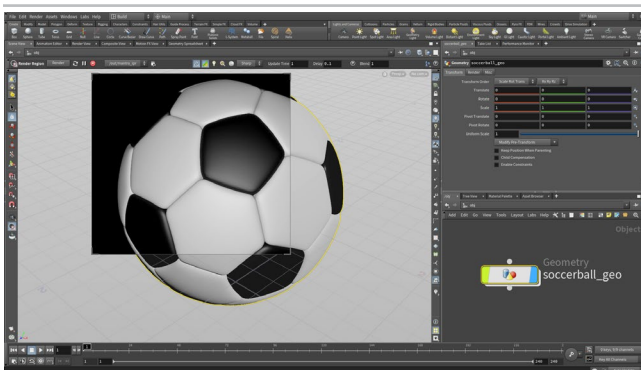
06 Click the checkbox next to **Single Pass** to explore what is happening. Drag on the slider to watch as each of the patches is polyextruded individually. You can also set values higher than 10 to see more of the patches.

Turn off **Single Pass** to see the full shape. The *for-each* nodes create all of the patches then return the final geometry. The for-each loop is a powerful set of nodes that you will use often with Houdini.



07 Add a **Fuse** node after the *foreach_end* node and set its **Display flag**. This connects the pieces into a single topology. The *for-each* nodes broke them into the different patches but didn't fuse them back together.

Add a **Subdivide** node after the **Fuse**. Set the **depth** to 2. This will give you more detail in the viewport that you can use to evaluate your model. This adds more polygons but will not yet render as a true subdivision surface. Houdini also lets you set Subdivision display in the viewport without adding geometry but this **Subdivide** node is needed for later in the lesson.

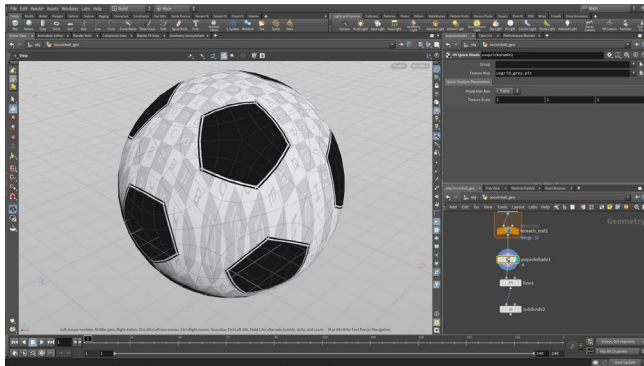


08 Play with *polyextrude* values to get a nice leathery soccer ball. Here you set a **Distance** of 0.1 and an **Inset** of -0.02. This gives nice rounded patches that look much better.

Go to the **Object level** and rename the object *soccerball_geo* in the Parameter pane. Either select the node and press **F2** or **double click** on the name. Click on the **Render** tab and turn on **Render Polygons as Subdivisions (Mantra)** to set up true subdivisions at render time. Select the **Render Region** tool, then draw a box around the soccer ball in the viewport create a preview rendering. To cancel, click on the **x button** in the top right of the region.

PART FOUR: Setting up UVs

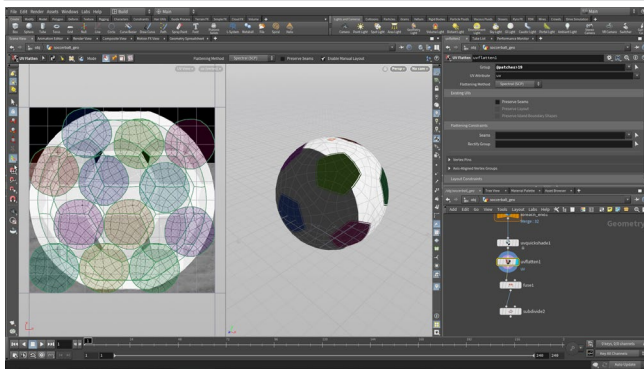
In order to set up materials and textures, it is important to make sure that there are proper UVs set up on your object. Geometry in Houdini does not come with UVs, therefore you must create them yourself. This means adding extra nodes to the network, which in this case means adding UV Quickshade and UV Flatten nodes.



01 Dive into the *soccerball_geo* object. In the Network view, press **tab** > **UV Quickshade** and place the new node right after the *foreach_end* node. Set its **Display Flag**.

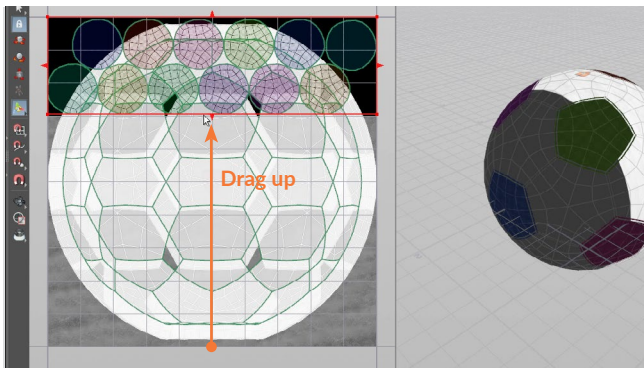
Click on the **File Selector** button next to **Texture Map**. Navigate into the `/tex` folder and select *soccerball_color.rat*. Now you can see this texture map on your geometry but everything seems stretched because the UVs were created using a projection method.

Note: Setting up UVs to match an existing texture is not the normal order of operations. We are taking this opposite approach so that you don't need to paint a texture yourself.



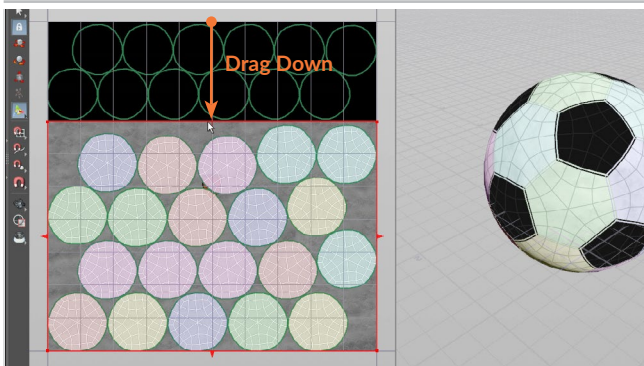
02 In the Scene view, press **n** to select all then press **tab** > **UV Flatten**. In the **Group** field, enter the expression `@patches>19`. This will flatten the dark patches on the soccerball geometry using the patch boundaries to lay out the UVs.

Using this tool brings up UV view. Click on the **UV (vertex)** menu in the top right and choose **Background** > *soccerball_color.rat*. Now you can see this texture in the background of the UV panel. This texture has a team insignia at the center of the image and a darker area at the top for the dark patches.



03 RMB-click on the Handle tool and turn on the **Min:** handle. Use the arrow handle at the bottom and pull it up until all the patches are inside the dark area at the top of the texture map.

If you had placed this node after the *fuse* or *subdivide* then there wouldn't have been boundaries to work with. Houdini's ability to let you set up UVs in the middle of an existing network offers a lot of flexibility.

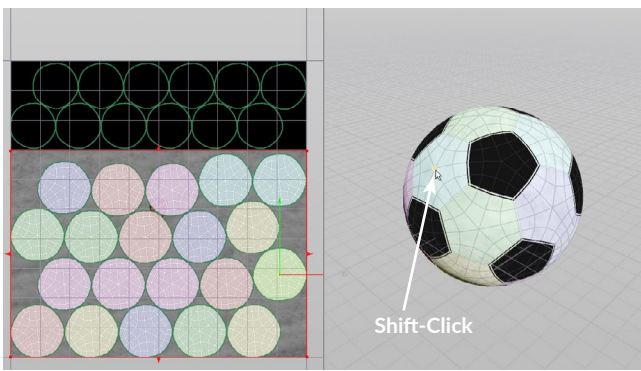


04 Add another **UV Flatten** node after the first *uvflatten* node and before the *Fuse* node. In the **Group** field, enter the expression `@patches<20`. This will flatten the light patches.

RMB-click on the Handle tool and turn on the **Min:** handle. Use the arrow handle at the top and pull it down until all the patches are inside the light area at the bottom of the texture map.

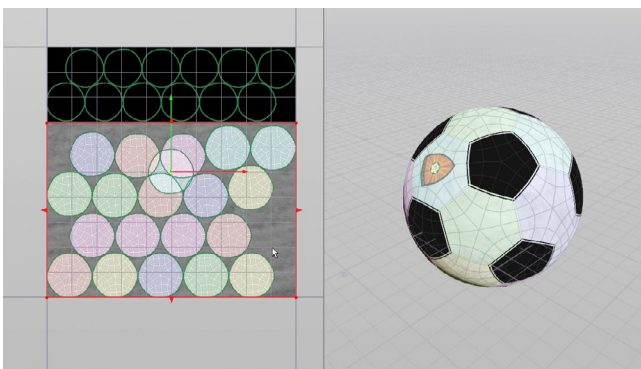
When you finish you can RMB-click on the Handle tool and turn off the **Min:** handle.

RMB-click in the Scene view and from the menu, select **Texture Visualization** > **Off**. This will remove the grid.



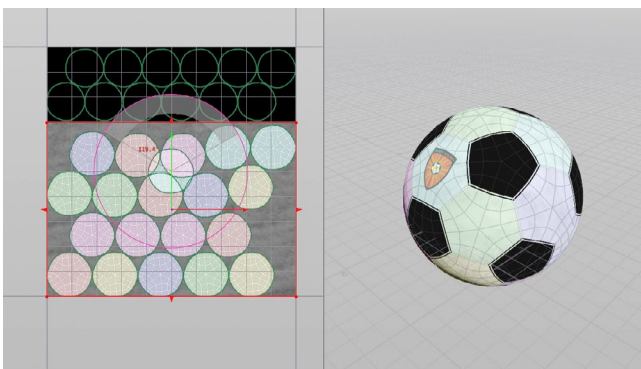
05 Select the *uvflatten* node and click on the **Handle** tool. Mouse over the geometry you can see the patches highlight. Click on the **Pin Vertices** button in the **Operation Controls** bar at the top of the viewport.

Mouse over the patch shown in this image and in the 3D view, **Shift-click** on the center vertex of the desired patch to select it. This adds a pin in the UV view and a handle to work with.

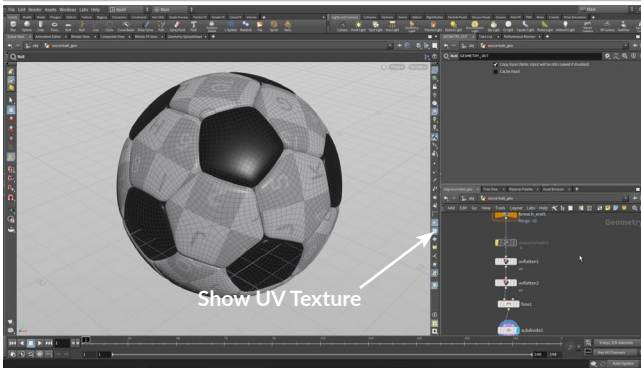


06 Go to the UV view and **move** the pin and the patch so that it is centered on the logo. **Press Y** to get a rotate handle and rotate the patch until you line up the logo.

