GRADES 9 AND UP

Argonne NATIONAL LABORATORY

TAME THE PARTICLE
BE A BEAMLINE SCIENTIST
Instruction Sheet

Particle Accelerators and their beams are tools of discovery and innovation. These tools take small bits of matter (particles) and accelerate them at high speeds.

At the Advanced Photo Source, photons are accelerated to over 99% of the speed of light around its ring, which is the size of a baseball field. (Image by Argonne National laboratory)

"Atoms are the building blocks of matter" is probably something you have heard before. You may also remember learning that atoms are made of three types of particles: neutrons, protons, and electrons. But did you know that charging and accelerating a beam of electrons or protons near the speed of light can help us answer some of societies greatest questions, like *"Why did the T-rex have such small arms?"*? Taming" these energetic particles is a delicate balance. Let's see how well you can do it!

ACTIVITY HIGHLIGHTS

- **Watch a short video explaining how particle accelerators work.**
- **Create a model.**
- **Test and improve your model.**
- **Share your model with Argonne Education**

MATERIALS

Make sure you have permission to use the materials from an adult! Follow the procedure below and data table to complete the activity.

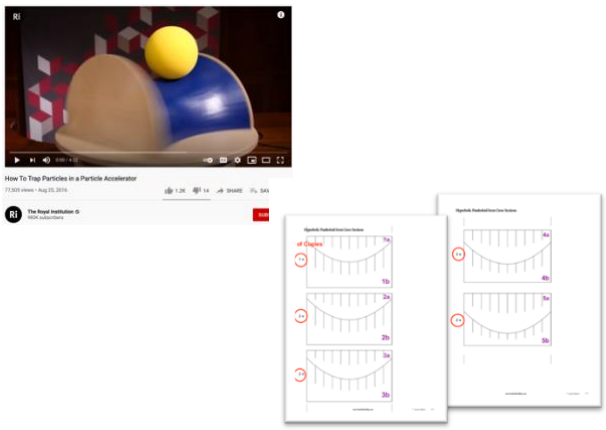
- Thick sturdy paper (cardstock, cardboard from cereal boxes, or poster board)
- Scissors
- Writing utensil
- Lightweight ball such as: ping pong ball, play pit ball, or small Wiffle ball
- Hyperbolic Paraboloid Template: https://www.cutoutfoldup.com/patterns/0972_us.pdf
- Rotating tray
  You can purchase a rotating tray online/store (ex: Lazy-Susan Turntable), use something similar, or **DYI** your own. There are many DYI tutorials online using at home materials. Below are two examples:
  - **Fidget Spinner Rotating Plate:** Fidget Spinner, 2 plastic lids (different sizes), tape or glue (see procedure for assembly instructions)
  - **Cake Pan Rotating Plate:** 2 cake pans, bag of marbles (see procedure for assembly instructions)

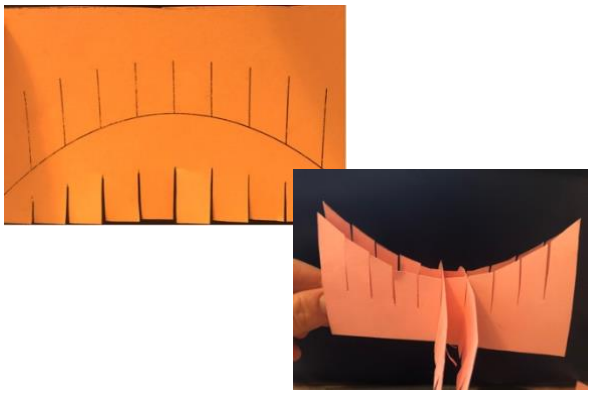
INTRODUCTION

Particle Accelerators and their beams are tools of discovery and innovation. These tools take small bits of matter (particles) and accelerate them at high speeds. Scientists and engineers have learned how to use electromagnetic force fields to accelerate and focus beams of particles, and scientists continue to build their knowledge and skills in this area. At Argonne's Advanced Photon Source (APS), scientists control electron beams moving at 99.999% the speed of light to produce some of the brightest x-rays on the planet. These x-rays are used to do all sorts of science and have numerous applications such as helping develop new vaccines or more efficient batteries. Understanding how these powerful and beneficial machines work can be difficult to understand. In this activity, you will watch a short video and create a model to explore how electromagnetic force fields interact with particles.

