

# UToledo Outreach Curriculum

This document gives brief descriptions of the demonstrations and activities we use for our outreach program. This list is not exhaustive, as we are constantly adding new things and finding new ways to use the demos we already have!

## **Gravity Well** - All ages

The gravity well consists of a large, stretchy black cloth spread over a circular PVC frame ~1.5 meters in diameter. It demonstrates gravity as the curvature of spacetime due to the presence of different masses. We use marbles, golf balls, and an exercise ball to show how the curvature of spacetime increases with increasing mass. We then use the exercise ball as a “star” and the marbles as solar system objects for a series of demos on orbits. With this setup we can show the variation in orbit eccentricities, accretion in the early solar system (clumps of marbles aggregating), and orbital dynamics. As such, the gravity well is the most versatile astronomy demo we have. This demo is great for people of all ages and allows everyone to participate as they attempt to put their marbles in stable orbit.

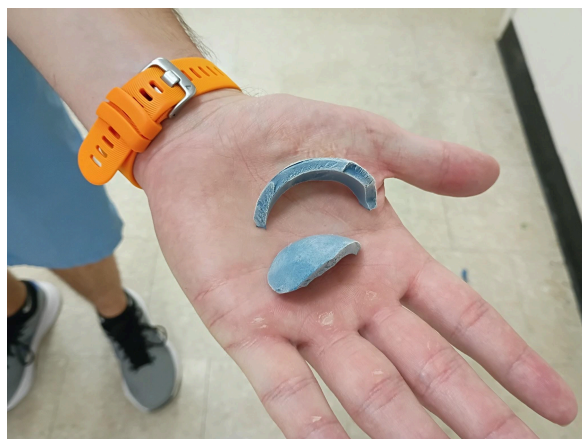


### **Liquid Nitrogen - All ages**

There are many demos possible with liquid Nitrogen (LN<sub>2</sub>). One of our favorites is to explode film canisters. To do this, we fill the canister about halfway with LN<sub>2</sub>, then seal it with the cap. The canister is then placed on the floor, where we wait for the pressure to build from the LN<sub>2</sub> boiling. While we wait, we explain what is happening to the audience. Eventually, the pressure gets so high that the canister lid explosively pops off. We can also flip the film canister upside down, so the lid is on the bottom and the canister blows off the lid. For safety, we only flip the canisters when we are in a gym or outside and have more room.

Shattering racquetballs and other objects is another staple of our LN<sub>2</sub> demos. For racquetballs specifically, we first show the audience that the ball is bouncy. Then we submerge it in LN<sub>2</sub> long enough for it to freeze solid (about 60 seconds). Then, we throw the racquetball on the ground, where it shatters safely, revealing that it has become brittle due to being frozen. We have also done similar demos with flowers, fruit, and candy. We often do edible demos like LN<sub>2</sub> ice cream, Hawaiian Punch slushies, and frozen marshmallows (very popular with all ages).

When we do LN<sub>2</sub> demos, we make sure to emphasize that the LN<sub>2</sub>'s extremely cold temperature is what enables all of them. We also explain why this requires that we use safety goggles and special gloves when handling the LN<sub>2</sub>. This naturally leads to many questions about what the consequences would be if we handled it improperly. We answer these questions honestly; improper handling could lead to serious and lasting bodily harm. Students are then shocked when we end our LN<sub>2</sub> demos by demonstrating the Leidenfrost effect, as doing so requires we pour a small amount of LN<sub>2</sub> onto our outstretched hands. We explain to students that this is safe only because a small layer of protection is formed by the LN<sub>2</sub> rapidly boiling off due to the difference in temperature between our skin and the LN<sub>2</sub>, temporarily creating a barrier of nitrogen gas. Students invariably want to volunteer to do it themselves, which we do not allow. However, if they are willing, we do usually repeat the demo with their teacher. It is extremely important to note that this must be done only on bare skin. All jewelry, watches, and cloth on the hand and lower arm must be removed beforehand. It must also only be done once per hand. The skin's temperature decreasing from the first time can limit the Leidenfrost effect if it is performed a second time, and even lead to injury if performed again too quickly.



