The first USA Science and Engineering Festival was a call by President Obama to invite the nation to the National Mall in Washington, D.C. for a celebration of science and engineering achievements and their contributions to our society. For two beautiful sunny days, Saturday and Sunday, October 23–24, 2010, thousands of people attended the festival at the National Mall and enjoyed talking to scientists and engineers to learn about their new inventions and discoveries. People of all ages played with scientific toys and machines, and participated in interesting and exciting activities presented in hundreds of booths located all over the Mall.

Mathematicians appeared in this national celebration by presenting mathematical ideas and activities at several booths, including ones for the AMS and the Mathematical Association of America (MAA). The award-winning mathematics writer Ivars Peterson, director of publications and communications at the MAA, was among the hosts in the MAA booth. One gift from the MAA booth was a folded one-sheet booklet, “A Field Guide to Math on the National Mall”, highlighting mathematical aspects of some interesting sites in the Washington, D.C., area.

The sculptor, mathematician, and computer scientist George Hart led a public sculpture barn-raising of his latest work, Gyrangle (Figure 1), at the AMS booth. The 38-inch-high sculpture consists of hundreds of laser-cut steel units bolted together in a novel way. To be exact, there are 490 flat or folded hollow equilateral triangles in four colors. It illustrates a discrete version of the gyroid surface, made entirely from equilateral triangles.

The gyroid is a smooth, infinite, triply periodic, minimal surface discovered by Alan Schoen in 1970. Channels run through it in many directions and connect at an angle to other channels. The direction of connection travels in a spiral along each tunnel, giving rise to the name “gyroid”. Figure 2, downloaded from Wikipedia, illustrates a cubical portion of the infinite gyroid surface.

The gyroid is a smooth surface, but Hart discovered a way to triangulate it entirely with equilateral triangles. Both the faces and vertices in the construction exhibit a property known as uniformity.

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Figure 1. Gyrangle.

Figure 2. Gyroid surface.
Although the gyroid itself contains no straight lines, Hart’s triangular discretization contains infinite straight lines embedded in various directions. It divides all space into two congruent but mirror-image volumes. Another interesting property is that the faces do not meet edge-to-edge, but instead each triangle shares six half-edges with six neighboring triangles. The construction is previously unpublished, so the sculpture serves as the first presentation of this discovery. As it illustrates a gyroid made of triangles, Hart coined the term Gyrangle for it.

The full infinite surface would be visually repetitive (and infinitely large) so is not itself suitable for a sculpture. Instead, Hart chose a tetrahedral portion of space as the outer form of the sculpture and inhabited it with the Gyrangle surface as a kind of three-dimensional texture. To seal off the edges he introduced a folded triangle unit that closes off the boundary. For visual and mathematical interest, the 100 pounds of laser-cut steel triangles are painted in four colors according to the directions of their normal vectors. It is one of a series of many sculptures Hart has created for assembly at “sculpture barn-raising” events. He prepares the components and invites the public to participate in the construction.

During this barn-raising at the Mall, Hart helped hundreds of children and adults screw pieces together. At the same time, he continuously answered questions about the mathematics, computer science algorithms, and fabrication aspects of the design. The AMS representatives at the booth were Annette Emerson and Mike Breen (see the photo at right in Figure 3). They patiently helped children successfully fasten screws and connect pieces together, while also answering their very interesting but occasionally difficult questions, such as “Why are we making this thing?” and “What is it used for?” The public often sees mathematics only as something useful, but here the goal was to show another aspect of mathematics: mathematics is beautiful!

Mathematical sculpture is a rich area of visual art that is approached in various ways. Some sculptors have no formal background in mathematics, yet their artworks present patterns or structures that make sense to mathematicians. On the other hand, there are mathematicians who use techniques from computer science or the arts to visualize abstract mathematical forms. This gives the public an opportunity to “see” mathematical properties that were previously accessible only to specialized mathematicians. In either approach, sculpture may present harmony and balance in a new way and bring an appreciation of mathematics to the public, in a way similar to how we enjoy music and feel its importance in our lives.

The AMS financially supported the construction of this unique piece of mathematical art and donated it to the Department of Mathematics at Towson University, Towson, Maryland. The department is known for educational activities concerning mathematical connections to the arts and culture. The president of the Bridges Organization, the author, is a faculty member of this department. The Bridges Organization is a nonprofit organization, which runs the international Bridges conferences on mathematical connections in art, music, and science [http://www.BridgesMathArt.org]; see “Bridges Pécs 2010”, by Paul Gallinunas, Notices, February 2011, pages 289–290. These annual conferences, held in various locations around the world, attract faculty members from mathematics and science, as well as from the arts, communications, and music. Hart is on the board of directors of the Bridges Organization.

Hart’s sculptures are recognized around the world for their mathematical depth and creative use of materials. He is a pioneer in using computer technology and solid free-form fabrication to create sculptures. Examples of his artwork can be seen at major universities, such as the Massachusetts Institute of Technology, the University of South Carolina, and the University of Illinois at Chicago. The AMS representatives at the booth were Annette Emerson and Mike Breen.
Institute of Technology, the University of California at Berkeley, and Princeton University. After having served as a faculty member at Columbia University and Stony Brook University, Hart is now chief of content at the Museum of Mathematics, which will open in New York City in 2012.

After two days of hard work to assemble Gyrange at the Mall, only two-thirds of the construction was completed. The partly finished sculpture was transported to Towson University, where faculty and students helped to complete it (Figure 4). The sculpture graces the glass lobby of the Department of Mathematics (Figure 5).

Thank you, George Hart and the American Mathematical Society, for your great gift to Towson University!