By pinning vertices on patches in the UV view, you can lock down their position. At first there is some overlap of the neighboring patches but you can easily fix this by repacking.



07 Click on the **Repack** button in the **Operation Controls** bar to reorganize the other patches around the new one. You can continue moving the patch around using the pin but will need another **Repack** to avoid overlapping UVs.



08 Set the *quickshade* node to **Bypass** to hide the assignment of the texture map. This node was only needed when you were setting up the UVs. You now see a UV grid on the soccerball.

To hide the UV display in the perspective view, got to the **Display Options** bar and turn **Off** the **Show UV Texture when UV's Present** button.

Add a **Null** node to the end of the chain and call it **GEOMETRY_OUT**. It is a good idea to have this kind of node to define the end of the network chain. **Save** your work.



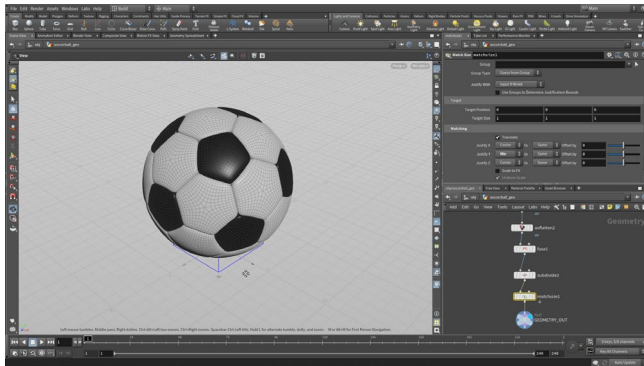
UV FLATTEN

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 creating a custom attribute called *patches* which will help you in the for-each loop.

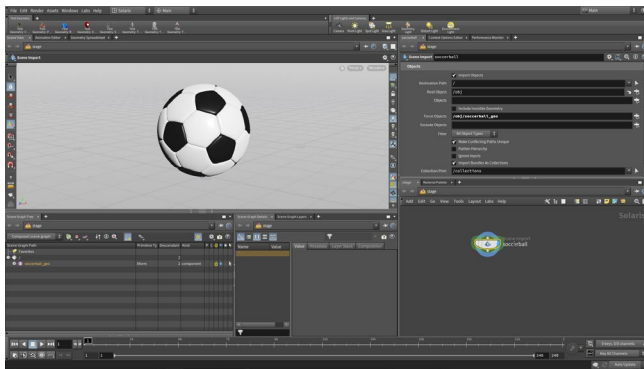
PART FIVE: Layout: Cameras and Lights

To create a scene for rendering, you are going to bring the geometry into the Solaris or LOPS context of Houdini. This is an environment dedicated to lookdev, layout and lighting and is built on the foundation of USD (Universal Scene Description). This will allow you to render to the Karma renderer which works right in the Scene View as part of the Solaris workflow.



01 In the Network View, press **tab** > **Match Size** then add the node between the *subdivide* and *GEOMETRY_OUT* null. Set the **Display flag** on the *GEOMETRY_OUT* node.

Select the *matchsize* node and set **Justify Y** to **Min** to raise the ball up to sit on the ground. This will put it in the right position for rendering.

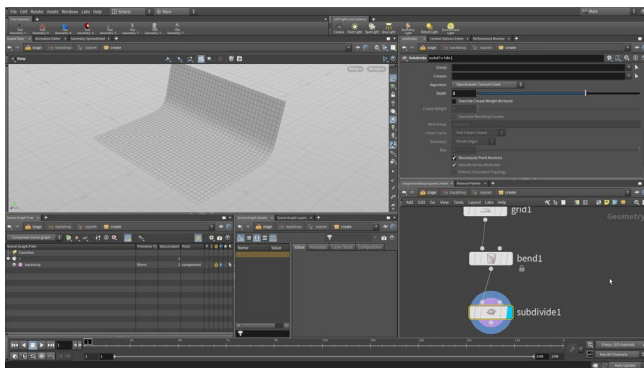


02 Change the desktop to **Solaris**. Make sure you are looking at the **Stage** in the path bar.

In the Network view, press **tab** > **Scene Import** and click to place the node down. Next to the **Force Objects** field, click on the **node selector** button and from the pop up window, select the *soccerball_geo* object then click **Accept Pattern**.

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

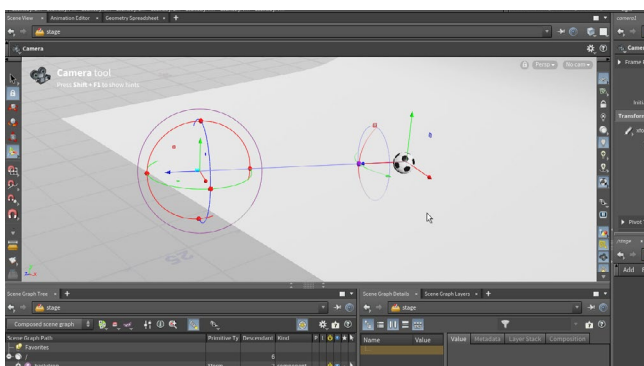
Note: *Force Objects* is used instead of the *Objects* field because it will bring the object into LOPS even if the object's display flag is off.



03 In the Network view, press **tab** and type out **Grid**. Click to place down the node and rename it *backdrop*. Double-click on the *backdrop* node to dive down to the geometry level.

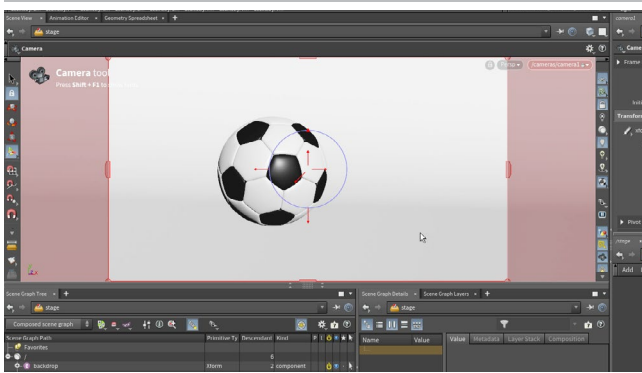
Select the *grid* node and set the size to **80, 80** and the **Center** to **0, 0, -20**. RMB-click on the *grid* node's output and type **Bend**. Click to place the node then set its **Display Flag** and set: **Bend** to **75**. In the **Capture** section, set **Capture Origin** to **0, 0, -30**, **Capture Direction** to **0, 0, -1**, and **Capture Length** to **5**.

RMB-click on the *grid* node's output and type **Subdivide**. Set its **Display Flag** then set **Depth** to **2**.



04 Go back to the **Stage** level. Wire the *backdrop* node into the *sceneimport* node. RMB-click on the output of *sceneimport* and type out **Camera**. Press **Enter** to place the node then set its **Display Flag**.

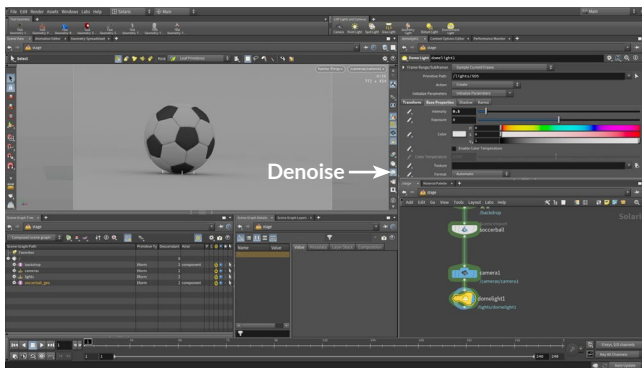
In the Scene View, you will see camera handles at the origin. Zoom out and look down at the scene then adjust the handles so the camera is looking at the soccerball from the left. You may want to activate the **Construction plane** so that you move the handles along the ground. You can also use the axis handles to control the direction and lift the camera up from the ground.



05 In the top right of the **Scene View**, click on the **No cam** menu and choose **camera1**. Now you are looking through the camera and can adjust how it looks.

This is probably not the view you are looking for therefore some view changes are needed. On 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 reposition the camera.

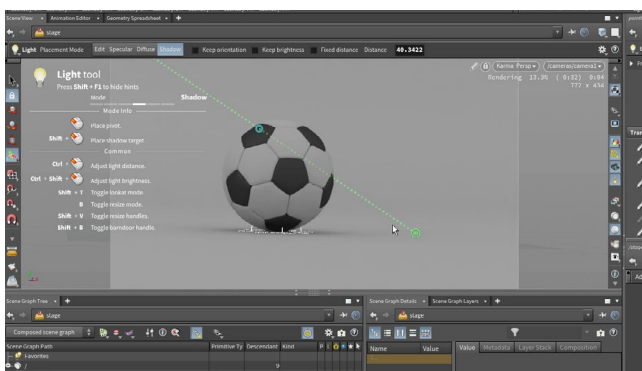
IMPORTANT: When you finish, toggle off the **Lock Camera** button.



06 From the **LOP Lights and Camera** shelf, click on the **Environment Light** tool then press **Enter** to place it at the origin. Set the **Intensity** to **0.5** to tone it down a bit.

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

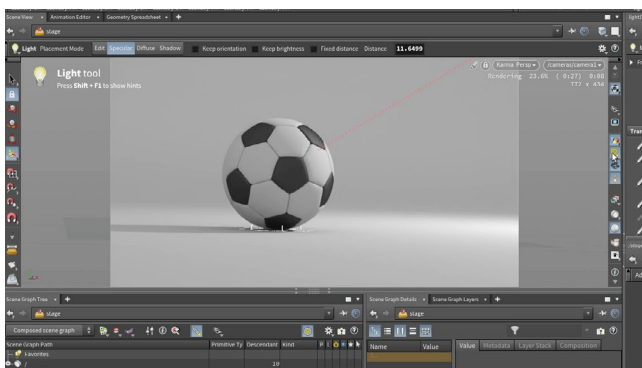
If you have an Nvidia graphics card and have the latest drivers installed, you can turn on the Optix Denoiser to resolve the image more quickly. Turn it on in the **Display Options** bar or press **d** and setting **Enable Denoising** in the **Render Display Options**.



07 From the **LOP Lights and Camera** shelf, click on the **Point Light** tool then press **Enter** to place it at the origin. You are looking through the light. Set the camera 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 soccerball to set a pivot point then **Shift-click** to place a target on the ground. **Ctrl-Drag** to set the light distance.

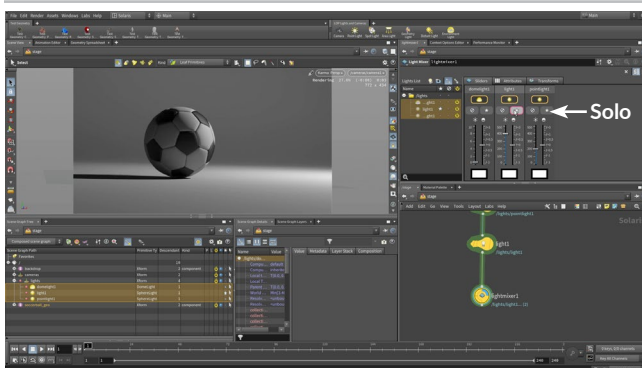
Now you can use **Ctrl-Shift-drag** to change the intensity of the light. You may need to set it quite high go see some impact on the look of the soccerball.



