5. HW 0 : Pendulum Simulation

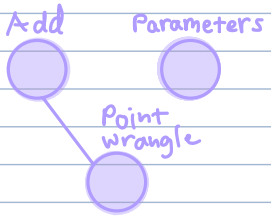
(1) How do we simulate a pendulum in Houdini? Provide all the steps.

(i) Geometry

(ii) Add (point)

(iii) Null (parameters)

(iv) Point Wrangle (state)



(1) (i) create "Geometry" node and step inside it.

(ii) Create "Add" node. In the "Parameter Editor" (P.E.) window, add one point. This places a point at the origin.

(iii) Create "Null" node. In P.E. window, click "Gear" icon and choose "Edit Parameter Interface". Choose "Float" from left column and click right arrow 3 times to add 3 new parameters.

First parameter
- Name : theta0
- Label : initial angle
- Range : -3.14 : 3.14

Second parameter
- Name : v0
- Label : initial velocity
- Range : -1 : 1

Third parameter
- Name : dt
- Label : time step
- Range : 0 : 1

Rename the node "Parameters".

(iv) Add "Point Wrangle" node and connect it to "Add" node. We'll use the point in "Add" to represent the state as follows.

Introduce new attributes by adding the following code to Point Wrangle node's VExpression editor window.

```
f@theta = ch("../Parameters/theta0");
f@v = ch("../Parameters/v0");
f@dt = ch("../Parameters/dt");
```

$\frac{\theta - \theta_{prev}}{\Delta t} = v$

↳

```
f@theta_prev = @theta - @dt * @v;
```

To ensure that the parameters are "channelled", open a Geometry spreadsheet (with the "Point Wrangle" node open). Then, click the "Pin" icon in the upper right to pin the spreadsheet. Then, select the "Parameters" node and adjust the parameter values to verify that the values in the Geometry Spreadsheet get updated. Be sure to unpin the Geometry spreadsheet before moving on to the next step.

(v) Tube (rod)

(v) Create "Tube" node. Choose Primitive Type to be "Polygon". Choose Scale = 0.006, center = (0,-0.5,0).

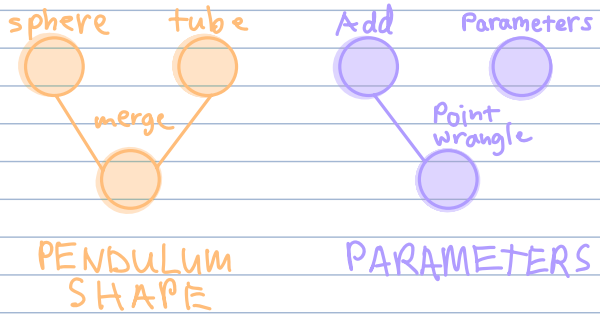
(vi) Sphere (mass)

(vi) Add "Sphere" node. Choose "Polygon" for Primitive Type. Choose Frequency = 10, Uniform Scale = 0.05, Center = (0,-1,0)

(vii) Merge (pendulum)

(vii) Add "Merge" node. Connect Sphere and Tube to Merge.

This is what we have so far:



(viii) Copy to Points (transform pendulum)

(viii) Create "copy to Points" node. Connect Merge and Point Wrangle to this new node in order to copy the pendulum geometry to wherever the point is.

(ix) Point Wrangle # 2 (rotate pendulum)

(ix) Give the pendulum geometry a proper orientation after it's transformed to the point. To do this, add a "Point Wrangle # 2" node in between the "Copy to Points" and "Point wrangle" nodes. Add a quaternion to the VEXpression as follows:

```
p@orient = quaternion(f@theta, {0,0,1})
```

(f@theta: angle; {0,0,1}: axis)

(x) Solver (animate pendulum)

(x) Finally, we animate the pendulum motion by changing theta according to some time-stepping update. To see RK4 implementation, go to timestamp [1:48:50] in Lecture 1 recording.

To do this, we add a "solver" node in between the two point wrangle nodes.

(x) Solver contin...

- point wrangle

Dive into the Solver and connect Prev_frame to a "Point Wrangle" node. Add your time-stepping scheme in this node.

You can lower dt in the "Parameters" node to make the animation slower. A value of dt = 0.1 looks pretty realistic. Note: the exported video will run a bit faster than that.

This is the final product: