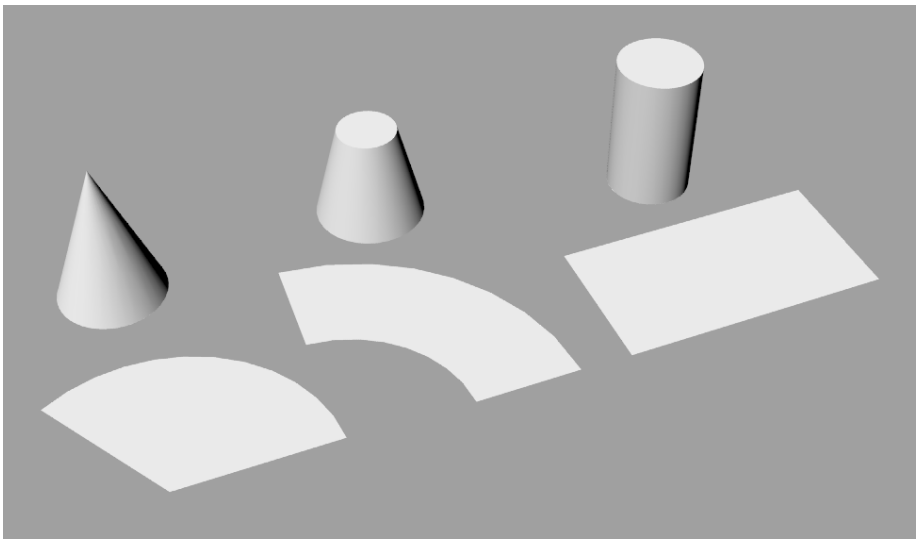
Why Some Surfaces Do Not Unroll

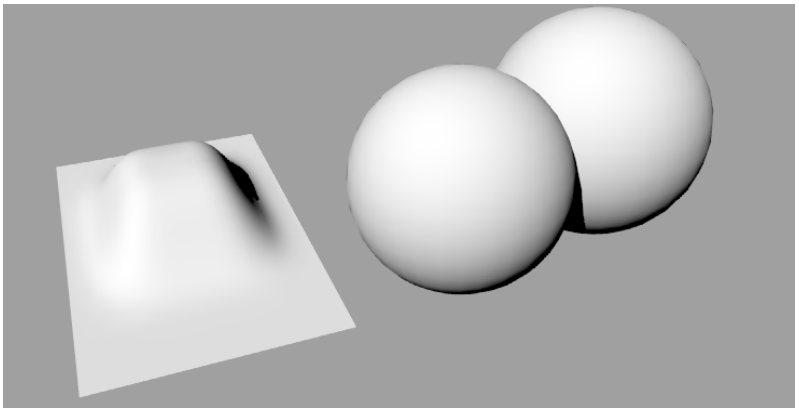
The goal of many designers is to obtain flattened, two-dimensional patterns from their three-dimensional designs. The three-dimensional surfaces are analyzed using Gaussian curvature analysis and classified into two types of surfaces: developable and non-developable.

Developable surfaces can be flattened using exact solutions. These are surfaces like cones, truncated cones, and cylinders.



Unrolled cone, truncated cone, and cylinder surfaces.

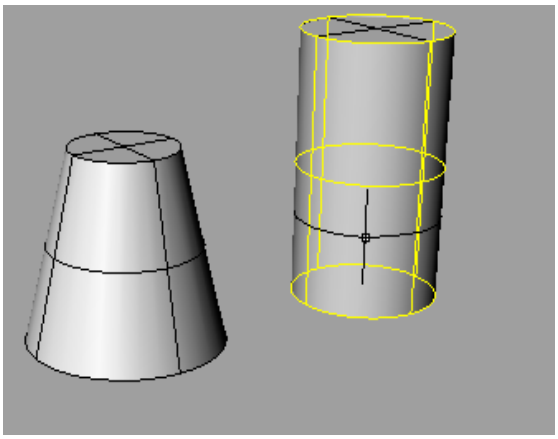
Spheres and other surfaces, that have compound curvature, cannot be unfolded or "developed" accurately without knowing something about the characteristics of the material (amount of stretch available and more.)