08 In the Network view, **RMB-click** on the *pointlights* node's output and type **Light** then press **Enter** to place the node and set its **Display Flag**.

With the node active, press **Shift-S** to turn on the **Specular** mode. Now click on the right side of the soccerball to define a specular area of focus.

Now you can use **Ctrl-drag** to move the light away from the soccer ball and **Ctrl-Shift-drag** to change the intensity of the light.

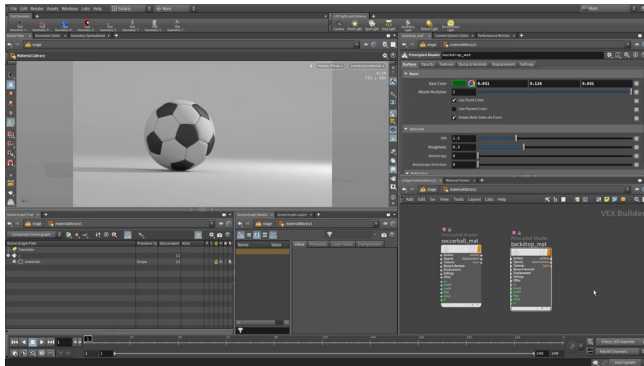


09 In the Network view, **RMB-click** on the *lights* node's output and type **Light Mixer** then press **Enter** to place the node and set its **Display Flag**. This will create a special panel in the Parameter pane which has a list of lights on the left side.

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

PART SIX: Lookdev: Materials

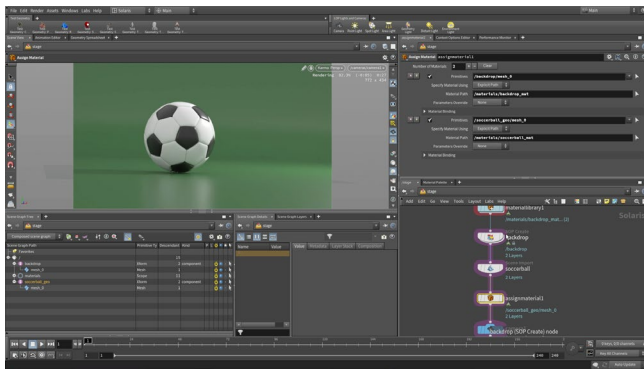
Materials and shaders can also be created within the LOPS/Solaris context. This involves adding the materials to the Scene Graph then assigning them to the geometry. The Materials are created inside a Material Library node then assigned at the LOPS/Solaris level. To add textures to the backdrop, UVs will have to be created to position the maps properly.



01 In the Network view, press **tab** > **Material Library** and place the node just above existing network of nodes then wire it into the *backdrop* node. **Double click** on the node to go down to the **VEX Builder** level.

Press **tab** > **Principled Shader** and place the node down. Rename it *soccerball_mat*. Change its **Base Color** to **white (1, 1, 1)**.

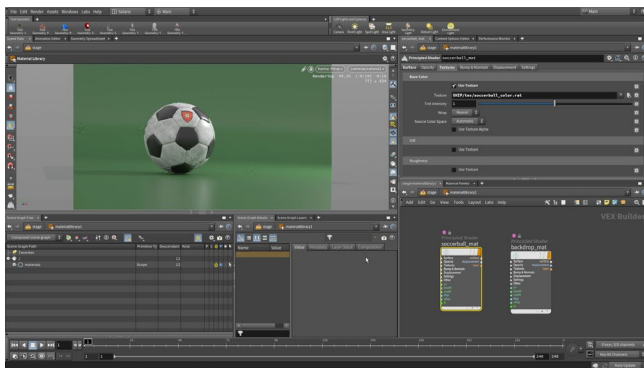
Alt-drag on this node to create a second principled Shader and rename this one *backdrop_mat*. Change its **Base Color** to a dark green.



02 Go back to the **Stage** level then press **tab** > **Assign Material** and place the node in between the *sceneimport* and the *camera* nodes.

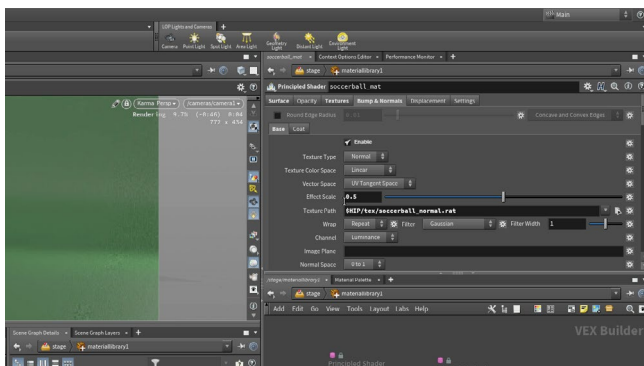
In the Parameter pane, next to **Primitives**, click on the **arrow** button and in the viewport select the *soccerball* geometry. **Press Enter** to add its path to the **Primitives** field. Now click on the **arrow** next to **Material Path** and from the pop-up window, select *materials* > *soccerball_mat* and click **OK**.

Click on the **+** **button** then repeat these steps for the *backdrop* and the *backdrop_mat*.



03 Double-click on the *materiallibrary* node to dive into it and select the *soccerball_mat* node. Click on the **Textures** tab and under **Base Color** click on **Use Texture** then use the button next to **Texture** to call up the file window. Click on **\$HIP** in the side list then click on the *tex* folder to open it and then click once on *soccerball_color.rat* to select it. Click **Accept** to assign the texture to the material.

The **\$HIP** reference makes sure that the reference is relative to the location of your scene file. That way if you were to move your project directories to another computer the reference will still work.



04 Under the **Textures** tab and use the technique you learned in the last step to assign textures to **Roughness** and **Reflectivity**. You will find the appropriate textures in the *tex* folder.

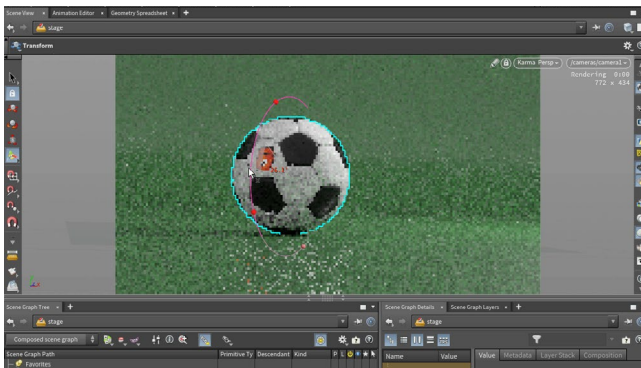
Go to the **Bumps & Normals** tab on the material and click the **Enable** button. Click on the arrow next to **Texture Path** and from the *tex* directory choose the *soccerball_normal.rat* file. Set the **Effect Scale** to around **0.5** and see how it looks.



MATERIALS IN HOUDINI

Materials in Houdini live in the **VEX Builder** context which in this case is nested inside the **Material Library** node. A material is made up of **VOP** nodes or **Material X** nodes that define the material qualities.

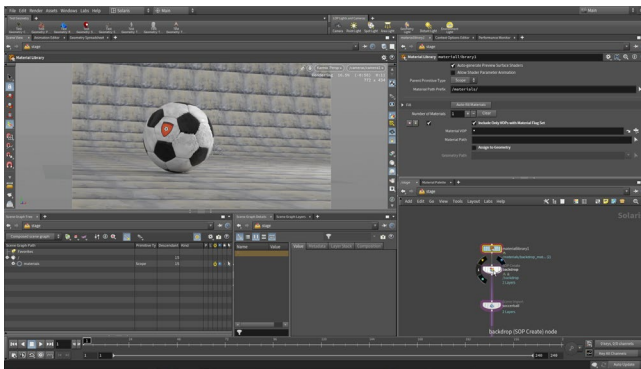
The **Principled Shader** is an uber material that can be used on its own to assign texture maps and achieve a large variety of looks. You can also build your own shaders and materials for more advanced looks.



05 In the Scene view, look through *camera1* to see your shot. The position of the soccerball's logo isn't quite right in relation to this camera therefore you need to rotate the ball.

In the Scene view, select the soccerball. Press **tab > transform**. This adds a transform node to the end of the chain. With the **Handle** tool, press **r** to get the **Rotate** handle and rotate the ball see the logo properly. You may need to tumble around to get this to work.

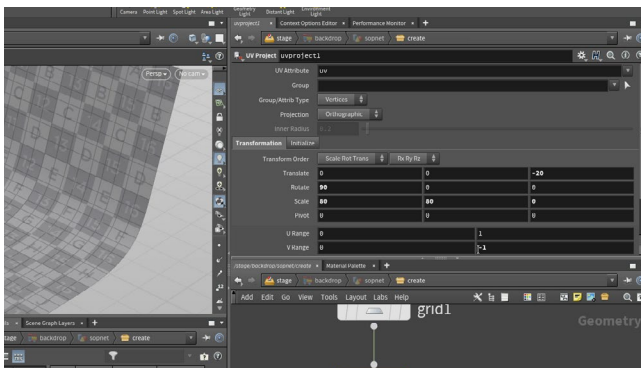
You can do this in the **Karma** or **Houdini GL** view. If you don't like the edits then you can delete the node and try again. To deselect the *soccerball_geo*, press **Ctrl** and click on it in the **Scene Graph**.



06 Now lets add some texture maps to the Backdrop material. **Double-click** on the *materiallibrary* node and select the *backdrop_mat* node.

Set the **Base Color** to **1, 1, 1** because this color will be multiplied with the texture map. Now click on the **Textures** tab and under **Base Color** click **Use Texture**. Click the **File Selector** button and use **\$HIP** to go to the `/tex` directory and choose *backdrop_color.rat*. You can also add the *backdrop_reflect.rat* texture to **Reflectivity**.

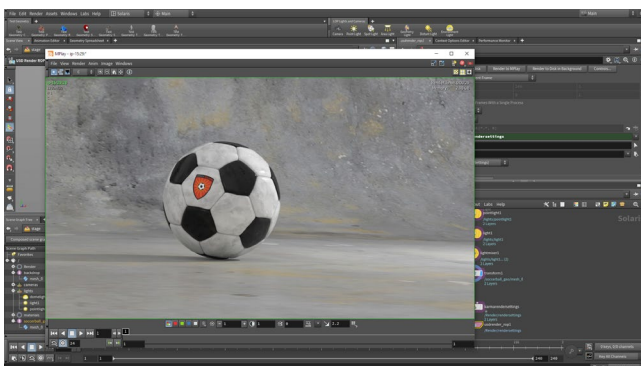
You can see in the **Scene View** that UVs are not set up properly and the texture map isn't working.



07 Go back to the Stage level then **double-click** on the *backdrop* node to go to the geometry level. Add a **UV Project** node between the *grid* and the *bend*. You are putting the nodes here so the UVs are created before the surface is bent.

On the *uvproject* node, 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.

