Simulation Nodes

Simulation Nodes are an extension of **Geometry Nodes** which introduce dynamic effects to a display.

The following is the definition from the Blender Manual.

Through the use of [Simulation Zones](), [Geometry Nodes]() can be used to create custom physic simulations through nodes. Simulation zones allow the result of one frame to influence the next one. That way even a set of simple rules can lead to complex results, with the passing of time. The most common type is physics simulation, with specific solvers for physical phenomena.

In essence, using **Geometry Nodes** with an Array created, a Node Field or **Simulation Zone** is added to the Node Pipeline in which Nodes are inserted and arranged to modify or control the movement of the Array when an Animation is played.

A further dimension may be added to the field which causes Objects in the Scene to physically interact within the Array.

To undertake a study of Simulation Nodes you must have an understanding of Geometry Nodes as described in **Chapter 15 of The Complete Guide to Blender Graphics, Edition 8, Volume 2.** This topic is included in these Supplements for your convenience.

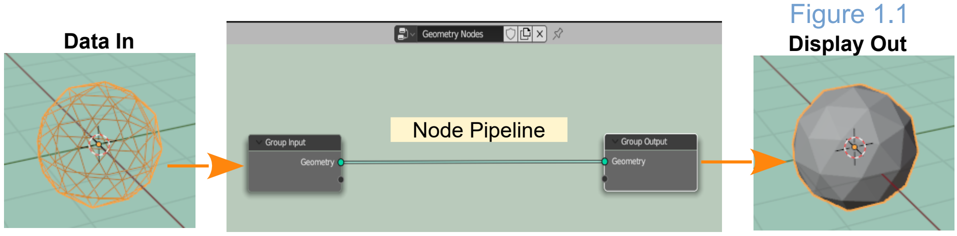
Start at the beginning, with Blender opened in the **Geometry Node Workspace**.

For the demonstration, replace the default Cube Object with an **Icosphere**.

Using an Icosphere provides a minimal number of Vertices, Edges and Faces to be used as **Points in an Array.**

With the Icosphere selected in the 3D Viewport add a **Node Pipeline** in the **Geometry Node Editor** by clicking the **New Button** in the Header.

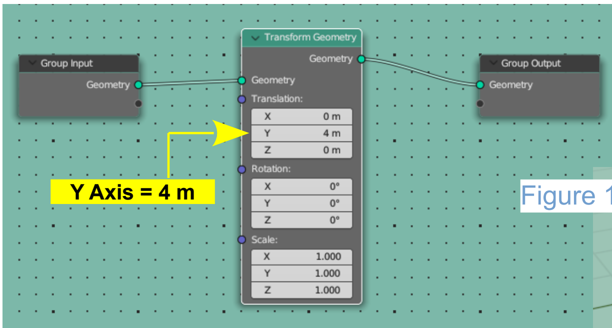
Figure 1.1



At this point the Data for the Icosphere is entered in the Group Input Node and conveyed to the Group Output Node which controls the display in the 3D Viewport.

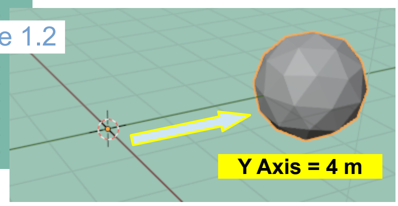
Nodes inserted in the Pipeline will control the display in the 3D Viewport.

As an example, insert a Transform Geometry Node and adjust the Y Axis Translation value in the Node (Figure 1.2).



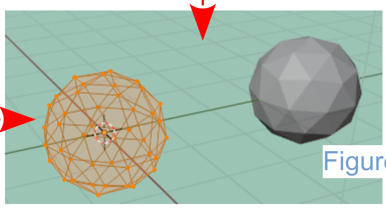
Setting the Y Axis Translation value to 4m in the Node moves the Icospher 4 M along the Y Axis in the 3D Viewport.

Figure 1.2



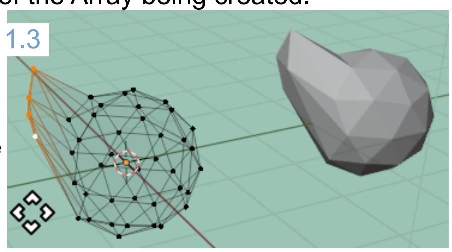
Be aware that the display in the 3D Viewport is controlled by the Transform Node in the Pipeline but the Data entered for the Icosphere remains in its original position. You see this with the **3D Viewport in Edit Mode**.

Original Data



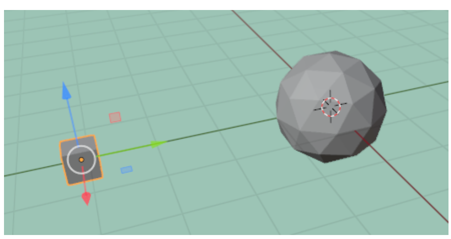
In Edit Mode you may select Vertices and modify the shape of the Icosphere which subsequently affects the shape of the Array being created.

Figure 1.3



To create an Array using the Icosphere, **Instance Objects** are displayed at the position of the Sphere's Vertices (Points).

Expand on the Node arrangement as shown in Figure 1.2. Deselect the Icosphere and add a Cube Object to the Scene. Scale the Cube down and park it too one side of the 3D Viewport.



Basic Icosphere without modification.

Figure 1.4

Select the Icosphere to display the Node Pipeline in the Geometry Node Editor. Add and arrange an **Instance on Points Node** and a **Object Info Node** as shown in Figure 1.5.

