Shielding Design Challenge (grades 8-12)

Materials Needed
<u>For Facilitator *</u> • Introduction to the Engineering Design Process (optional) • Shielding Challenge Facilitator Slides <u>For Students</u> • Shielding Design Challenge- student sheet (PDF) • Several sheets of paper • Pencil • Building materials- several items that are roughly brick shaped (i.e. wooden blocks, dominoes, small paper or cardboard boxes, Legos, Jolly Ranchers, or make your own from things you can find around the house (Be creative)

* If your students are already familiar with the Engineering Design Process the Intro to EDP is not required but may be a good review.

Sample Schedule

Pre-work: Introduction to the Engineering Design process (~15 minutes)

Students think about engineering and review the design process

Pre-work: Shielding Design challenge- student sheet (~10 minutes)

Students learn more about the MJD experiment and its shielding dilemma

Part 1: The Challenge (~30 minutes)

Students learn about the experiment and associated design constraints

Students are presented with the design challenge

Students have time to ask questions

Individual work time (over several days)

Students will design and create an enclosure- include time to brainstorm, find/create necessary materials, test, and improve.

Part 2: Design Solutions (~30 minutes)- will vary with class size

Students will share their design solution, discuss challenges and resolutions.

Students will then see the lots of pictures of the real-life design.

Students have time to ask questions

Optional (but encouraged) Virtual Davis Campus tour (~20 minutes)

Design Challenge

	Design and Build a Lead Shield
Overview	**Overview** During this challenge, students will design a lead enclosure that will be used to protect the MAJORANA DEMONSTRATOR (MJD). They will then test the effectiveness of their brick stacking pattern and consider the feasibility of using this design with large quantities of lead brick. Students will utilize the engineering design process. • Identify • Imagine • Design • Create • Test • Improve • Share
Background Information	The MAJORANA DEMONSTRATOR (MJD), which is being housed 4,850 feet underground in the Sanford Underground Research Facility (SURF), is looking for one of the rarest forms of radioactive decay--neutrinoless double-beta decay. Its detection could help explain why matter—us and everything else in the universe—exists. To work properly, MJD requires a radiation free environment. Researchers are building the detector underground to eliminate the interference from cosmic rays. However, there is also radiation in the surrounding rock, equipment, specks of dust, and people. To completely shield the detector, it will be placed within a copper box and surrounded by a lead enclosure. **What is SURF?** (1.5 minutes) https://vimeo.com/889967101
Questions	**Questions to Ponder** • What is your task? • What are your design constraints? • How will you determine the success of your design? • What problems might there be if you were to build a traditional brick pattern wall for each layer? • What aspect(s) of your design do you think worked best? Why? • What challenges did you have? How did you resolve them? • If you could use another material(s) what would you like to try? How do you think this might help with the challenge? • Now that you have some experience, is there anything you might change to optimize shielding?

Design Challenge

Launch (~15 minutes)	
Engagement and Communication	**Introduction to the Engineering Design Process** During this challenge, students will utilize the engineering design process. It is recommended that time be set aside to ensure students have a basic understanding of the process. • Introduction to EDP (synchronous)
The Challenge (~30 minutes) plus time to work	
Procedure	**The Challenge- Part 1** Shielding Design Challenge- student sheet Students should have time to read the student sheet before the introduction to the challenge. This will give them time to think about designing an enclosure to protect a sensitive science experiment located nearly one mile underground at the Sanford Underground Research Facility (SURF). The facilitator's slides (presentation) contain an introduction to the experiment and associated challenge- part 1. There will need to be time for students to work on the challenge before part 2. The challenge in designing the enclosure will be to ensure that the bricks are stacked in such a way that no lines are created that could allow radiation from any source to reach the detectors. Scientists working on the MAJORANA DEMONSTRATOR have determined that a minimum of 18 inches of lead brick will be necessary to sufficiently shield the detectors from outside sources of radiation. **Reminder to students:** If your stacking pattern doesn't work as well as you hoped, you can always redesign and try again! If you are looking for ideas about questions to help students move forward or get unstuck, we have some ideas. See *Questions to help students get unstuck*
Share (~30 minutes)	
Communicate	**Design Solutions- Part 2** Students will share design solutions and debrief the challenge. This would be an ideal time to invite a member from SURF education and outreach to join your class :0) Authentic audiences help connect the classroom and the real-world and provide an opportunity for students to connect personally with a presenter who can answer their questions and share real-life experiences and design solutions.

Optional (but encouraged) Virtual Davis Campus UG tour (~20 minutes)