IMPORTANT: Set the **Display Flag** back to the *subdivide* node.

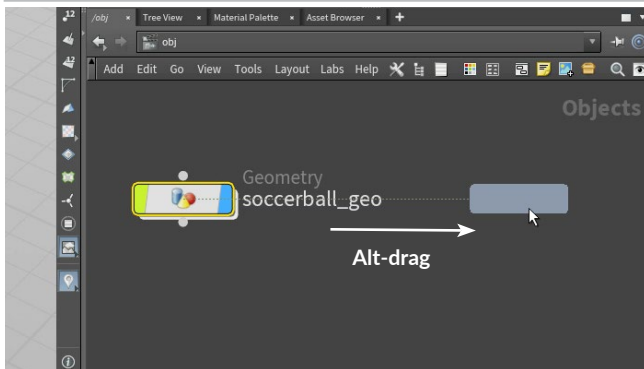


08 Go back to the Stage level. In the **Network View**, press **tab > Karma** to add a **Karma Render Settings** and **USD Render ROP** node. Wire them into the end of the chain. Select the *karmarendersettings* node and on the **Image Output > Filters** tab set **Denoisier** to **nvidia Optix Denoisier**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

Select the *usdrender_rop* node. Click on the **Render to Mplay** button. This opens **Mplay** which shows the rendering as it progresses. Choose **File > Save Frame As** to save the image to disk.

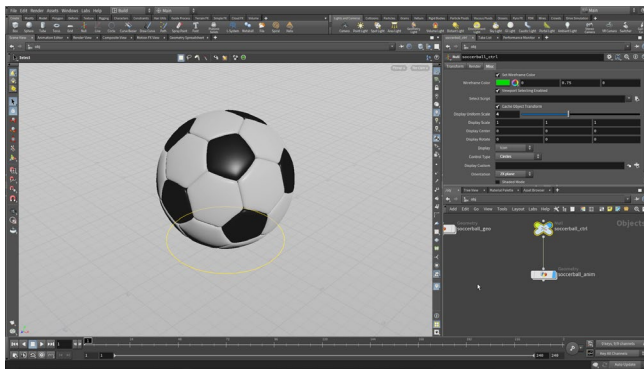
PART SEVEN: Rig the Soccerball

In order to create an animation of the ball bouncing, you will start by building a simple rig that will make it easier to keyframe. This will involve setting up null objects so that you can work interactively in the viewport and adding nodes to the soccerball geometry network to accommodate the ball rotation along with squash and stretch.



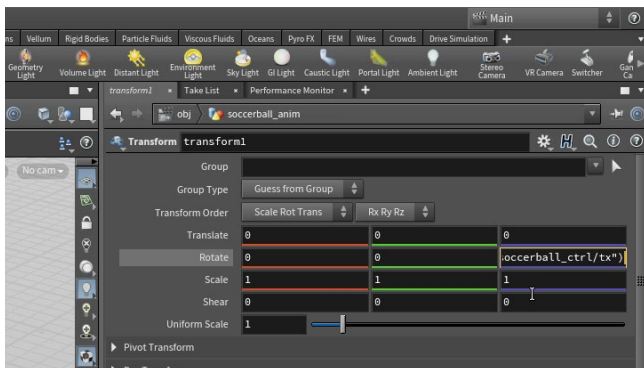
01 Change back to the **Build** desktop and navigate to the object level by clicking on one of the path bars and choosing *obj*. Now in the network editor, **Alt-drag** on *soccerball_geo* to make a copy of it. Rename this node *soccerball_anim*.

You will use *soccer_anim* to build your rig. Now turn off the Display Flag on the *soccer_geo* node to hide it. You don't want to make changes to the original setup because that object is being used in SHOT 1 in the Solaris context. This new soccerball will be used for an animated SHOT 2.



02 On the **Create** shelf, click on the **Null** tool then press **Enter** to place it at the origin. Name it *soccerball_ctrl*. Go to the **Misc** tab and set **Control Type** to **Circles** and **Orientation** to **ZX Plane**. Set the **Display Uniform Scale** to **4**. This creates a handle for the rig that is easy to select that won't render later on.

In the network editor, connect the input of the *soccerball_anim* object to the output of the *soccerball_ctrl* null to create a child/parent relationship. Moving the null will move the ball. Turn off the **selection flag** on the *soccerball_anim* so that you don't select it by accident in the viewport while animating. You will use *soccerball_ctrl* instead.

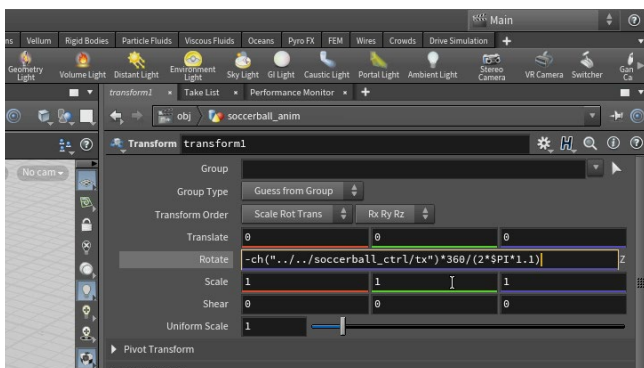


03 Select the *soccerball_ctrl* node. In the Parameter pane, click on the **Transform** tab then **RMB-click** on the **Translate X** parameter. Choose **Copy Parameter**.

Dive into the *soccerball_anim* object. Add a **Transform** node between the *subdivide* and the *matchsize* nodes. **RMB-click** on the **Rotate Z** and choose **Paste Relative References**. This places a channel reference expression in this parameter.

```
ch("../././soccerball_ctrl/tx")
```

This will connect the movement of the control object to the rotation on this node.

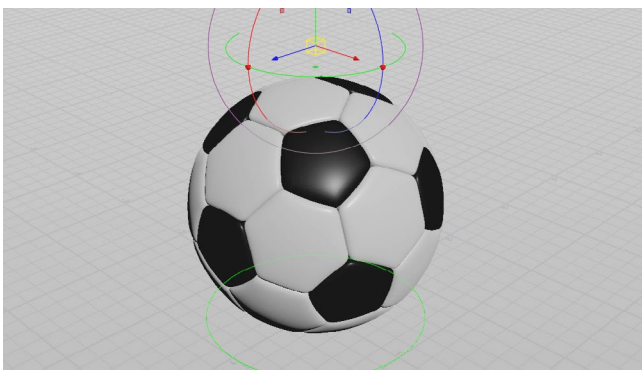


04 Click on the parameter to expand the channel. You are now going to use the **ball's circumference ($2\pi r$)** to determine the ball's rotation as it moves forward.

Edit the expression to read:

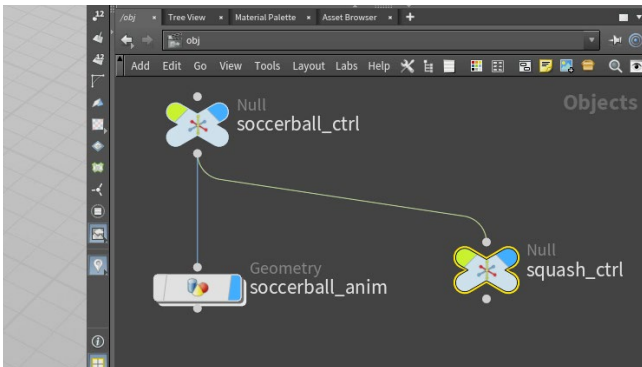
```
-ch("../././soccerball_ctrl/tx") * 360 / (2 * $PI * 1.1)
```

First you add a negative (-) at the front. You then multiply the position of the ball by **360** degrees and divide by $2\pi r$ - π being $\$PI$ in the expression. At the object level, move the *soccerball_ctrl* along the **X** axis. The expression will rotate the ball to match the motion. Put it back at the origin when you are finished.



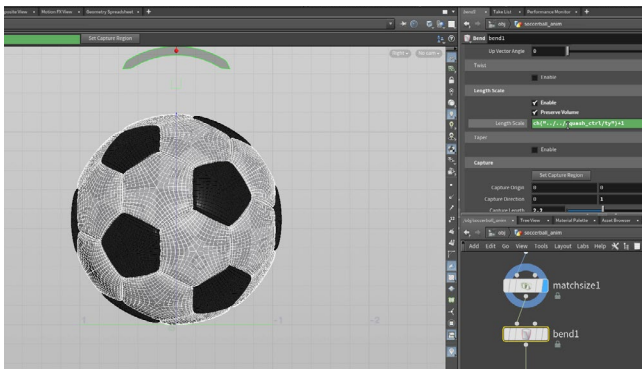
05 In the Viewport, create another **Null** object at the origin. Call it *squash_ctrl*. Go to the **Misc** tab and set **Control Type** to **Box** and the **Display Uniform Scale** to **0.2**.

Move the null up just above the ball. **Translate Y** should be about **2.5**. In the Parameter pane, choose the **Modify Pre-Transforms** menu and select **Clean Translates**. This sets the **Translate Y** value of the null to **0** even though it is above the ground. In order for this null to drive the squash and stretch, it needs a default value of **0**.



06 Parent the *squash_ctrl* null to the *soccerball_ctrl* null. This will ensure that this secondary null moves when you animate the control null.

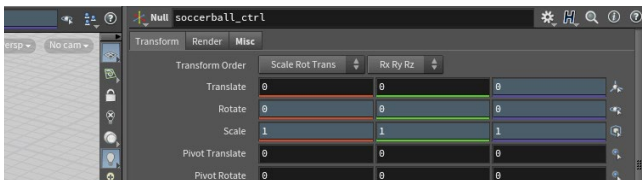
RMB-click on the *squash_ctrl* node's **Translate Y** parameter. Choose **Copy Parameter**. You will use this parameter to drive the squash and stretch of the ball. This will allow you to control the squash and stretch from the viewport interactively.



07 Go into the *soccerball_anim* object. Add a **Bend** node after *matchsize*. Turn **Off** the **Limit Deformation to Capture Region** checkbox.

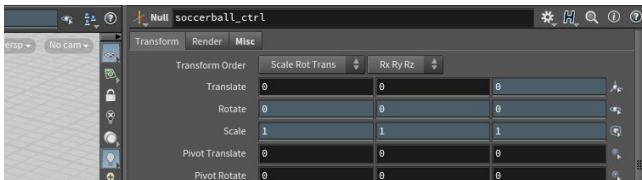
Go to a **Right View** then click the **Set Capture Region** button. Turn on **Grid Snapping** and place a point at the base of the ball and another at the top. This should set **Up Vector** to **0, 0, 1**, **Capture Direction** to **0, 1, 0** and **Capture Length** to **2.2**.

Turn on **Length Scale** and **Preserve Volume** then **RMB-click** on **Length Scale** and choose **Paste Relative References**. Add a **+1** at the end of the expression.



08 Go to the Object level and a perspective view. **RMB-click** on the **Transform X** and **Transform Z** parameters and choose **Lock Parameter** to lock these parameters on *squash_ctrl*. **RMB-click** on the **Scale** and **Rotate** parameters and choose **Lock Parameter** to lock all three channels.

