National Museum of Mathematics
Laser Shapes Student Design Challenge

Win $1,000 by designing a new generation of geometric learning aids for America's only Museum of Mathematics

About the challenge

Based in New York City, the National Museum of Mathematics (MoMath) is the only museum in America dedicated to sharing the joy of mathematics with visitors of all ages through over 40 engaging and interactive exhibits. One visitor favorite exhibit, the *Wall of Fire*, demonstrates cross sections of three-dimensional geometric solids by shining lasers through translucent versions of these shapes. The solids are made of durable plastic and must strike exactly the right balance of light transmission and diffusion to achieve the visual effect.

With over 150,000 visitors a year interacting with the exhibit and with its traveling version, the *Ring of Fire*, the plastic shapes need periodic replacement. The current method of manufacturing the shapes is inefficient and costly, and we are are looking for a new design which will be easier to manufacture without compromising durability or the visual effect.

We would also like to develop a portable version of the exhibit for use in schools across the country. This will require much smaller solids that are cheaper to produce in larger quantities (several hundreds or thousands) but that again do not compromise the visual effect.

And this is where you come in. We're opening up the design process and issuing a challenge to design and engineering students: can you design a better set of solids? If so, you could win a $1,000 prize, a custom trophy, and the glory of seeing your design used in a real-life exhibit used by hundreds of people every day.

The challenge is open to individuals or teams who are registered students at any academic institution in the United States. The deadline for entries is April 30, 2020, so don't delay: form your team, read the rest of this document for more details, and start working on your winning design...

How to enter

You may enter a design for the large shapes (exhibit version), small shapes (school kit version), or both. If two different teams design the winning small and large versions, we will award a $500 prize to each.

Entries must include a detailed description, with drawings if necessary, of the design for all of the required solids. Entries must also include a physical prototype of at least one solid for each type of solid (large/small) in the entry. Your entry must describe the materials used, the proposed manufacturing process, and details of how you achieve the visual cross-section effect. Entries should include the names of all team members, your institutional affiliation, and a contact email address and telephone number.

Email your entry, including photographs of any prototypes, to lasershapes@momath.org by 5:00 pm EST on April 30, 2020. Do not send in your physical prototypes; we will contact finalists and request the physical prototypes for evaluation as needed. Send in photographs of any prototypes, preferably demonstrating them illuminated by a laser light source (cheap laser line generators for testing can be found online).

Requirements: large shapes (exhibit version)

There are five solids in use: a cube, tetrahedron, cone, dodecahedron and cylinder. For a dimensioned drawing of each of these shapes, see Annex A.

The existing shapes are constructed out of 5-mm or 6-mm polycarbonate, but you may propose any suitable material that is durable enough to withstand long-term use in a busy public setting without breaking, cracking, or developing significant scratches that impede the visual effect.

The optical properties of the solids are critical to the successful operation of the exhibit. Attaining the desired characteristics may be the most challenging aspect of fabricating the solids. It is essential that the illuminated cross section formed when the laser beam intersects the object be a complete, crisp, well-focused line covering the entire perimeter of the cross section, as illustrated in the photograph on the first page. How you achieve the optical effect is up to you: it may be any combination of material choice, manufacturing techniques, and/or surface treatment.

Note that although both the *Ring* and *Wall of Fire* have lasers shining inwards from all directions, it is not acceptable to rely on 360º laser coverage to

achieve full-perimeter illumination, as sections of the laser 'curtain' may be occluded by participant's arms or (in the case of the *Wall of Fire*) their entire bodies. It is essential that there be the correct balance of reflection and transmission of the laser beam to ensure that the full perimeter is visible even if the shape is illuminated by only a single laser source (note that all laser sources have a line-generating optical element which produces a line-shaped pattern of light instead of a simple point).

The manufacturing process you propose should be cost effective in small volumes (10-20 copies of each solid).

Requirements: small shapes (school version)

The goal of the classroom version is to provide a smaller, lower-cost kit to replicate the effect the *Ring/Wall of Fire* exhibits in a classroom setting. Compared to the exhibit version, the durability requirements of the classroom version are lower: though they will need to be resilient enough to support hands-on classroom use for many years, the shapes for the classroom version will not be subjected to the same level of wear and tear as the exhibit shapes.

The classroom version should use the same five shapes as the exhibit version (cube, tetrahedron, cone, dodecahedron, and cylinder). They must have the same basic optical properties as the exhibit version solids, i.e. they should show a clear, full-perimeter cross section when illuminated with a laser. We expect the classroom kit to include a single laser with a line-generating optical element and a stand. At present we expect that the laser will be red as in the exhibit, but if the proposed optical treatment is particularly effective for a different wavelength of light, you may indicate a preference for an alternative color laser light source (e.g. green). Dimensions should be appropriate for a classroom setting; as a guideline you can plan on a cube with a side length of 75-100 mm, with other shapes scaled appropriately to match.

The manufacturing process you propose should be cost effective in volumes of hundreds to low thousands of copies of each solid.

Contacting us

If you have any questions or need any clarification of the requirements, you may contact lasershapes@momath.org before the entry deadline. Please allow up to five business days for a response.

The fine print

- The Museum reserves the right not to award any prizes if no entries of a suitable standard are received.
- By submitting an entry, you certify that the design is the original work of the named entrant(s) and is free of any intellectual property or other encumbrances, and you acknowledge that all entry materials, including designs and physical prototypes, become the property of the Museum upon submission.
- Winning entrants agree to allow the Museum to use their names and photographs in any publicity material relating to the challenge and/or the exhibits.