### **Angular Momentum Stool - All ages**

For this demo, we usually start with a discussion of how ice skaters pull in their arms and legs when they want to spin faster. The recent Winter Olympics make this more relevant, even for young audiences. We then demonstrate by spinning on the stool while holding dumbbells out at arms length. We then pull our arms in to spin faster. As we do this, we explain that angular momentum always stays the same, so if we increase the distance between the axis of rotation and our distribution of mass, we will slow down. Decreasing this distance means we speed up again, increasing angular velocity. After demonstrating, we allow anyone who wants to try it for themselves to do so. For little kids, the demo does not require dumbbells; extending their arms is enough.

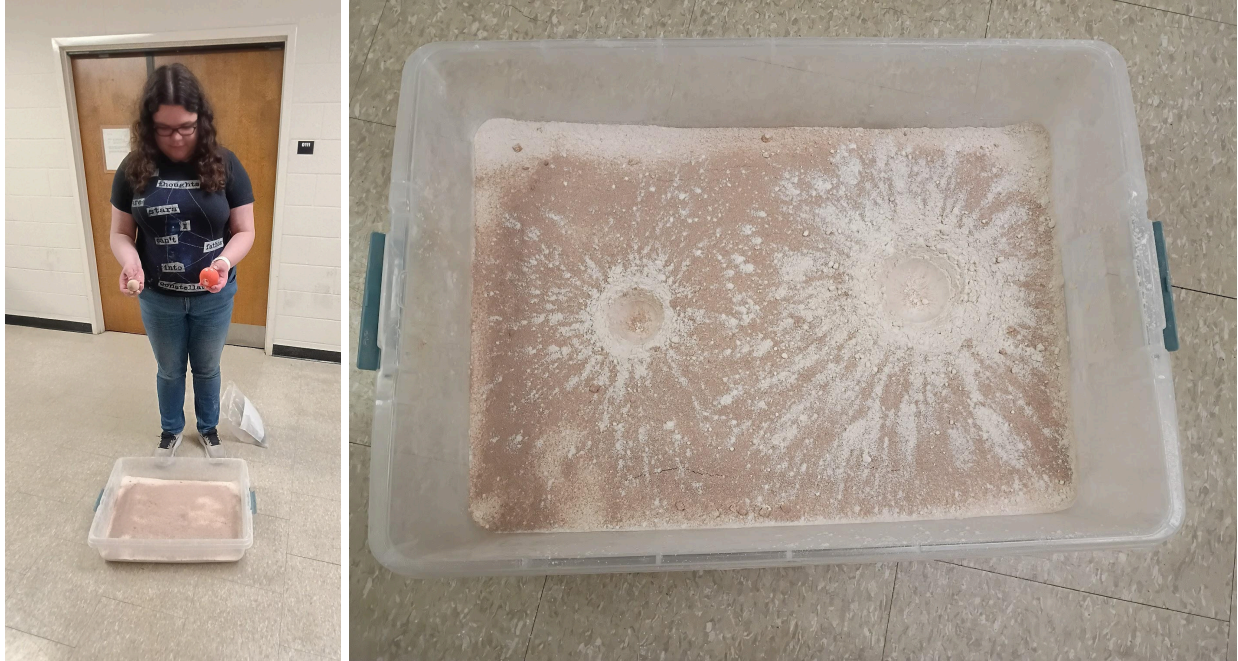
If we have additional time, we sometimes do this demo with a spinning bike tire, where the person on the stool can change the direction of their spin by flipping the orientation of the spinning tire.

If we have access to a basketball hoop, we will have a few students spin on the stool for 30 seconds and then race to see who can make a free throw the fastest. Afterwards, we explain that the fluid in their inner ear continues spinning due to inertia after they have stopped, causing them to be dizzy and have less coordination.