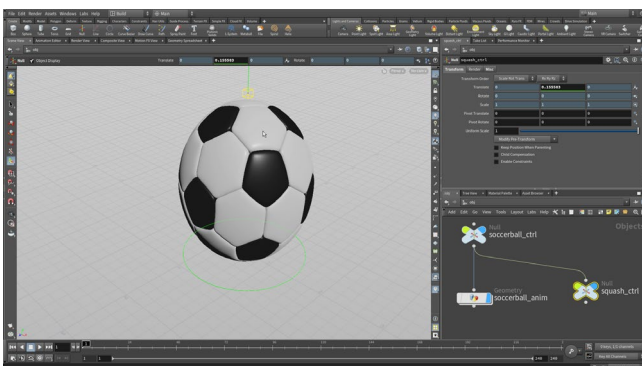
Select the *soccerball_ctrl* object. **Lock** all the channels except **Translate X** and **Translate Y**. Now when you select the controls you will only see handles for the unlocked channels. This will make it easier to work with the rig because the animator can only manipulate the chosen parameters.



09 Now test out the rig by moving it around in X and Y and using the second handle to squash and stretch it. Once you are sure that all the parts are working, return all the values to 0 and get ready to animate.

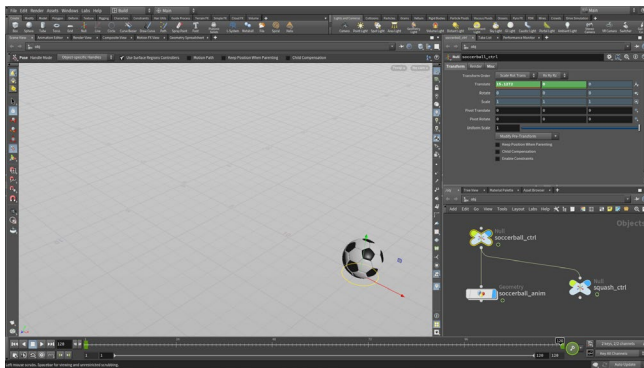
You may want to turn off **Secure Selection** in the toolbar on the left side of the Scene view. This will make it easier to select the two control nulls while in the **Move** tool. If not then you will need to press the **S** key every time you want to switch selections.

Save your scene file before proceeding.



PART EIGHT: Animate a Bouncing Ball

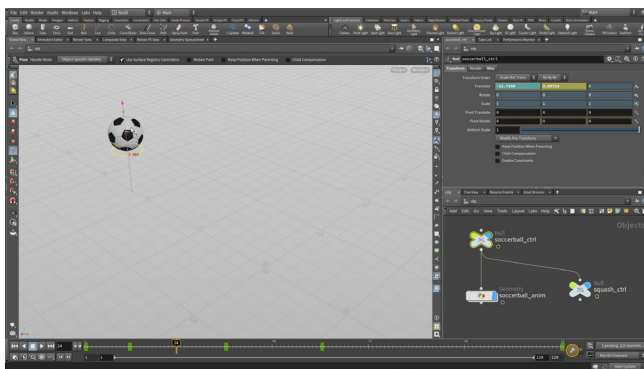
You can now take the soccer ball rig and use it to animate the ball bouncing. You will learn how to set keyframes, adjust animation curves and work with time-space handles in the viewport. The bouncing ball is a classic animation exercise that offers a great opportunity to learning the basics of animating in Houdini.



01 At the bottom left edge of the **Timeline**, click on the **Global Animation Options** button. Set the **End** to **120** and click **Close**. This will set the timeline range to 120 frames.

Make sure you are on **frame 1**. Click on the **Pose** tool on the toolbar to your left and select the *soccerball_ctrl*. Move the ball to around **-15** in **X** and **press K** to keyframe it. Move the timeline to **frame 120**. Move the ball to the around **15** in **X** and **press K** to set a second keyframe.

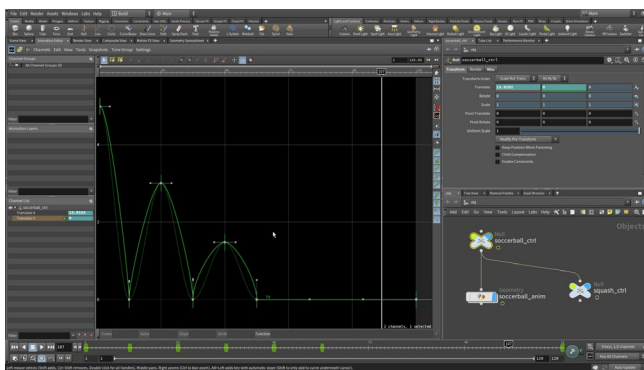
Scrub through the timeline to make sure that the ball is animating. It should be moving and rotating based on the rig design.



02 Move the timeline to **frame 12** and **press K** to set an intermediate key. Repeat at **frames 36** and **60**. All of these keyframes are sitting on the ground.

Now go to **frame 1** and lift the ball up in the **Y** direction. You don't need to set another key because this move simply updates the keyframe you already set at **frame 1**.

Move to **frame 24** and lift up the ball in the **Y** direction a little less than you did at **frame 1**. **Press K** to set a keyframe. Move to **frame 48** and lift the ball up even less. **Press K** to set another keyframe.



03 **Scrub** through the timeline to see that the ball appears to float whereas you want hard hits when the ball contacts the ground. Click on the **Animation Editor** pane tab.

From the Scoped parameter list, click on the *Translate Y* channel.

Press H to home the view of the curve. Select the three keyframes where the ball contacts the ground and press the **Untie Handles** button on the **Functions** bar found just above the graph. Now click in empty space to deselect then start tweaking the tangent handles to create a sharp bounce at each point. You can also stretch out the handles at the top to slow the ball down at the peak.

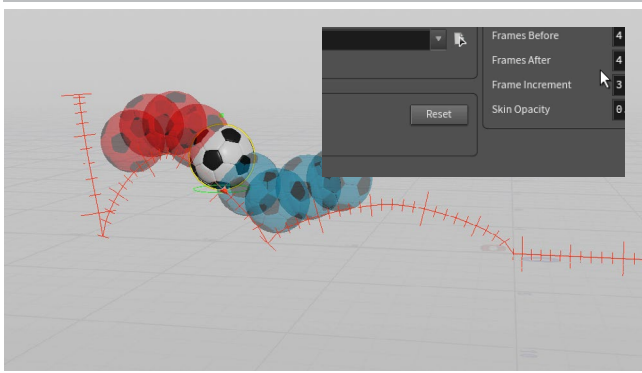


THE POSE TOOL

You can easily manipulate the two control objects in the soccerball rig using the **Move** or **Handle** tool. The advantage of using the **Pose** tool is that it gives you access to the **Motion Path** handle and if you were working with Inverse kinematics, there are special handles that you can use to control the system. Therefore be sure to remember this tool when you start setting keyframes on your rigs. The **Secure Selection** does not restrict the **Pose** tool from selecting different objects.

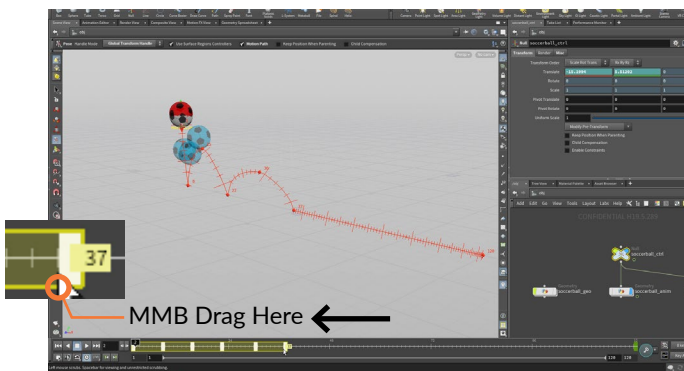


- Select
- Secure Selection [~]
- Move [T]
- Rotate [R]
- Scale [E]
- **POSE** [Y or Ctrl R]
- Handle [Enter]



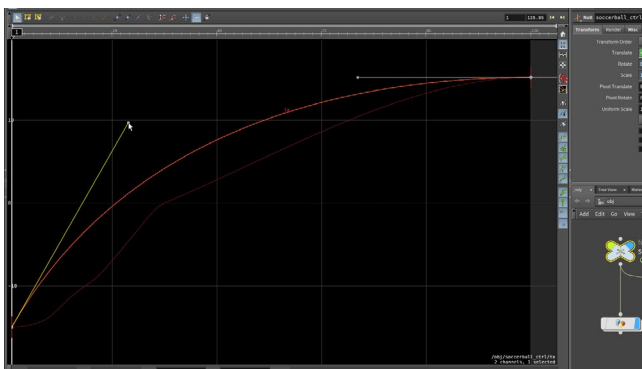
04 Go back to the **Scene view** and preview the results. You now have a sharper hit each time the ball hits the ground. Make sure you have the **Pose** tool active and the **soccerball_ctrl** node selected. In the top bar, turn **On** the **Motion Path** handle. This shows a path outlined where the ball is bouncing. Click on each keyframe marker to tweak the bounce. **RMB-click** on the handle to **Show tangents** for more control over the curve.

Go to the **soccerball_anim** object's **Misc** tab, set **Onion Skinning** to **Full Deformation**. Press **spacebar-d** and from the **Scene** tab adjust **Frame increment** and the **Frames Before** and **After** color.



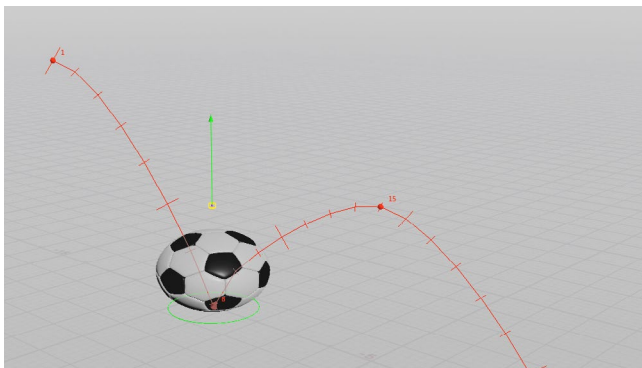
05 To adjust the timing, you can also use the timeline. Press **Shift** and drag a bounding box from frame 1 to the last key in the timeline to **select** all the keys. Next, **MMB drag** on the end of the box underneath the handle to scale the timing of the bounces to speed them up. You can also select each key using **MMB** and then drag with **MMB** to time each keyframe the way you want.

This is where you will determine the timing of the bounces. Keep exploring until you get the look that you want. Note that there may be some awkwardness in the bouncing because of the translate X values. You will fix that in the next step.



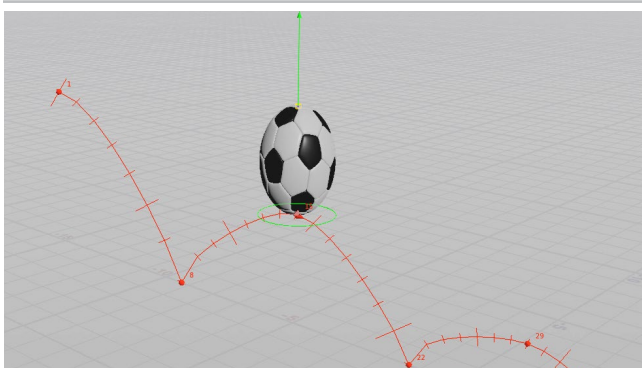
06 Click on the **Animation Editor** pane tab and you will see two curves. From the Scoped Parameters list, click on **Translate X** for **soccerball_ctrl**. Now select all the keys except for the first and the last. Press **Delete**. Now use the curve handles to go from a high slope to a low slope. This will have the ball moving faster at the beginning and slower at the end.