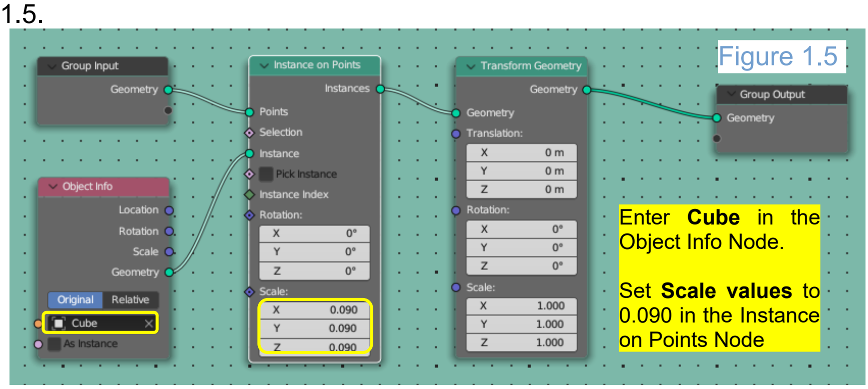


Figure 1.5

The Node arrangement in Figure 1.5 produces the **Array of Cube Objects.**

Instance Cube

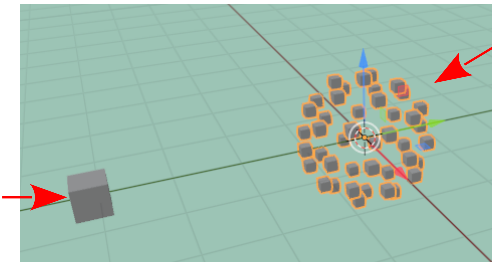


Figure 1.6

Reading the Node Tree, Data is transferred from left to right. Data for the Icosphere is entered in the Group Input Node and transferred to the Instance on Points Node. The instance on Points Node causes the Cube Instance Object to be displayed at each Point (Vertices) of the Icosphere. Data for the Cube is entered via the Object Info Node. The position of the Icosphere (hence the Array) in the 3D Viewport is controlled by the Transform Geometry Node with all Data being fed back to the 3D Viewport via the Group Output Node.

Note: In the Object Info Node, **Original** is active (highlighted blue). By selecting **Relative** instead of Original you will see the Array relocate away from the center of the 3D Viewport. By adjusting values in the Instance on Points Node and the Transform Geometry Node you affect the display of the Array in the 3D Viewport. Be prepared for experimentation to determine logic when adjusting the values.

Simulation

The foregoing is a simple example of using **Geometry Nodes** to generate a static Array. Simulation, as the name implies, is the process of simulating a Physical effect which usually entails motion or a change in state.

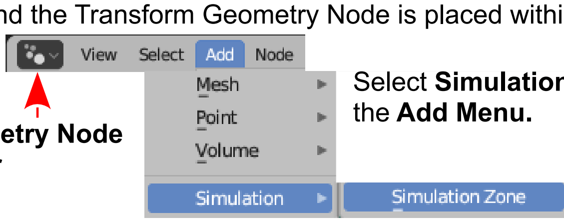
To demonstrate a basic Simulation the Array of Cubes in Figure 1.6 will simply Traverse in the Scene. You will have to use your imagination to determine what the Array represents.

Simulation Nodes may be considered as Geometry Nodes placed in a **Simulation Zone**. The Zone is linked to the Animation Timeline in the Timeline Editor. Values set in the Nodes within the Simulation Zone are incremented (recalculated) at each Frame in the Animation Timeline which produces motion or a change in state.

For example, when referring to the Y Axis Translation value in the Transform Geometry Node in Figure 1.5 the 4m value would not take affect until Frame 2 in the Animation Timeline and then increment at each successive Frame.

Frame 1= 0.00m, Frame 2= 4.00m, Frame 3= 8.00m etc.

For the incrementation to take place a **Simulation Zone** is inserted in the **Node Tree** and the Transform Geometry Node is placed within the Zone (Figures 1.8, 1.9).

