Textiles and the Body: The Geometry of Clothing

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In 1868 the Italian mathematician Beltrami had described a surface called a pseudosphere, which is the hyperbolic equivalent of a cone. He actually made a version of his model by taping together long skinny triangles - the same principle behind the flared gored skirts some folk dancers wear.

Margaret Wertheim, "Crocheting the Hyperbolic Plane: An Interview with David Henderson and Daina Taimina," *Cabinet*, issue 16, Winter 2004.

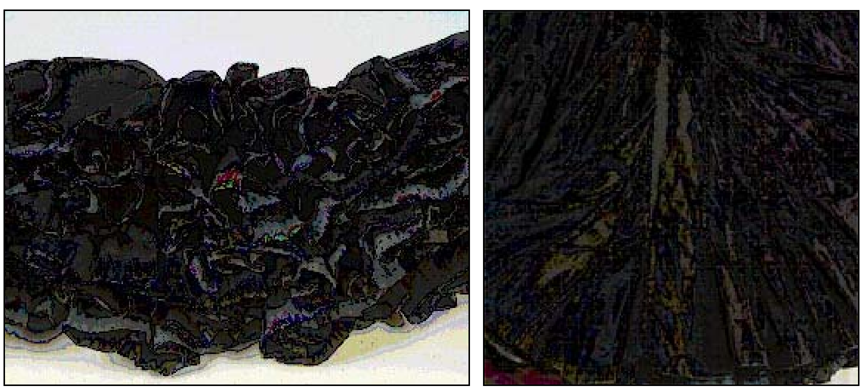
Figure 1. Jumlo*, dress, from Nuristan. Rhode Island School of Design, Museum of Art.*

Physics and mathematics are not usually perceived as being closely connected with textile and clothing design or construction, either by scientists or by artists. Those who make clothing from cloth, however, must always take into account two geometries: the plane geometry of the cloth and the solid geometry of the body. In order to clothe the body we begin with cloth. Woven, knitted, knotted, or otherwise constructed, the inherent structure of cloth reflects mathematical principles. Interlaced threads create square or triangular grids, techniques such as knitting or crocheting can make grids of any shape, from triangular to polyhedral.

Those who make clothing transform flat fabric planes into three-dimensional forms through a variety of means. A single plane figure—such as a square, rectangle, or circle—can be used to create a garment without cutting or tailoring. Simple modifications are all that is required to fit a length of cloth around the body. The sari and the kilt, for example, use pleating, gathering, tucking, and tying to make the flat plane follow the contours of the three-dimensional body form. Cut and sewn clothing can also follow those principles. A single plane figure can become a garment through the medium of a single seam, as in the tubular sarong. Some designers have utilized these simple forms to great effect. Claire McCardell made an evening gown whose skirt is simply two rectangles seamed together, at the sides, and along the top edge for about one third of the way from each edge. The open portion is then gathered to the waistband, and the points are

left to hang and drape in ripples at the side seams.[1] Halston plated with the time-honored sarong effect in some of his designs, wrapping and tying a tube of supple silk charmeuse over the bust to create another striking evening dress. More interesting in terms of construction is the caftan he created by origami-like folding of a narrow textile length into an almost square robe, which still exploits the drape of the bias to mold the body.[2]

Combining planar elements through complex cutting and seaming is yet another way to create a garment. A Nuristani *jumlo* or dress (fig. 1) in the Costume & Textile collection at the RISD Museum is a fascinating example of how a seamstress can modify a flat cloth plane to become what is essentially a model of hyperbolic space (fig. 2). The body rectangle, folded at the shoulders and slit to make the neck opening, is sliced into strips from the hem to about chest level, and then triangles are inserted into each slit. Then the triangles are slit, with smaller triangles inserted into those slits, and so on until the flat cloth plane turns in and around on itself (fig. 3). It is a common method of adding width and shape to the hem of a garment while keeping the upper portion narrow. Madeleine Vionnet used the same idea in one of her evening dresses, although she cut the bottoms of her strips into points, which acted in the finished garment to feature the flared gores or godets even more.[3] In 1997 Cornell University mathematician Daina Taimina began crocheting seamless physical models of hyperbolic space, which mathematicians considered a great improvement over taped together paper models—if only they had known about the jumlo. Single element techniques such as knitting and crocheting, of course, allow the formation of many complex geometric forms - not only models of hyperbolic space - without seams.