Note that if you go back to tweak the points in X on the motion path handle, you will get strange results because there are no longer intermediate keys in that direction - only use it to tweak in Y from this point on.



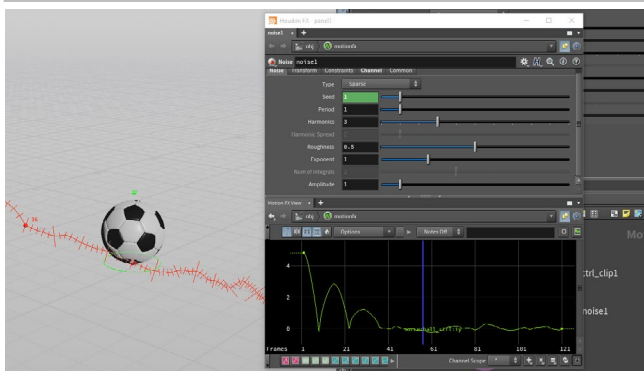
07 Go back to the Scene view. **RMB-click** on the **Motion Path** handle and choose **Persistent**. This will keep it around as a guide as you set keyframes on the squash and stretch.

Select the **squash_ctrl** and turn off its **Motion Path**. Go to the first bounce and move back one frame. Select the **squash_ctrl** handle and stretch out the ball a bit. **Set a Keyframe** using the **K** key. Now go to the bounce frame and move the handle down to create squash. **Set another key**. Go one frame forward and stretch the ball until it is round. **Set another key**. Repeat for all the bounces.



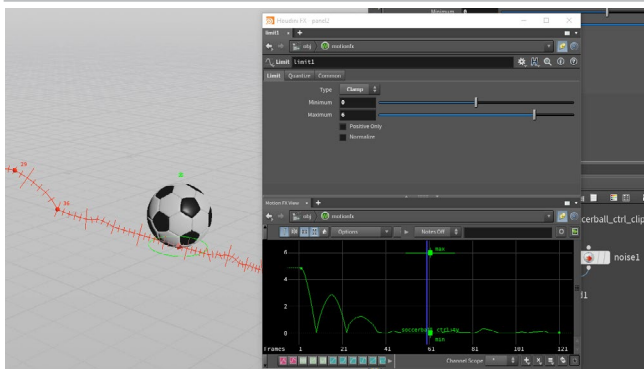
08 When you are finished, scrub and playback the motion to preview the results. Make sure the peaks of the bounces are stretched out. Make sure the **Real Time Toggle** is **On** in the Timeline to properly evaluate the motion.

You can now use the **Animation editor** to make tweaks to the squash and stretch. Make sure you keep the keyframes aligned with the bouncing of the soccer balls.



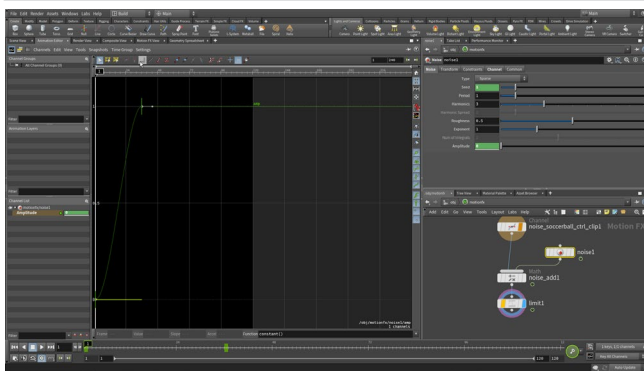
09 Select the *soccerball_ctrl* null object. **RMB-click** on the **Translate Y** and choose **Motion FX > Noise**. A panel pops up with parameters that you can use to control the noise. A new subnetwork was created with the CHOP nodes that send their information back to the *soccerball_ctrl*'s **Translate Y** channel.

Set the **Amplitude** to **5** and press **Play** to see how this looks. This adds dramatic up and down motion which make it feel like there is some serious turbulence. Set the **Amplitude** to **1**. This offers a more subtle bump to the motion of the ball.



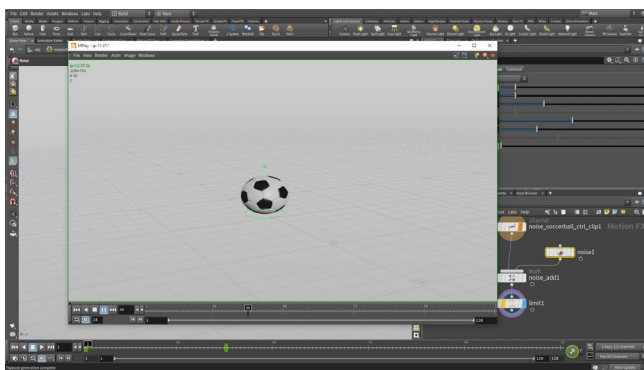
10 Some of this motion goes below the ground. You will want to focus on creating bumps above the ground.

Go back to the object level. Select the *soccerball_ctrl* null object. **RMB-click** on the **Translate Y** and choose **Motion FX > Limit**. Set **Minimum** to **0** and **Maximum** to **6**. Now the ball moves flat with some bumps instead of going up and down the whole way.



11 There should not be any noise while the ball is bouncing. It is only needed when the ball is rolling. You can keyframe the **Amplitude** to turn the noise on and off.

In the newly created *motionfx* network, select the *noise1* CHOP node. Go to **Frame 37** where the ball stops bouncing and starts rolling. **Alt-click** on **Amplitude** to set a keyframe. Go to **Frame 1** and set **Amplitude** to **0**. **Alt-click** on **Amplitude** again to set a second keyframe. Go to the **Animation Editor** and select the curve. Click on the **Constant** button in the Functions bar. This creates a sharp cut from no amplitude to an amplitude of 1.



12 When you are finished, close the window then **RMB-click** on the **Motion Path** handle and turn off **Persistent** so that it isn't visible when you deselect.

In the toolbar at the left side of the Scene view, click on the **Render Flipbook** button. Leave the default settings and click **Start**. Wait while the sequence is captured and then you will see the flipbook in an **Mplay** window. You can **Play** this back and scrub through to evaluate your motion.

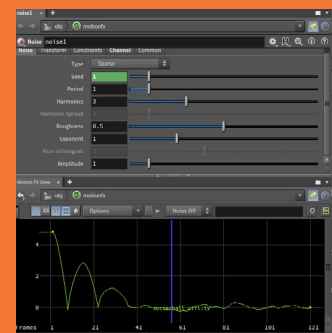
Save your work.



MOTION FX

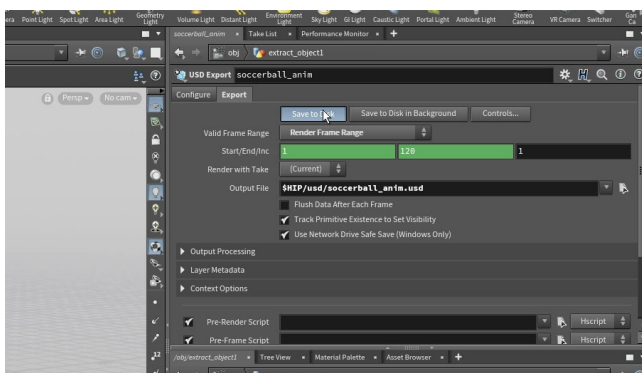
While keyframes and animation curves are stored in the parameters of your nodes, you can also use **channel operators (CHOPs)** for a more procedural node-based approach to working with motion.

Motion FX can be applied to keyframed motion which is extracted and stored in a **Channel CHOP**. You can then apply effects such as **cycle**, **noise**, **smooth**, **limit** or **lag** to the existing motion. On the **Constraints** shelf, you have tools which let you have one parameter either **look at**, **lag** or **jiggle** behind another.



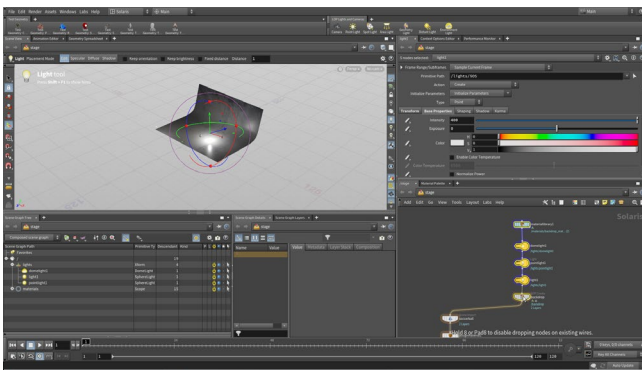
PART NINE: Lights, Camera, Action!

To render out the animated soccer ball, you will need to go back to the Solaris environment and set up a second shot. You will begin by branching off new LOP nodes from backdrop geometry then adjust the lights and cameras to suit the bouncing soccer-ball animation. You will also set up motion blur for the deforming geometry.



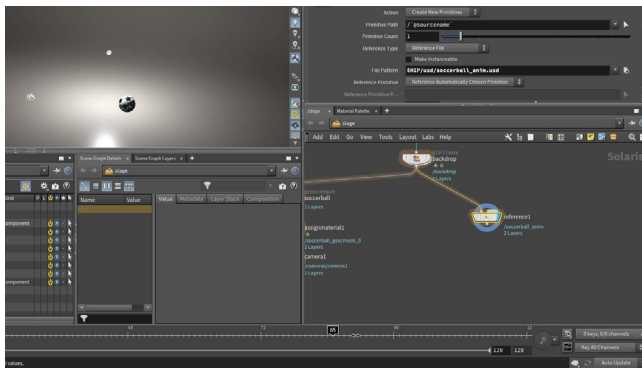
01 Go to the Object level. **Double-click** on *soccerball_anim* to dive into it. **Press n** to select all the geometry then go to the **Modify** shelf and select **Extract**. This takes all the motion and bending of the ball and puts it in one network.

You can see an *objectmerge* node which is extracting the ball into a new object called *extract_object*. **RMB-click** on the output and find **USD Export** then click to place this node. **Rename** this node to *soccerball_anim*. Click on the **Export** tab then set **Valid Frame Range** to **Render Frame Range** and set **Output File** to *\$HIP/geo/soccerball_anim.usd*. Click the **Save to Disk** button.