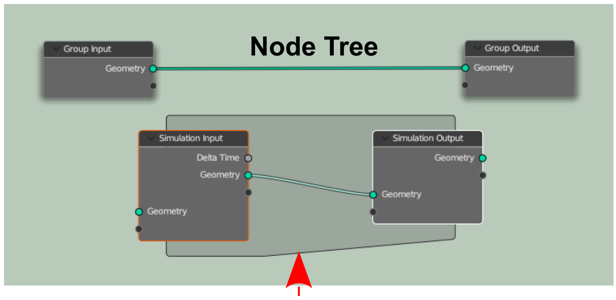


Geometry Node Editor

Select **Simulation Zone** in the **Add Menu.**

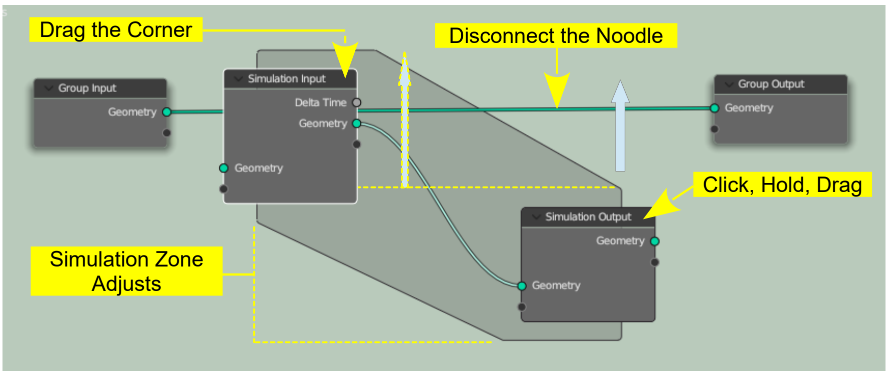
Figure 1.7

Figure 1.8



Simulation Zone

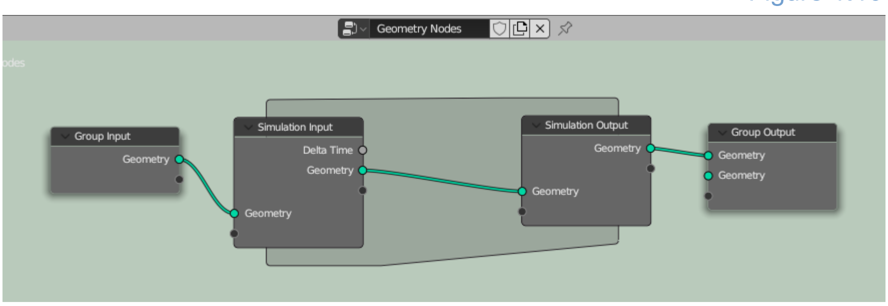
Figure 1.9



To insert the Simulation Zone click, hold and drag on the upper RH corner of a Simulation Node and position as shown. Do the same for both Simulation Nodes. As the Nodes are moved the Simulation Zone adjusts accordingly.

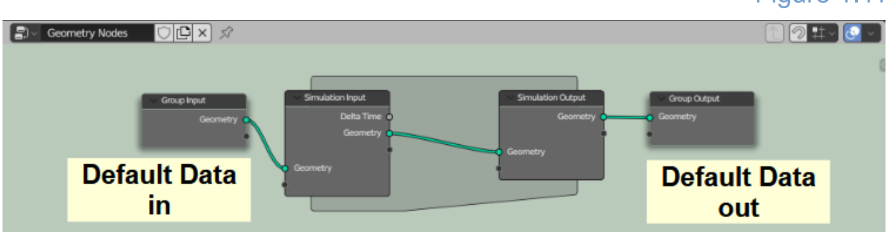
Disconnect the Noodle between the Group Input and Output Nodes and connect as shown (Figure 1.10).

Figure 1.10



Remember; The Node Pipeline is controlling the display of the UV Sphere Object in the 3D Viewport. At this stage there is no change to the display since the Data relevant to the UV Sphere is the default Data. This default Data is being transferred through the Simulation Zone via the Pipeline.

Figure 1.11



To demonstrate the significance of the Simulation Zone, insert a **Transform Geometry Node**

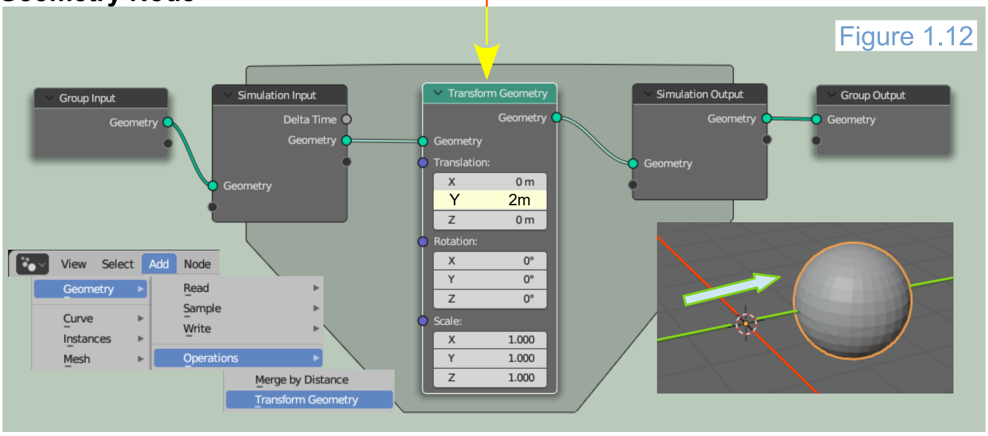


Figure 1.12

Adjusting the **Translation Y** value in the **Transform Geometry Node** will see the UV Sphere move along the Y Axis in the 3D Viewport. This Translation in itself could be accomplished without the **Simulation Zone** by having the Transform Geometry Node between the Group Input and Group Output Nodes in the Node Pipeline as shown in Figure 1.2.

The significance of the Simulation Zone can be seen by setting a value in the Transform Geometry Node, when it is inside the Simulation Zone, then in the Timeline Editor, incrementing the Frame Number. At each successive Frame the UV Sphere in the 3D Viewport moves in accordance with the value set in the Transform Geometry Node.

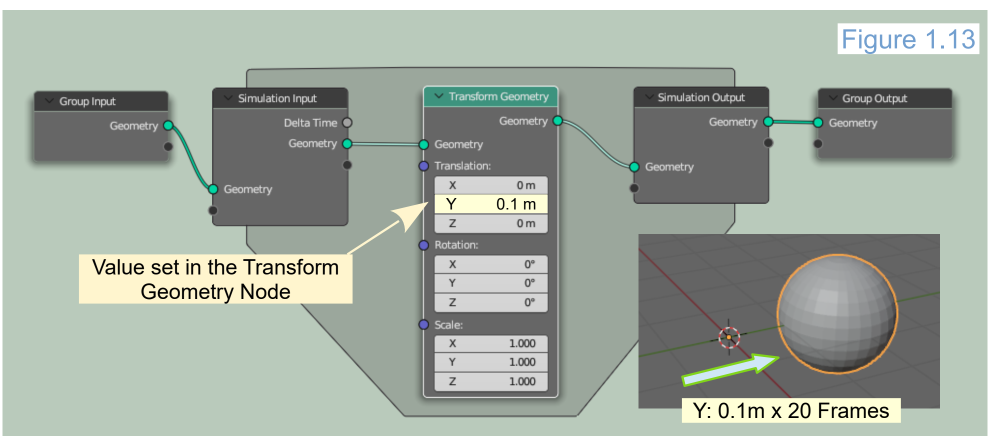
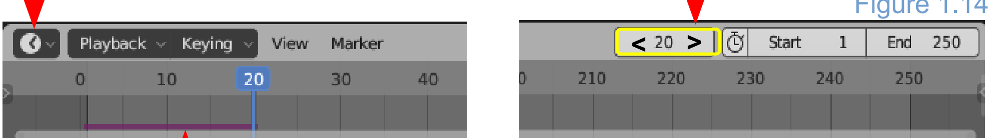


