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Homework 3 Part C: Melting (and by extension, Viscosity)

The Effect

Melting is a natural phenomena in which a solid changes into a liquid at a fixed temperature, or melting point. It requires a certain amount of heat in order to occur. The reverse of this is called freezing, when a liquid becomes solid. In terms of physics and thermodynamics, a liquid has more energy and instability than a solid, and it occupies a larger volume than a solid.

Liquids have a number of characteristics and properties that describe themselves. They are fluid, meaning that they can flow and take the shape of its container, are incompressible, and will diffuse and mix with other liquids when put into the same container. Another characteristic is viscosity. Viscosity is a liquid's resistance to flow; honey and syrup have high viscosity, meaning that they will flow out very fast, while water has a low viscosity and is quite fluid.

Water melting

Ice cream melting

Implementation

I feel that melting is a good phenomena to study through shaders. If we think about real life through 3d objects, a solid is a static, unchanging mesh that is highly subdivided. At a certain temperature, or the melting point, the mesh slowly starts to "melt." The vertices of the object slowly flow down and outwards, just like the picture above. But the amount of vertices that flow away from object will ultimately depend on the viscosity of the substance.

In terms of GLSL shaders, most of the calculations will be done in the vertex shader. We will have to focus careful on vertex displacement and provide external variables to the shaders, like time, temperature, and viscosity. I imagine that a difficult part of the calculations will come from which parts of the mesh will flow change into liquid faster. Just like how ice cream melts, melting is rarely uniform; the whole mesh does not become liquid at the same time. If we use an irregular mesh like a bird or a rabbit, parts of the mesh will fall and flow faster than other parts. Another difficult problem will be the smooth deformation of the object. A solid will hold its form and structure, but a liquid, by definition, has no shape. Thus, if a portion of the mesh melts faster than its other parts, like a head of a bird that has melted down onto the floor, I will have to make sure that there aren't weird distortions, like a hanging vertice that is still in the air while its neighboring vertices are melted below it.

Putting down my thoughts here, I believe that these are the steps and pseudocode I would take to making a melting shader:

1.Make a melting point happen at an adequate temperature/variable value

2.Slowly displace all vertices downwards. More so based on a texture or map.
3. If a vertice is below a certain height, slowly spread it outwards
    -By outwards, I mean taking the vector of the object origin and its xz position in the world and go in that direction.
4. Smoothstep the positions of all liquified vertices.
5. Dampen the vertices' outward movement from its origin based on the viscosity.

If the object is in a container, I would set the maximum position that a vertice can move to those boundaries.

The fragment shader will most likely be used to color which parts of the mesh are liquid and solid. I will also probably try to use fresnel for a cooler looking substance.