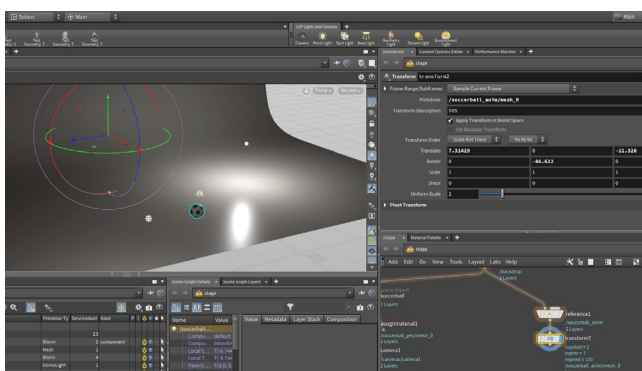
02 Go back to the **Solaris** desktop and point it to */stage*. In the **Network View**, add a **Null** node just before the *karmarendersettings* node and call it *SHOT_01*.

Disconnect the three **light** nodes (not the *lightmixer*) and move them above the *backdrop* node. This will not change how the first shot looks, but will let you share the nodes between the two shots. Move the *backdrop*, *light* and *materiallibrary* nodes to the right.



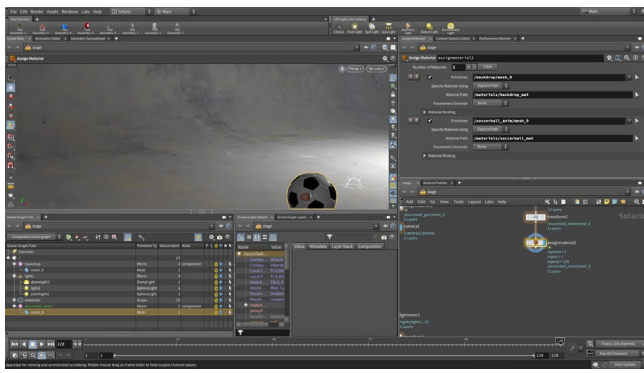
03 Zoom in and add a **Reference** node to the right under the *backdrop* node. Connect the *backdrop* node to this new node and set its **Display Flag**. Next to **File Pattern**, click on the **File Chooser** and find the *soccerball_anim.usd* file. Rename the node to *soccerball_anim*.

Scrub in the timeline, in Houdini GL view, to see the cached animation which is part of the USD file.



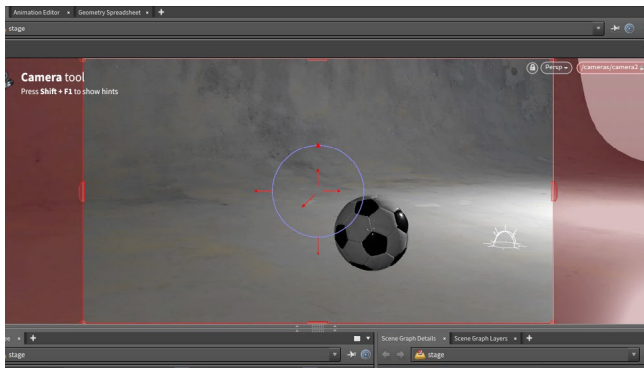
04 Use the **Select** tool and click on the new animated soccerball. In the Scene View, press **tab > Transform** to add a transform node to the graph.

In the Scene view, use the Transform handle to **Move** the Ball to the back of the backdrop in the middle. **Scrub** the timeline to watch the ball bounce to the right. Leave it at somewhere around frame 80. **Press R** to get the rotate handle. **Rotate** to move the ball so that it is bouncing at an angle from the backdrop. **Scrub** the timeline to see if you like its direction.



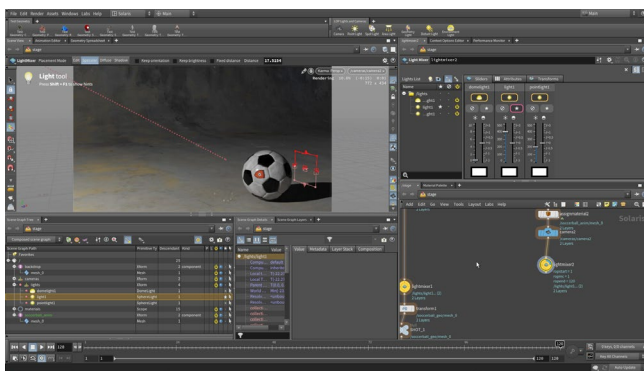
05 In the Network view, **Select** the *assignmaterial* node from the SHOT 1 network then **Alt-drag** to create a copy of this node. Wire the *transform* node into the *assignmaterial* node then set its **Display Flag**. This will assign the material to the *backdrop* but since the soccerball primitive has changed it needs to be reassigned.

In the field next to **Primitives** for the *soccerball_mat*, change the primitive name to */soccerball_anim* to reassign the material to the new geometry.



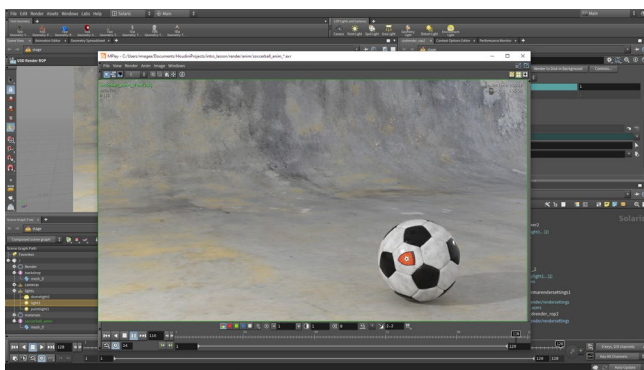
06 Tumble around until you see the ball animated towards the camera from the top left to the bottom right. In the **LOP Lights and Cameras** shelf, **Alt-click** on the Camera tool to place a camera from the angle you are currently looking.

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 tweak the camera to get the framing that you want for the shot. Scrub the timeline to make sure the camera works for the whole sequence.



07 Add a **Light Mixer** node after the *camera*. On the *lightmixer* node you will need to move over the lights. This will let you use the same light handles you learned about earlier to make lighting decisions for this shot and use the **Karma** display in the viewport to verify your setup. You can also use the *lightmixer* node to play with **intensity** and **exposure** for this shot.

These edits are being held in the *lightmixer* node and changes are not being made to the original lights. The *lightmixer* lets you tweak existing lights when working in a multi-shot setup.



08 In the Network view, **Alt-drag** the *SHOT_01* and *karmarendersettings* and *usdrender_rop* nodes. Wire the *lightmixer* node into this chain. Select the new *karmarendersettings* node and make sure that **Camera** is set to */camera2*. Set **Valid Frame Range to Render Frame Range** and set the **Output Picture** to *\$HIP/render/anim/soccerball_anim_-\$F2.exr*. The *\$F2* adds frame numbers to the renderings with a padding of two and the */anim/* creates a directory to hold these frames.

On the *usdrender_rop* node, click **Render to Disk**. When you finish, choose **Render > Mplay > Load Disk Files** and open up the rendered images to review the final sequence. **Save** your work.



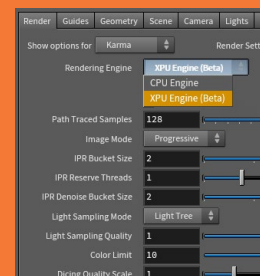
KARMA RENDERER

Karma is a physically-based **HYDRA** renderer built to work with **USD** files in the Solaris/LOPS context. This allows it to be used in the **Viewport** for interactive updates or to be rendered to disk using a **Karma** node.

Note: Houdini 19 includes a preview for an upcoming **Karma XPU** render engine. This hybrid GPU/CPU renderer is **Alpha** with many features still under development and is for **testing purposes only**. You can choose **XPU** in the Scene view's **Display Options** or in the **Karma** node.



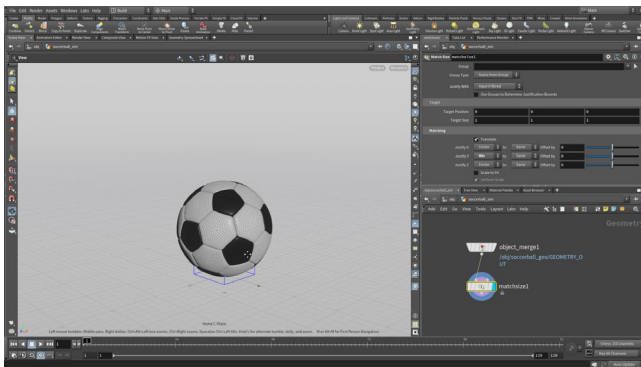
Viewport Menu



Display Options

PART TEN: Set up a Rigid Body Simulation

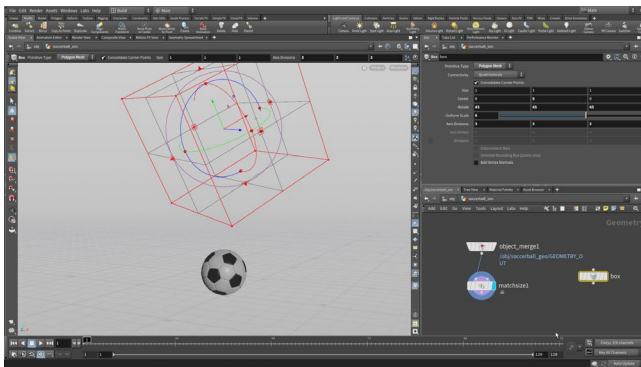
While traditional animation is great for animating a single soccer ball, dynamics would be a better option if you want to animate a bunch of soccer balls. Dynamics requires a simulation so that the solver can go frame by frame determining how each of the participating objects interact with each other. You will use packed geometry to get an efficient result for this simulation.



01 Change back to the **Build** desktop and navigate to the object level. Hide all of the animation rig nodes and the *extract_object* node by turning off their display flags. Turn on the *soccerball_geo* display.

Select the *soccerball_geo* node then from the **Modify** shelf click on the **Extract** tool. This creates a new object with the soccerball object merged. Jump up one level and rename *extract_object* to *soccerball_sim*. Hide the *soccerball_geo* object.

Dive back in to the *soccerball_sim* object to work with the geometry. Add a **Match Size** node to center the ball around the origin.

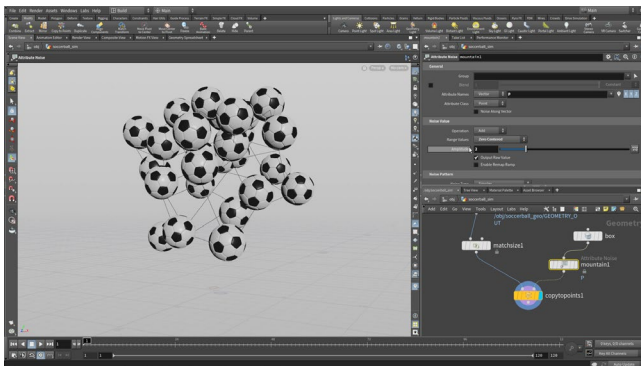


02 In the Network view, press **tab > Box** then place it to the right of the *matchsize* node.

Set the following on the *box* node:

- **Center** to 0, 8, 0
- **Rotate** to 45, 45, 45
- **Primitive Type** to Polygon Mesh
- **Uniform Scale** to 6
- **Axis Divisions** to 3, 3, 3

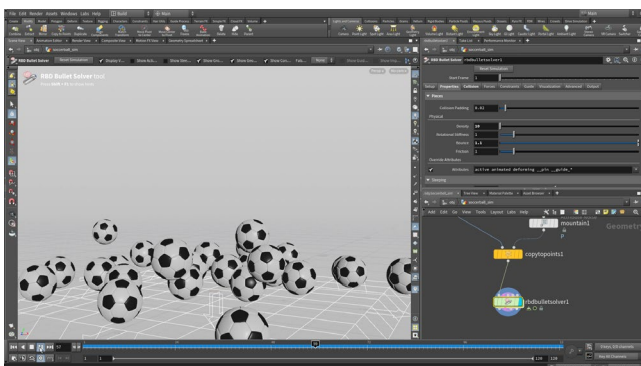
This puts it in the right position for the simulation.