Figure 1.13

UV Sphere moves 0.1 m along the Y Axis at each successive Frame.

Timeline Editor Mouse over and click to increment the Frame Number.

Figure 1.14



Purple line indicates Data for the movement stored in the **Cache**.

Playing the Animation in the Timeline Editor will see the UV Sphere automatically move along the Y Axis. As the Animation plays Data for the position of the UV Sphere is stored in a **Cache Folder** as indicated by the purple line which displays in the Timeline Editor. With the Animation paused this allows you to scrub the Animation and view the position of the UV Sphere in the 3D Viewport at any Frame in the Animation.

Note: The data in the Cache is for the Blender File being worked and is temporary. Even though you save the Blender File, when you close the File and reopen the Data in the Cache is lost unless you **Bake the Data to a Folder** before closing.

More on Baking Data later but before that a note on the detail of values set in the Transform Geometry Node in the Simulation Zone.

Figure 1.15

With the Y Axis Translation value set at 0.1m you may not notice, with this small number, that at Frame 1 in the Timeline the Object (Sphere) in the 3D Viewport is immediately Translated when the value is set in the Node. This may be irrelevant unless you are seeking precision. To have the Object display at it's original position at Frame 1 (the intersection of the X-Y Axis) open the Object Properties Panel in the 3D Viewport Editor (press the N Key) and set the transform, Y Axis Location value to -0.1m.

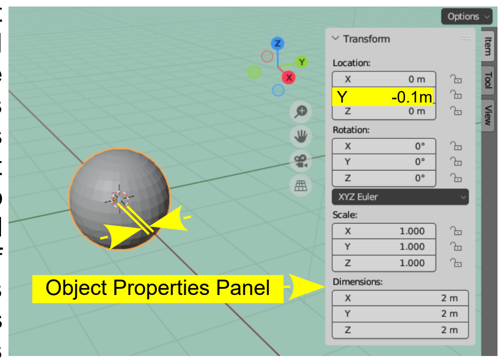
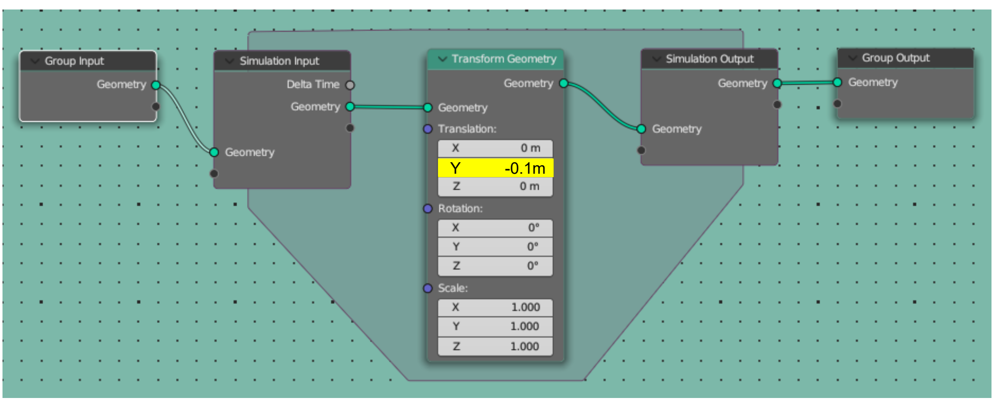
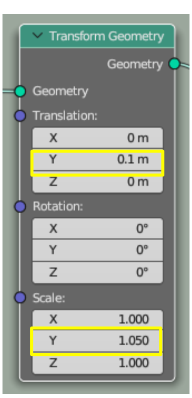


Figure 1.16

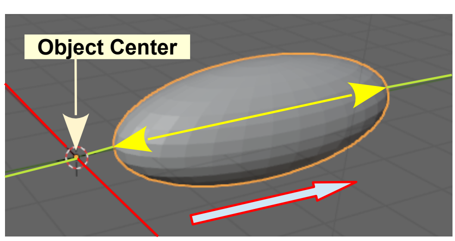




More on Simulation Nodes

By setting a **Y Axis Scale** value in the Transform Geometry Node as well as the **Y Axis Translation** the UV Sphere increases in size along the Y Axis as it Translates.

Figure 1.17



With the addition of a Join Geometry Node in the Simulation Zone, at each successive Frame in the Animation Timeline the Sphere moves along the Y Axis in the 3D Viewport and at the same time appears elongate on the Y Axis.

