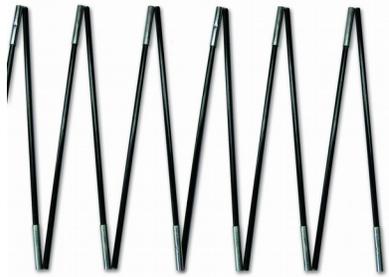


Parts List and Instructions for Gravitational Well Vortex Demonstration

David H. Bradstreet, LIPS 2016

1. tent poles

- a. **Stansport Replacement Shock Corded Fiberglass Tent Poles** for 722-200 and 723-200 Tents, (2 included, each 185-inches long) - \$24.53
- b. https://www.amazon.com/gp/product/B00DFZYX9G/ref=oh_aui_detailpage_o02_s00?ie=UTF8&psc=1



c.

2. tent pole splints (2)

- a. **Gear Aid Tent Pole Splint (0.5 inch diameter)** – order 2 at \$5.54 each
- b. https://www.amazon.com/Gear-Aid-Tent-Pole-Splint/dp/B00BH7BAKE/ref=sr_1_3?s=sporting-goods&ie=UTF8&qid=1471368731&sr=1-3&keywords=tent+pole+splints



c.

3. binder clips

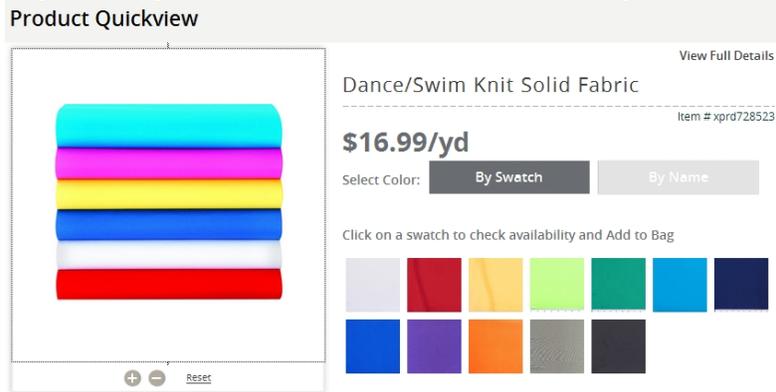
- a. **Staples® Medium Metal Binder Clips, Black, 1 1/4" Size with 5/8" Capacity** – 24 count - \$3.39
- b. http://www.staples.com/Staples-reg-Medium-Metal-Binder-Clips-Black-1-1-4-Size-with-5-8-Capacity/product_831602



c.

4. fabric

- a. 6 yards of polyester/spandex fabric (depends on how large a vortex you wish to create; I needed 6 yards in order to sew to 3-yard pieces together to form a 9 x 10 foot piece of fabric for a 7-foot diameter hoop)
- b. I used 6 yards (comes in 58-inch widths) of **Dance/Swim Knit Solid Fabric** from JoAnn Fabrics. Go online and obtain a coupon. I found a half price coupon (!) which reduced the cost from \$16.99/yard to \$8.50/yard = \$51.00. This fabric is 82% nylon and 18% spandex and works very well. My very talented wife carefully machine-sewed the two pieces together using a **ballpoint** needle (also available at JoAnn's Fabric stores – ask the sales person)
- c. <http://www.joann.com/dance-swim-knit-solids/xprd728523.html>



d.

- 5. 1 kg masses – preferably spherical or cylindrical (borrow from your physics dept.)
 - a. You can use different masses at your discretion to make different mass ratio binary systems, less or more extreme vortices, etc.
- 6. marbles

- a. **Pavilion Games 160 Marbles Bonanza** - \$4.99
- b. <http://www.toysrus.com/product/index.jsp?productId=57984826&cp=&parentPage=search>



c.

Basic Instructions:

The hardest part beyond gathering all the parts is to have someone who knows how to sew well sew the two 3-yard swatches very carefully together so that the seam will be even and not stick up too much. My wife is an expert! She sewed them together first

with a straight stitch and then when back and did a zig-zag stitch to make it even stronger. But you need to end up with roughly a square of material that will more than cover the area of the hoop that you're going to construct. I wanted a 7-foot diameter hoop, and hence I went with the 9 x 10 foot piece since the material came in 58-inch swatches.

For a 7-foot diameter hoop, I needed a circumference of $C = \pi D = (3.14159)(7 \text{ ft}) = 22 \text{ ft}$ circumference. I then cut and retied the elastic strings of the tent poles so that I turned the two 185-inch long poles into two 132-inch long poles = 22 ft. (The poles come in approximately ~11-inch sections so I took off 5 poles from each section – piece of cake!)

Using the two tent splints, carefully insert each end of the two poles into the splints and turn them into a nice circle. The tension of the poles will hold them snugly inside the tent splints.

Next, with two people, roughly clamp the fabric onto the hoop using the binder clamps. We clamped one per metal part of the tent pole sections which roughly equaled one clamp per foot = 22 clamps for the 22-foot circumference. These hold the fabric very tightly. We place the hoop on four table edges about 30 inches high, but you can use whatever you have. Just don't let the edges of your supports intrude too far into the hoop area or your marbles will hit their solid support surfaces.

Next, carefully go around and tighten and reclamp sections of the fabric until it is very snug and flat all around the hoop. This is not as difficult as it may appear, and once you get the hang of it, it takes half the time of your first trial! We actually pressed in slightly on the hoop and stretched the fabric outwards and then clamped which helped make it taut. Just be careful because you can turn the hoop into an ellipse if you make its tension too uneven around the circumference.

You can go on the Internet (YouTube) and find video of people making just this type of demo and also see the various kinds of experiments that you can perform with such an apparatus. Ours takes 20-minutes to setup and we use it in our planetarium dome (the only floor space large enough for us!). It's a LOT cheaper than purchasing a plastic conical surface (~\$100) and with its flexible surface you can do a lot more experimenting with more than one mass.