03 In the Network view, add a **Copy to Points** node just below the other nodes. Wire the *matchsize* node into the first input and the *box* node into the second.

Turn **ON** the **Pack and Instance** option. This will create a faster simulation because the geometry is being instanced to the points of the cube. Set the *copytopoints* node's **Display Flag**.

In the Network view, press **tab > Mountain** and place the node between the *box* and the *copytopoint* nodes. Turn **Off** the **Noise Along Vector** option then set **Amplitude** to 2 and **Range Values** to **Zero Centered**. This will jiggle the points on the box.



04 Make sure you are on **Frame 1**. Add a **RBD Bullet Solver** node after the *copytopoints* node. Click on the **Collision** tab, scroll down to **Ground Collision**, and set **Ground Type** to **Ground Plane** to **Ground Plane**. Press **Play** to test out the simulation. The sim is cached which lets you scrub in the timeline to review the results.

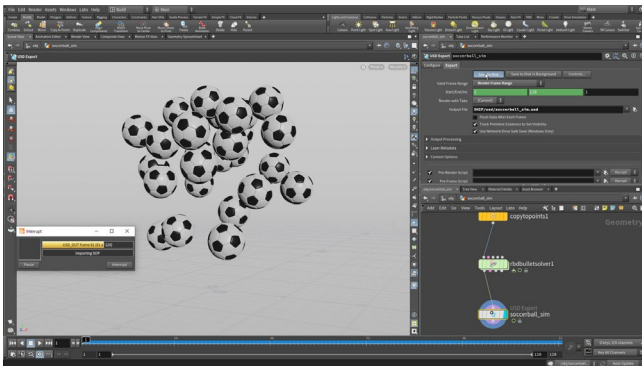
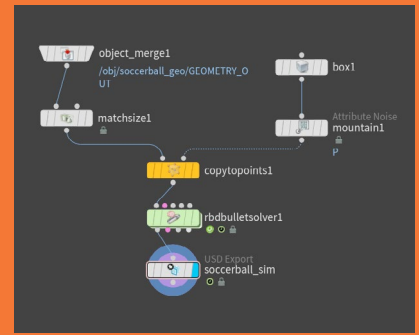
Under the **Collisions** tab, set **Bounce** to 0.8. Under the **Properties** tab, set **Density** to 10, **Bounce** to 1.1. At the top of the Parameter pane for this node, click the **Reset Simulation** button and then press **Play** to resim. Scrub to evaluate.



DOPS hidden inside SOPS

In Houdini, simulations are processed using the **Dynamic Operators** or **DOPs**. With the **RBD Bullet Solver** node in the **Geometry/SOP** context, you are working with a node that has a Dynamics network buried inside it.

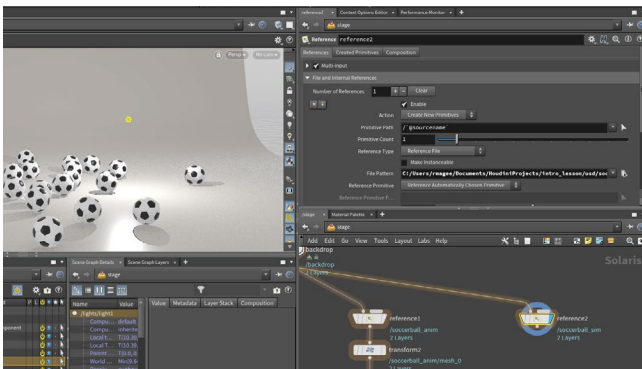
This makes it easy to set up at the geometry level with all the DOP nodes are wired up and ready to go but hidden from view. For simpler setups, working at the geometry level will give you a proper simulation. If you need more control over the different solvers then you would need to work directly in DOPs.



05 At the end of the chain, add a **USD Export** node, set its **Display flag** and rename it to **soccerball_sim**.

Set **Valid Frame Range** to **Render Frame Range** and set the **Output File** to **\$HIP/geo/soccerball_sim.usd**.

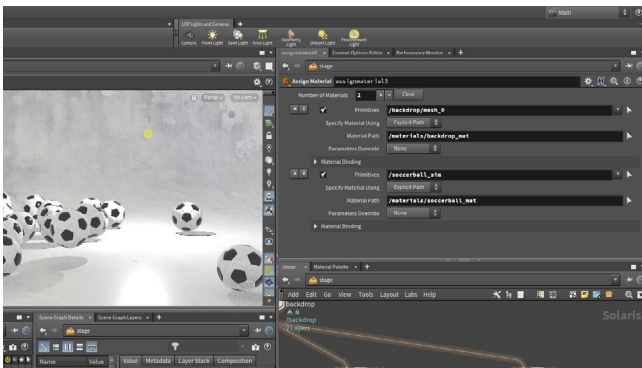
Click on the **Save to Disk** button and this will save the USD file into your geo directory. You will reference this cached asset into the Solaris setup as a third shot.



06 Change your **Desktop** back to **Solaris** and set the path to **/stage**. Make sure you are choose **Houdini GL** from the **persp** menu.

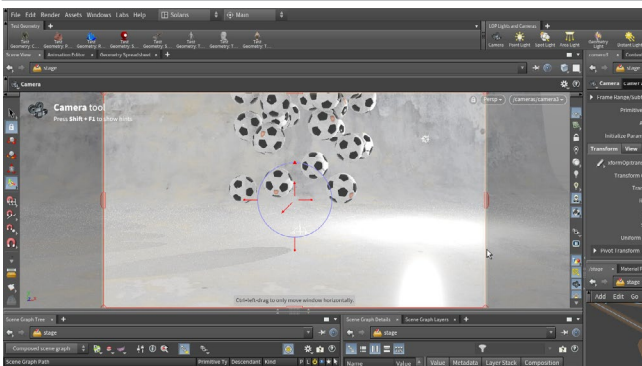
Alt-drag the **soccerball_anim** **Reference** node and set its **Display Flag**. Set **File Pattern** to **\$HIP/geo/soccerball_sim.usd**.

Rename this node to **soccerball_sim**.



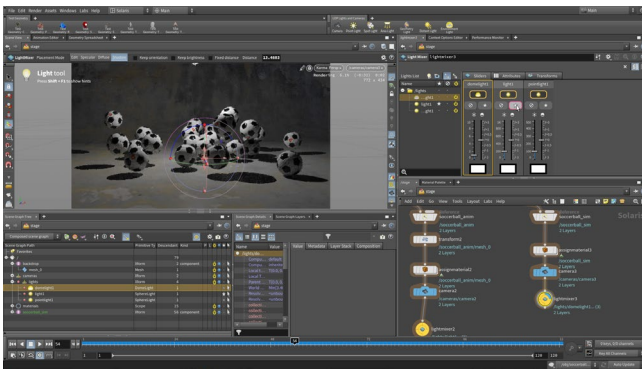
07 In the **Network** view, **Select** the **assignmaterial** node from the **SHOT 2** network then **Alt-drag** to create a copy of this node. Wire the **soccerball_anim** node into it the **assignmaterial** node then set its **Display Flag**. This will assign the material to the **backdrop** but since the soccerball primitive has changed it needs to be reassigned.

In the field next to **Primitives** for the **soccerball_mat**, change the primitive name to **/soccerball_sim** to reassign the material to the new geometry.



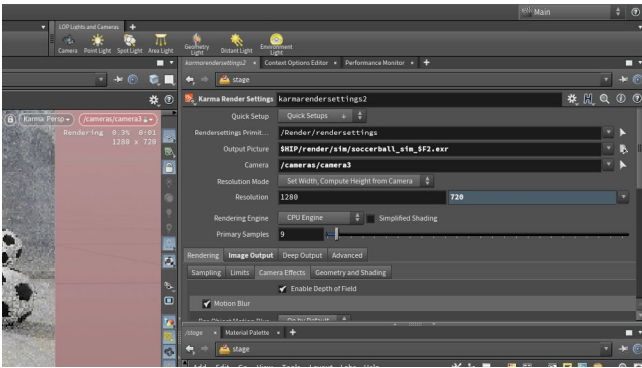
08 Tumble around until you see the balls animated towards the camera. In the **LOP Lights and Cameras** shelf, **Alt-click** on the **Camera** tool to place a camera from the angle you are currently looking.

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 tweak the camera to get the framing that you want for the shot. Scrub the timeline to make sure the camera works for the whole sequence.



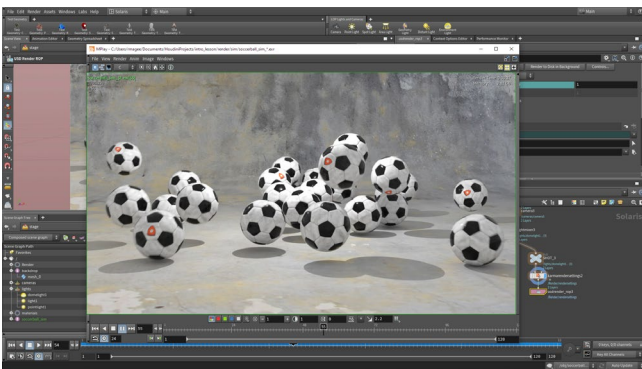
09 Add a **Light Mixer** node after the *camera*. On the *lightmixer* node you will need to move over the lights. This will let you use the same light handles you learned about earlier to make lighting decisions for this shot and use the **Karma** display in the viewport to verify your setup. You can also use the *lightmixer* node to play with **intensity** and **exposure** for this shot.

These edits are being held in the *lightmixer* node and changes are not being made to the original lights. The *lightmixer* lets you tweak existing lights when working in a multi-shot setup.



10 In the Network view, **Alt-drag** the *SHOT_02* and *karmarendersettings* and *usdrender_rop* nodes.

Wire the new *lightmixer* node into this chain. Select the new *karmarendersettings* node and make sure that **Camera** is set to /*camera3*.



11 On the *usdrender_rop* node, set **Valid Frame Range** to **Render Frame Range** and set the **Output Picture** to *\$HIP/render/sim/soccerball_sim_5F2.exr*. Click **Render to Disk**.

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



CONCLUSION

You have now built a scene from scratch, touching on many different aspects of Houdini. You have modeled, set up textures, animated, rendered and simulated. Along the way you have learned about the different Houdini contexts and how to navigate back and forth between them.

While this lesson doesn't result in blockbuster VFX, it introduces you to fundamental skills which you will carry with you as you dive deeper into Houdini and begin exploring its comprehensive toolset.

There is a wealth of learning material available on the SideFX website to help you take your next steps.

Best of luck on your journey!