Figure 1.18

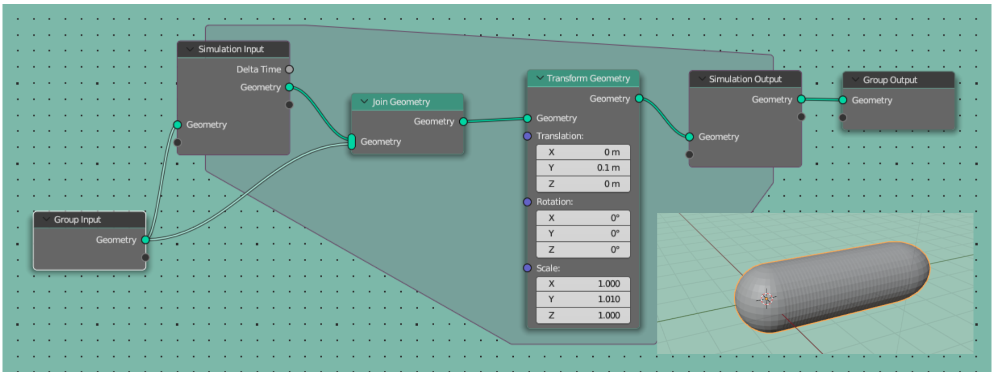
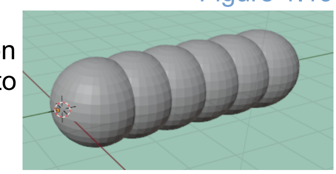


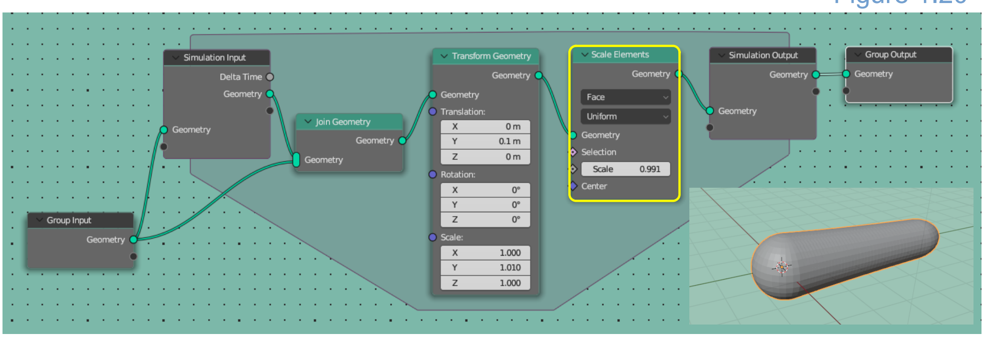
Figure 1.19



In fact, the Sphere is being duplicated at each Frame. The duplication is evident when the Y Axis Translation value in the Transform Geometry Node is increased to 0.9m.

A variation on the arrangement follows:

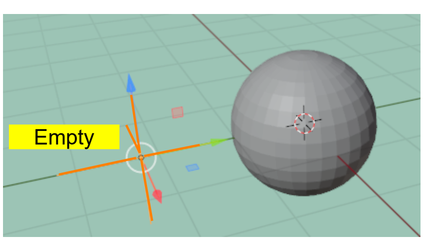
Figure 1.20



By adding a **Scale Element Node** to the Simulation the Sphere appears to elongate and Scale down.

To progress to a dynamic display effect in the 3D Viewport, deselect the UV Sphere and Add an **Empty Object**. The Empty will probably be hidden by the Sphere, therefore, Scale the Empty up and move it to one side.

Figure 1.21



Outliner Editor

In the **Outliner Editor**, click on **Empty**, hold and drag into the **Geometry Node Editor** to place an **Object Info Node**.

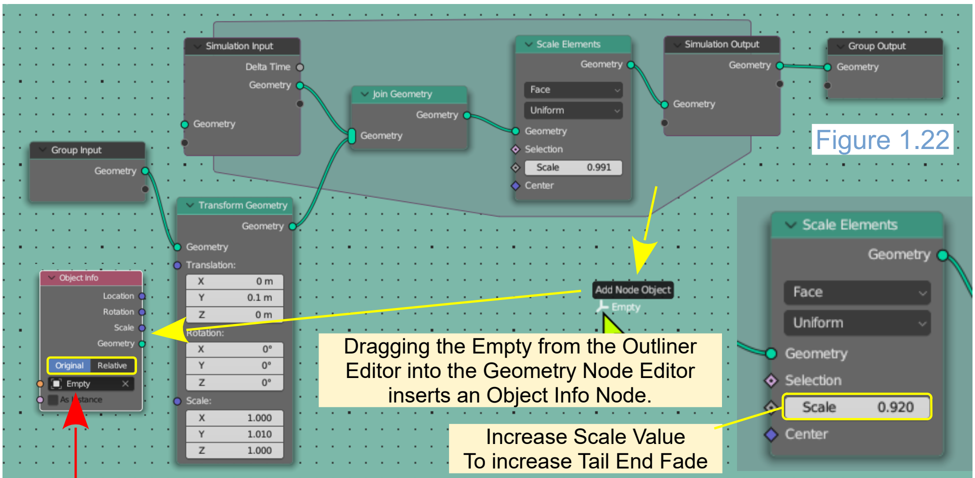
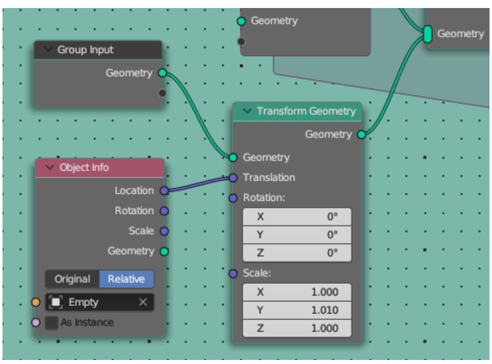


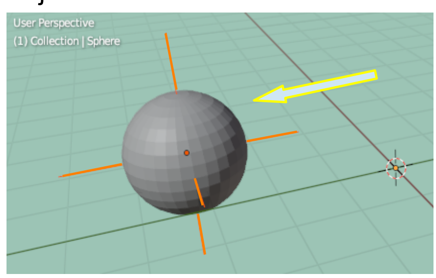
Figure 1.22

Note: The **Object Info Node** automatically has the value **Empty** assigned and is placed outside the Simulation Zone. In the **Object Info Node** switch **Original** to **Relative.** Connect the **Location Socket** of the Object Info Node to the **Translation Socket** of the Transform Geometry Node.