**Cratering Demo** - 6th grade and under

The cratering demo is great for little kids, although it can get a bit messy! To start, we pour a few inches of flour into the bottom of a large plastic bin, then add a light dusting of hot cocoa powder on top. This increases the visibility of the craters we are about to make. We then form craters by dropping balls with different masses and radii into the bin. Next, we create larger craters by throwing the balls instead of dropping them. Before each drop or throw, we ask students to predict which ball (smaller or larger, heavier or lighter) will form the biggest crater. After demonstrating the different craters we can form, we pass out the balls and let the kids create craters of their own. Having a broom to clean up afterwards is essential.



**Spectra** - 6th grade and up

We have a few gas element lamps (H, He, Ne, Hg) that emit single-element spectra, and dozens of simple spectroscopes. For this demo, we explain the concept of a spectrum and have the audience start out by looking at white light as an example of a continuous spectrum. Then, we turn off the lights and turn on the gas lamps so the audience can look at the emission spectrum of each element. We explain the difference between absorption and emission spectra and how each element has specific lines associated with it. Our go-to analogy is that spectra are fingerprints of the elements, and allow astronomers to determine what elements are present in a given celestial body.

**Infrared Camera** - All ages

Our department has an infrared camera that is used for both classroom and outreach activities. For outreach, we typically hook the camera up to a projector so that we can display the video for a large crowd. We have several demos for the IR camera. These include: showing how the transparency and reflectivity of different materials varies between the optical and infrared, using ice to “paint” funny faces on volunteers, determining the temperature difference in cups of water, and tracking people’s footprints on the floor.



**Polarizers** - All ages

We have a few large circular light polarizers which we use to explain what light polarization is and how it works. We typically do this demo by holding one of the polarizers ourselves and handing the other to the student, orienting them such that they are completely transparent. We then tell the student to rotate their polarizer, decreasing the transparency and eventually eliminating it all together. This is a nice quick demo that we can show to a large group of people. We like to draw the connection between this demo and explaining how polarized sunglasses work.

**Boom Whackers** - 10 and under

Boom Whackers are plastic tubes of different lengths, measured so each matches a different note on the musical scale. Because each makes a different note, we can play basic songs (e.g. Mary Had a Little Lamb). We use these to explain resonance of air at different pipe lengths. These are really good for little kids as they are fun, simple, and mostly indestructible.

**Stomp Rockets** - All ages

These are small rockets which are propelled by stomping on a small air pack. First we show the students how the rocket will launch if we stomp on the air pack. We then ask the students if they think it will go higher if we jump on it. Finally, we ask if we get a running start if it will launch higher and then explain how the height of the rocket is only affected by the force when we land, so it should be the same with just a normal jump or a running start because our acceleration due to gravity is the same. We then allow kids to take turns launching the rockets, often launching two at a time so the kids can compete to see who will get the higher rocket.

**Model Solar System** - All ages

For this scale model, a 1-inch blue bouncy ball serves as our model for Earth. On that scale, Saturn is the size of a regulation NBA basketball (9 inches in diameter). We have constructed scale-accurate rings for Saturn out of posterboard and can attach them using a wire net that hangs over the ball. We also constructed a model of the Sun out of PVC and yellow tablecloth on the same scale (110 inches in diameter). We frequently have people guess the distances to the Sun and Saturn on this scale, and can extrapolate it to other objects (Mars, Neptune, Alpha Centauri, etc.). We often use the model at stargazes and school assemblies.