Figures 2 (left) and 3 (right). Details of jumlo *in figure 1.*

A huge database hosted by St. Andrews University in Scotland, of mathematically derived, named, curves, was another exciting find.[4] While these named curves are not necessarily exact matches for pattern pieces, there is enough similarity to encourage the mathematical exploration of the relationships. For example, Halston sewed circular shapes together to create volumetric dresses, with the resulting pattern pieces resembling the *Cartesian Oval* in the named curve index.[5] The Folium curve is strikingly like the petal-shaped skirt panels in a Vionnet dress from

[1] Kohle Yohannon and Nancy Nolf. *Claire McCardell: Redefining Modernism*. New York: Harry N. Abrams, Inc. 1998. Illustrated p. 84-85.
[2] Elaine Gross and Fred Rottman. *Halston: An American Original*. New York: Harper Collins, 1999. Illustrations pp. 115, 119. For additional examples of Halston's intuitive geometry, see pp. 116, 118.
[3] Betty Kirke. *Madeleine Vionnet*. San Francisco: Chronicle Books, 1998. p. 147.
[4] Access the web site at: http://www-groups.dcs.st-andrews.ac.uk/~history/Curves/Curves.html.
[5] Gross, *Halston*, pp. 124-125. Issey Miyake has also used this shape.

1921.[6] The *Bicorn* curve not only illustrates a Napoleonic era men's hat but a variety of necklines, and the opened out side seams of a Bonnie Cashin coat in the RISD Museum's collection parallel one of the curves seen in *Newton's Diverging Parabola*. Designs by Charles James, Cristobal Balenciaga, and Rudi Gernreich are also particularly interesting when viewed with the Curves index at hand.

In the past year or so I've become more aware of the applications of what I've come to think of as the geometry of "between" – the spaces between the threads in woven cloth – to contemporary applications such as digital animation and video games. Computer modellers seem to be hung up on the expansion of cloth over the body, and treat it as somehow elastic, like knitted fabric, with the spaces between the threads expanding and contracting over the round form of the body. What they seem to be forgetting, or are unable to imitate, is the deformation of the cloth, the translation of the square tilted on one point into the diamond with two elongated sides, and multiple ripples.[7]

Elastic theory and hyperbolic geometry must both be taken into account in the interaction of cloth and clothing. Whether a garment follows the contours of the body or imposes a shell upon the body without regard to the human substructure, mathematics and geometry are at work.

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[6] Janet Arnold. *Patterns of Fashion 2: Englishwomen's Dresses and their Construction, c. 1860-1940*. New York: Drama Books Specialists, 1980. pp. 74-75.

[7] See for example the illustrations in: Jeff Lander. "Devil in the Blue-Faceted Dress: Real-Time Cloth Animation." *Gamasutra*. (March 27, 2000). URL:http://www.gamasutra.com/features/20000327/lander_01.htm and: Haeyoung Lee, Viying Tong, and Mathieu Desbrun. "Geodesics-Based one-to-One Parameterization of 3D Triangle Meshes." *IEEE Multimedia Journal*, volume 12, issue 1, (January-March 2005), pp. 27-33. URL:http://www.geometry.caltech.edu/pubs/LTD05.pdf and: Mark Meyer, Gilles Debunne, Mathieu Desbrun, and Alan H. Barr, "Interactive Animation of Cloth-like Objects in Virtual Reality." *The Journal of Visualization and Computer Animation*. Volume 12, Issue 1, (May 2001), pp. 1-12. URL:http://www.geometry.caltech.edu/pubs/MDDB01.pdf.