Figure 1.23

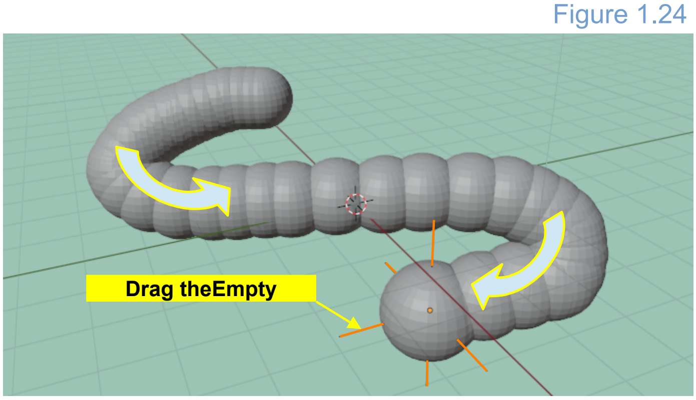
In the 3D Viewport the UV Sphere locates at the position of the Empty Object.

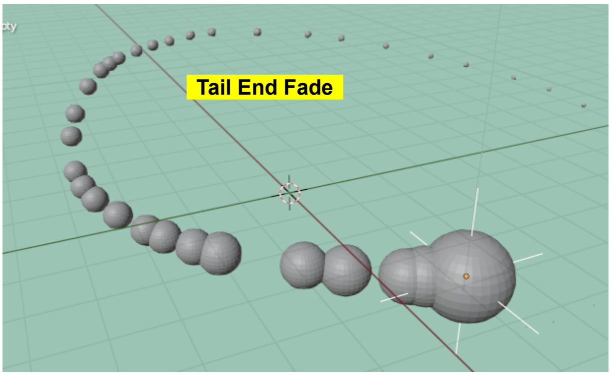




At this point the location of the UV Sphere in the 3D Viewport is controlled by the Empty Object. Have the Empty selected. Press the Play button in the Timeline Editor Header and Drag the Empty in the 3D Viewport.

Figure 1.24





Note: Reducing the **Scale** value in the **Scale Element Node** will cause the tail end display to fade more quickly Figure 1.25.

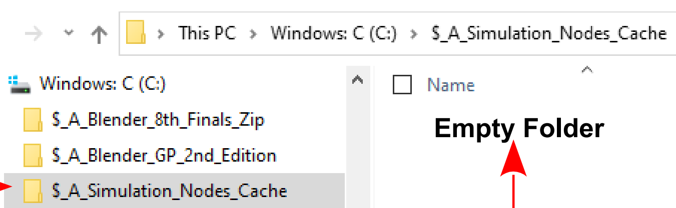
Note: The Simulation is Not Baked (saved) to the Cache.

Its time to explain Baking.

Figure 1.25

Baking Simulation Data

To Bake Data, create a Folder in which to save the Data. Figure 1.26



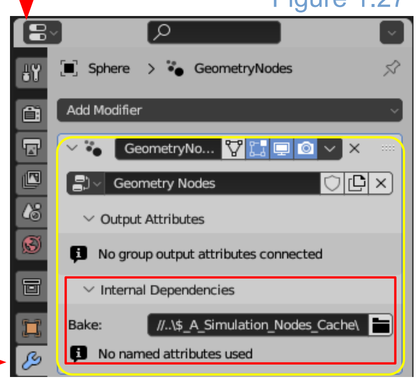
Folder created in the C: Drive of a Windows PC.

Instruct Blender where to save the Bake.

When a Geometry Node Pipeline is introduced for the UV Sphere Object in the 3D Viewport Editor a **Geometry Node Modifier** is automatically added in the **Properties Editor, Modifier Properties**.

Properties Editor

Figure 1.27



In the Modifier Panel expand the **Internal Dependencies Tab** to display **Bake**.

Click the Folder Icon at the end of the black Bake panel to open **Blender File View.** Navigate to the Folder you have created to store your Bake Data and click **Accept.**

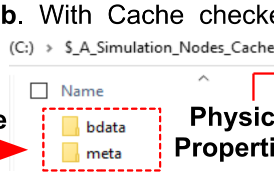
Clicking Accept enters the File Path to your Bake Data Folder.

Modifier Properties

Having set the File Path to the Bake Folder you can Bake the Data.

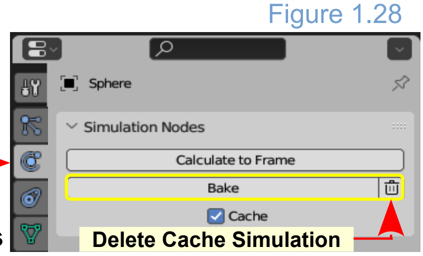
Figure 1.28

To Bake Data go to the **Properties Editor, Physics Properties** and expand the **Simulation Nodes Tab**. With Cache checked click the Bake button.