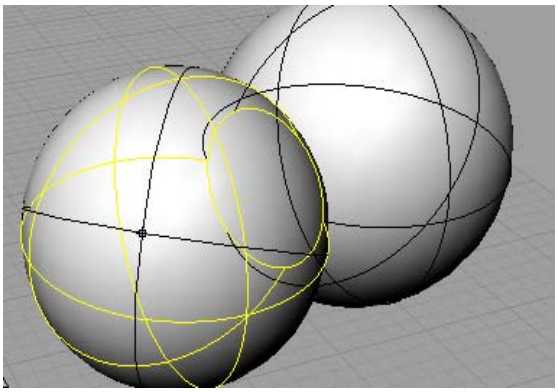
Non-developable Surfaces

Non-developable surfaces have compound curvature, that is, curvature in two directions, not just one. Flattening or developing these surfaces requires stretching or shrinking of the material used.

The Rhino ***Curvature*** command will show the curvature curve as you move your cursor over the surface. The non-developable surface show the curvature with two arcs, to illustrate the compound curvature. Developable surfaces will show curvature with a single arc and a line, illustrating the curvature in a single direction.



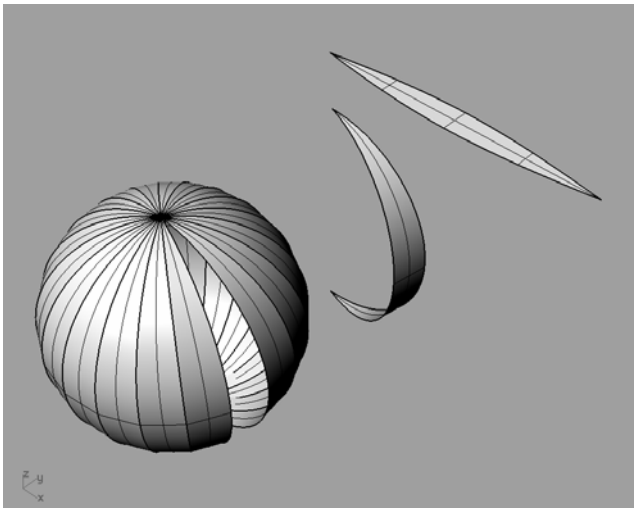
Curvature circle of a developable cylinder.



Curvature circles of a non-developable sphere.

The unrolling or flattening of non-developable surfaces is based on complex transformation matrices that factor in material characteristics and transform the surface on to the XY plane as a two-dimensional boundary. The material's characteristics help determine stretch that material will experience to produce the shape.

It is helpful to imagine cutting and folding paper. A developable surface can be folded or rolled from a sheet of paper. Clearly, a sphere does not fit that criterion. A sphere of sorts can be constructed from a series of developable panels and can be developed panel by panel, but of course it will not be a true sphere, but an approximation. In short, if a surface can be constructed with paper, then it is determined to be developable and Rhino should be able to unroll it. If you need a sheet of rubber to make the 3d shape, then it is non-developable and Rhino's UnrollSrf command will not unroll it.

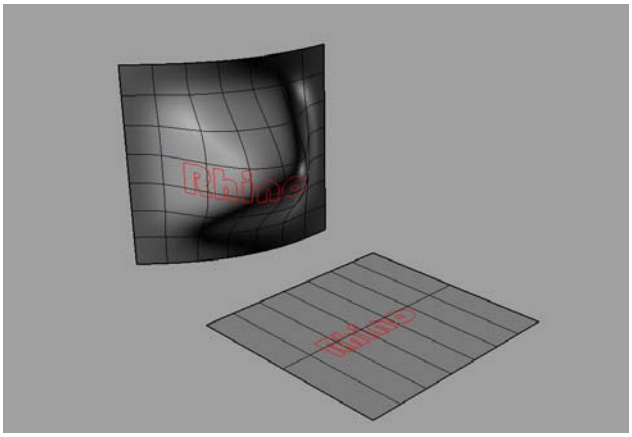


A sphere made from developable panels

Rhino 4 added the Smash command. Smash makes an approximate 2-D development of surfaces that have compound curvature. This command can be used to deal with fabrics that have a certain amount of flexibility and stretch.

The Smash command is a modified version of the UnrollSrf command. With UnrollSrf, the surface has to be linear in one direction to unroll, and with the Smash command it does not.

Since it is not possible to flatten a double-curved object (like a half a coconut shell) to get a paper pattern, the answer is always inaccurate to some degree. This command is useful if the object you are flattening is not extremely curved and you want to make the pattern out of a stretchy material like rubber.



Smashed surface and curves

There are specialized programs that flatten non-developable surface.

One product is Mesh Flatten for Rhino which gives Rhino the ability to unroll the selected mesh model.
http://www.resurf.cn/products.htm

Another is a prototype of the Advanced Flattening Tools add-on for Rhino 4.
http://en.wiki.mcneel.com/default.aspx/McNeel/AdvancedFlattening.html