**Van de Graaff generator - All ages**

We have a Van de Graaff generator that we use for electricity demos. First, we will place one hand on the Van de Graaff and allow charge to build up. We show students how this slowly makes our hair stand up as the charge increases. Next, we discharge the generator and place a styrofoam plate on top. Then we allow the charge to build on the generator and subsequently the plate. Eventually, the plate flies off the generator and we explain that this is due to like charges repelling each other. Finally, if we have time and are with high school students we will have them sit on their desks with their feet off the ground. We then have them form a chain by placing their hands on each other's shoulders. The person at one end of the chain touches the generator, allowing charge to build across the chain for about two minutes. Then, we ask one brave volunteer who is not part of the chain to touch the person at the opposite end of the chain, thereby grounding them. Everybody in the chain will receive a small shock as a result of the electricity discharging.

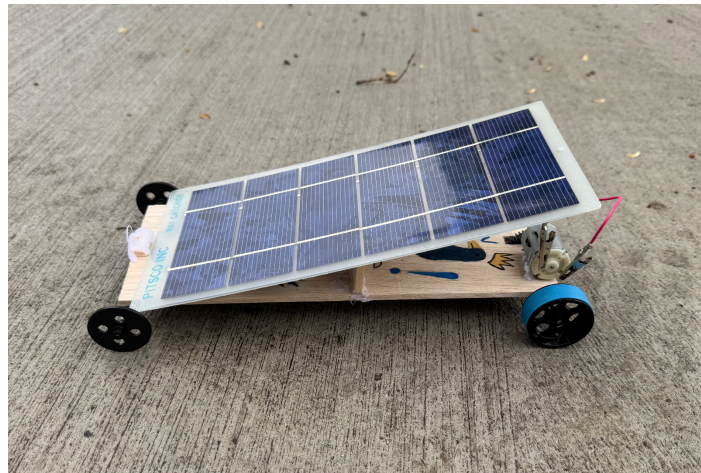
**Bowling Ball Pendulum** - All ages

This is an exciting demo that teaches students about energy. We have drilled a hook into a bowling ball and have a 5-foot cable that attaches to it. We usually hang the bowling ball from a basketball hoop. Then we demonstrate that energy is conserved by bringing the bowling ball up to the tip of our nose and letting it go. Students and adults alike get very animated watching, convinced it will swing back and hit us in the face. It is hard not to flinch! After demonstrating and explaining why it works, we ask for volunteers to try it themselves. However, we do handle the bowling ball for them to ensure nobody gets hit.

**Solar Cars** - All ages

We have small model cars that we power with 10x4 inch solar panels. The cars are made of balsa wood and use size 280 hobby motors. The solar panels produce about 3 V and 1 amp. We typically race these cars and have students guess which one will win. We have also used these cars to discuss how solar cells work.

In the future we plan to expand the use of these cars to host a solar car derby for high school students. Teams of participants will build their own car and compete to win prizes. We will provide everyone with identical solar panels and motors. However, students will have the freedom to design and build their own car using a variety of base materials, wheels, and axles.



**Star Talks** - All ages

We host both campus and off-campus stargazes. For campus stargazes, we use our 14-inch telescope. We pick a specific target to be the focus for the night and advertise for a week or so ahead of time. These stargazes are open to the entire UT community. During the stargaze, one of us operates the telescope inside the dome while other students float around the observation deck to help people stargaze and answer any questions they may have. These have proven to be among the most popular activities we do.

For off-campus stargazes, we have a longstanding relationship with a local wildlife refuge which has much lower light pollution than we have on campus. We advertise the event on their social

media pages and ours. For these events, we use a 6-inch Dobsonian telescope, and plan the stargaze to last ~60 minutes. We spend the first 15-20 minutes doing naked-eye observing: pointing out constellations, any planets that are up, and teaching people various observing tricks. We then spend the rest of the stargaze using the telescope, and usually have enough time to point it at 3-4 objects. While people are waiting to observe with the scope we describe the object they are looking at and answer any questions people have, both about the object and general questions from throughout the night.



### Outreach Handouts

Here's a selection of some of the handout materials we take to school outreach visits to get kids excited about physics and astronomy opportunities here at the University of Toledo! Younger kids really like the stress balls, and older kids tend to like the rocket pens.