Data Baked to the Bake Folder

Physics Properties



To delete the Baked Data click the **Bin Icon** at the end of the Bake Button. Be warned, deleting the Cache Simulation deletes the entire Folder you created for saving the Cache. To Re-Bake after running another Simulation you have to create a new Folder.

Return to the Array

In the forgoing the discussion has digressed from the Array explaining the application of the Simulation Zone with respect to Objects.

Remember; Geometry / Simulation Nodes are not intended to shape objects for modeling but to position and shape Objects, providing points for an **Array**. With an Array created it's dynamic display in the 3D Viewport may be controlled via the Simulation Zone.

Figure1.29 shows the Node Arrangement for generating the Array previously created in Figure 1.6 when a Simulation Zone is employed.

Figure 1.29

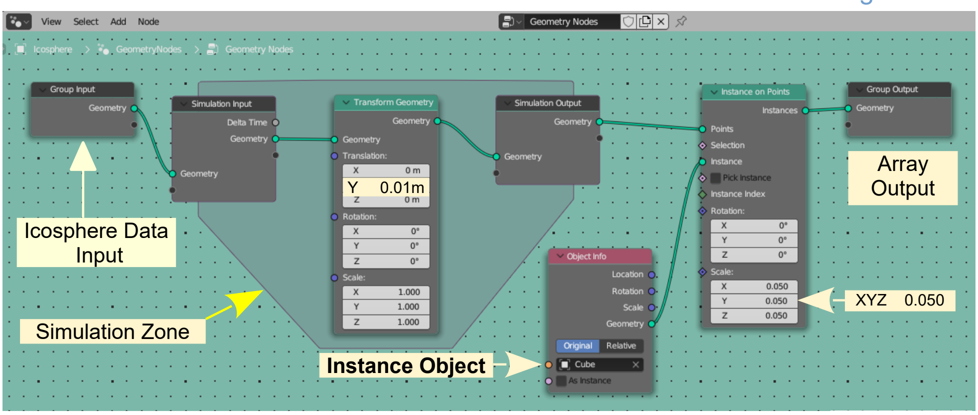
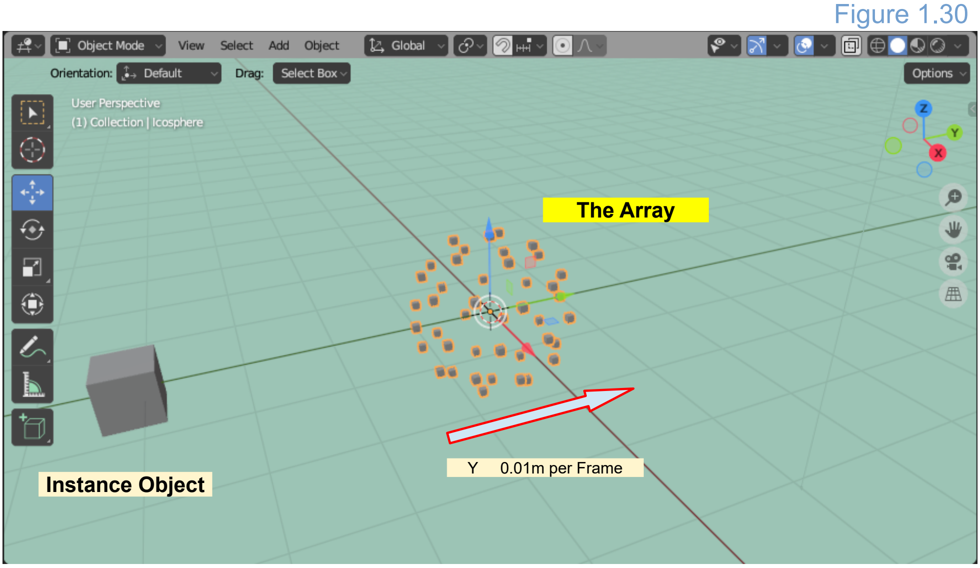


Figure 1.30



You will observe that the **Instance on Points** is applied, following and external to the Simulation Zone. Playing the Animation in the Timeline Editor sees the Array in the 3D Viewport move along the Y Axis of the Scene.

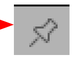
Reassigning the Node Tree

A **Node Tree** which has been designed to affect one Object may be assigned to affect a different Object.

For example the Node Tree in Figure 1.22 which affects the UV Sphere can be reassigned to affect a Plane Object.

To reassign a Node Tree it is advisable to name the Tree as something meaningful to the effect being produced. In this case; **Fade Out**.

With the UV Sphere selected in the 3D Viewport and the Node Tree **Pinned** rename the Tree in the Geometry Node Editor Header.



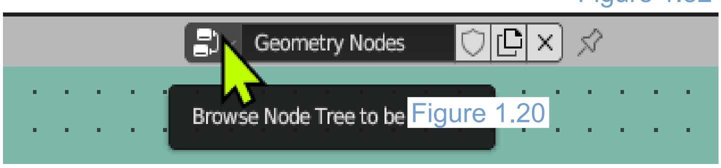
Unpinned (Not) Pinned

Figure 1.31

In the 3D Viewport, deselect the UV Sphere and select the Plane. The display in the Geometry Node Editor disappears and only the New Button shows in the Header.

Click the **New Button** to create a default Node Tree for the Plane. The Node tree is named **Geometry Nodes**.

Figure 1.32



Click the **Browse Node Tree to be Linked** button and select (click on) **Fade Out**.