STEP ONE: WATCH VIDEO & PREP MATERIALS

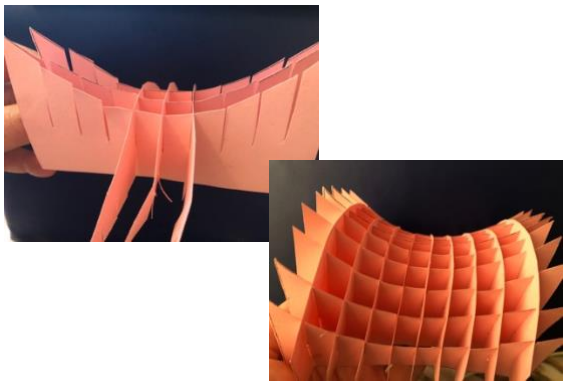
1. Watch Video “How to Trap Particles in a Particle Accelerator” by The Royal Institution: https://www.youtube.com/watch?v=LR_aNOcnH0Q
2. **Print a copy of the Hyperbolic Paraboloid template**. If you have cardstock (heavy paper) and a printer that can print on cardstock, print 2 copies. If you do not have a printer at home, let us know by emailing learninglabs@anl.gov and we will send you copies.
3. **Label the top and bottom of each cross section**: 1a, 1b; 2a, 2b; 3a, 3b; 4a, 4b; 5a, 5b (see photos).
4. Use the template and cut along the black lines to cut out the cross sections on the sturdy paper or cardboard you are using. If you were able to print template directly on cardstock, just cut out the pieces from the template.
5. **Note**: Cut a little extra when cutting the slits so they are a little more spaced out. It should look like teeth on a comb. This will make it easier to assemble later.
6. **Note:** Make sure you have two copies or duplicates of each cross section except the first one. For example, you should have two 2as and two 2bs.





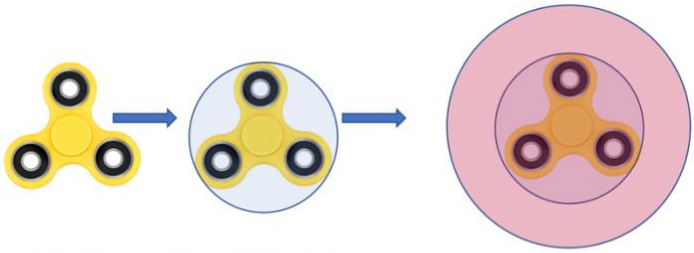
STEP TWO: ASSEMBLE HYPERBOLIC PARABOLOID & DYI ROTATING PLATE

7. **Start by sliding the 1a and 1b cross sections together between the middle slits**. This will be the center and starting point of the shape.
8. **Next, add the 2a and 2b cross sections** to the right and the other two copies to the left.
9. **Continuing adding cross sections** one at a time, moving from the center outward on both the left and right.
    - **Note:** The top cross sections (a’s) will gradually become deeper, and bottom cross sections (b’s) will gradually become narrower



DYI ROTATING PLATE STEPS EXAMPLES

10. **Fidget Spinner Rotating Plate**
    - Adhere (glue or tape) small plastic lid onto fidget spinner. (Let dry if using glue).
    - Adhere larger plastic lid onto smaller plastic lid. (Let dry if using glue).
11. **Cake Pan Rotating Plate**:
    - Pour marbles into cake pan so it covers the pan in a single layer of marbles.
    - Place second pan on top.



Fidget Spinner Image Source: Wiki Creative Commons

TEST MODEL

12. Place your Hyperbolic Paraboloid on top of the “Lazy-Susan” turntable.
13. **Spin** the “Lazy-Susan” or turntable quickly.
14. **While spinning, drop a small, lightweight ball into the center.** Ideally the ball should remain in the center without falling off like the video.

STEP FIVE: IMPROVE & SHARE YOUR MODEL

How long was the “particle” (ball) able to stay in the center of the Hyperbolic Paraboloid before falling off? Improve your model so that the “particle” stays in the center for a longer duration. For example, you may need to increase the speed of the turntable, choose different materials, or secure parts or pieces.

Take a screenshot of your program and send it to Argonne Education at learninglabs@anl.gov or have an adult tweet it out to @Argonne and #ArgonneAtHome.