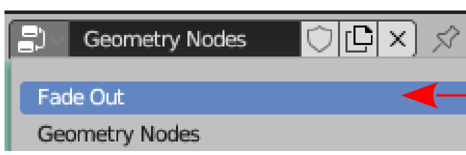


Figure 1.33

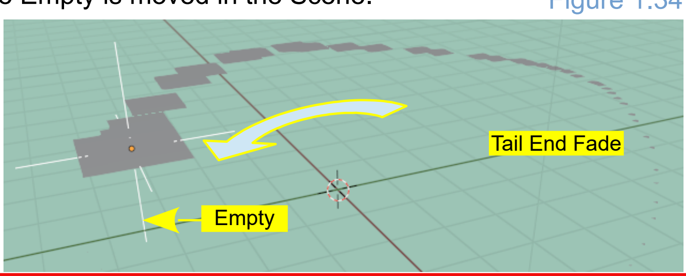
The Node Tree you named.

The **Node Tree** named **Fade Out** displays in the Geometry Node Editor and is assigned to the Plane Object **BUT, the Plane disappears from the 3D Viewport**.

In the 3D Viewport, delete the UV Sphere leaving only the Empty Object.

Remember; The **Empty Object** controls the position of the assigned Object when the Animation is played in the Timeline Editor. Select the Empty in the 3D Viewport, press the G Key (Grab). Play the Animation and drag the Empty by moving the Mouse. The Plane Object reappears attached to the Empty with tail end Frames fading as the Empty is moved in the Scene.

Figure 1.34

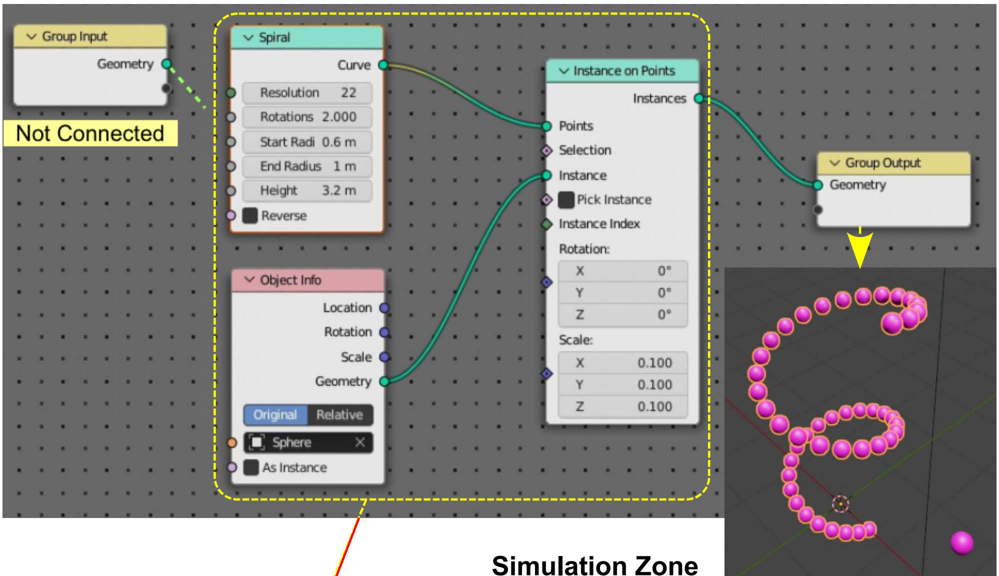


in the forgoing, controlling an Object’s Translation and Transformation and the transferring of a Node Arrangement to a different Object have been the topics with detail on the operation of specifics such as Pinning and Baking.

By including a Simulation Zone in a Node Tree which has created a static display an Animation may be generated.

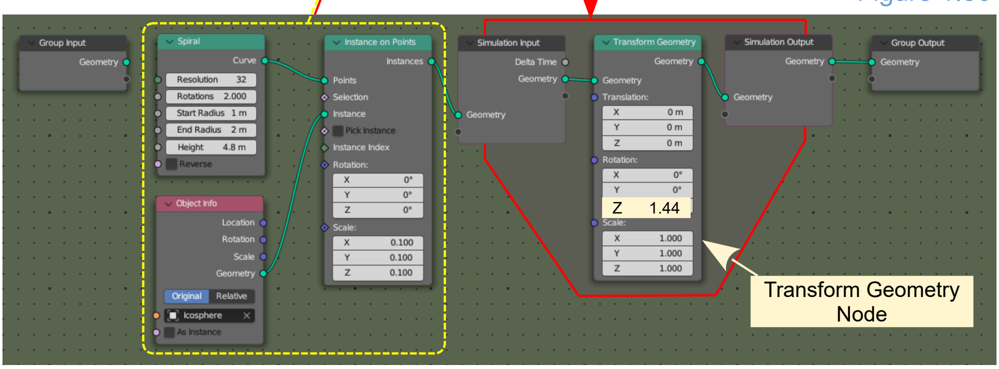
As an example, the simple array generated in Geometry Nodes 15.0 Spiral (Figure 15.1) can be animated to Rotate.

Figure 1.35



Simulation Zone

Figure 1.36



By adding a Simulation Zone encapsulating a Transform Geometry Node to the Node Tree shown in Figure 1.36 and setting the Z Axis value in the Transform Geometry Node to 1.44 the Spiral Array will rotate when the Animation is played in the Timeline Editor.

$$360° \div 250 \text{ Frames} = 1.44$$

The default Animation Length is 250 Frames. Setting the Z Axis Rotation at 1.44 produces a continuous Rotation.

With this fundamental knowledge it is hoped that a study of tutorials on the internet will be more easily understood. By following examples which demonstrate specific effects you will build a library of detailed information on how Nodes are assembled to generate similar effects.