INVESTIGATIONS

		HOVERBOARD DESIGN CHALLENGE		
At A Glance	**Investigation 1** The Bologna Test	**Investigation 2** Tensile Test and Durability	**Investigation 3** Thermal Test	**Challenge**
Grade Level **Time Required** (Duration based on 60-min periods)	Middle School (6/7/8) Engage/Xplor: 1 class period Xplain/Elaborate/Evaluate: 1 class period	Middle School (6/7/8) **A:** Engage/Xplor: 1 class period Xplor/Xplain: 1 class period Elaborate/Evaluate: 1 class period **B:** Xplor/Design/Build: up to 2 class periods	Middle School (6/7/8) Engage: 1 class period Xplor/Xplain: 1 class period Elaborate/Evaluate: 1 class period	Middle School (6/7/8) 1-4 class periods
Group Size and Roles (see ROLES document)	3-5 students Materials manager, Technician, Spokesperson	3-4 students Materials manager, Technician, Spokesperson, Document controller	3-4 students (keep in same groups) Materials manager, Technician, Spokesperson, Document controller	3-4 students (keep in same groups) Materials manager, Technician, Spokesperson, Document controller
Xploration	**Question to Xplore** – How do safety scientists and engineers solve problems? Can we see the energy in a single button cell battery? Safety scientists ask why a phenomenon happens. Safety engineers ask how they can solve the problem and keep people safe. Both ask how they can design and communicate solutions. The button cell battery is a case study in science and engineering for safety.	**Question to Xplore** – What is the most durable material to use for an enclosure? Safety scientists understand the problem of hoverboards to be related to thermal runaway. As we saw in the XplorLabs investigation of thermal runaway, when a lithium-ion battery is punctured, crushed, overcharged or overheated, or a short-circuit is caused in other ways (like dropping the hoverboard), there is a greater risk of overheating and fire. Safety engineers ask how they can solve the problem and keep people safe. Enclosures help to enclose things for the protection of the internal components and keep people from the hazards inside the product. Even though the enclosure provides the physical protection for components inside a product like the battery pack, it's also very important that it doesn't trap too much heat, creating a situation where a person could burn themselves when they touch it, or ride it, like a hoverboard! In the case of the hoverboards, the challenge is to select a material with the best performance in durability (tensile strength) and heat (thermal performance) that protects the battery pack from the outside world, and protects the user from the battery pack's heat.	**Question to Xplore** – Can a hoverboard enclosure protect the battery pack (durability) and protect the user from the heat produced by the battery pack (thermal performance)? In XplorLabs, engineers follow a set of standards that determine the order and testing a product must go through, be exposed to, and pass to be certified for safety. There are multiple tests required to pass a product design. So, even though the enclosure provides the physical protection for components inside the hoverboard (like the battery pack), it's also very important that the enclosure doesn't trap too much heat, creating a situation where a person could burn themselves when they use it. There are trade-offs in the engineering design process. In the case of the hoverboards, the challenge is to select a material with the best performance in durability (tensile strength) and heat (thermal performance) that protects the battery pack from the outside world, and protects the user from the battery pack's heat.	**Think you have the best design?** Sell it! Communicate the safety benefits of your design in a video, poster, or radio ad. **Want to tell the safety story?** Tell it! Make a public service announcement about how to care for products with lithium-ion batteries.

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Problem to be Solved	*"Electronic devices are a part of daily life. And they're getting smaller, slimmer, and sleeker. But inside the battery compartment of mini remote controls, small calculators, watches, remote keyless entry, flameless candles, singing greeting cards, and other electronics, may be a very powerful coin-sized button battery. When swallowed, these batteries can get stuck in the throat and cause severe burns. Small children often have easy access to these devices, and many parents do not know there is a risk." (http://thebatterycontrolled.com.au, September, 2016).*	Safety scientists explain the problem of thermal runaway. Engineers create ways to solve the problem! Hoverboards need to be made of material that protects the battery, protects us from the heat from the battery pack, and is stable enough for someone to stand on it and handle it in normal and abusive ways (i.e., tossed in a backpack, dropped on accident...hey, it happens!). What types of testing do safety engineers put materials through? One type of testing is tensile performance – the resistance of a material to breaking under tension. But it's not just the strength of the material that matters, the design is also important. The enclosure shape needs to protect the battery pack (and other components, but for this lab, we'll focus on the batteries) and keep the unavoidable battery pack heat from harming the user. Does the design stand up to the can of soup that represents the relative weight of a hoverboard passenger?	Now that the hoverboard enclosure will hold the weight and has the durability to stand up to daily use, does it keep the battery safe while at the same time not overheating internally or overheating the parts that are handled by the user? If not, what changes/modifications can be made to the design?	
Summary of Lab	In small groups, students will place a piece of bologna on a non-combustible surface. They will place one dropper full of saline in the center of the meat slice, then place a button cell lithium-ion battery in the pool of saline on the bologna. Using a timer, they will observe what happens each minute for 10 minutes.	**Part A**: Students will test the mechanical strength (durability) of four materials using a tensile test – can the material hold more than one pound for two minutes without sagging, ripping, tearing, stretching, or showing other types of damage? If the material shows signs of wear or damage, students will have the opportunity to change the composition of the material by adding more layers, etc., to retest the material with modifications (redesign). **Part B:** Students will use the class data from the tensile test to select a material to build the enclosure for the hoverboard meeting a certain set of criteria – the enclosure must be 8"x3"x3" and hold more than one pound for two minutes without damage. Other materials may be used to support the structural integrity of the enclosure. (Option: to include criteria for weight).	Using a bundle of 4 handwarmers that represent the battery pack, students will test the thermal performance of their hoverboard enclosure designs. The final design must protect the battery, support the weight of one pound, keep the internal heat of the battery from rising more than 5°F, and the external temperature of the enclosure from rising more than 7°F.	

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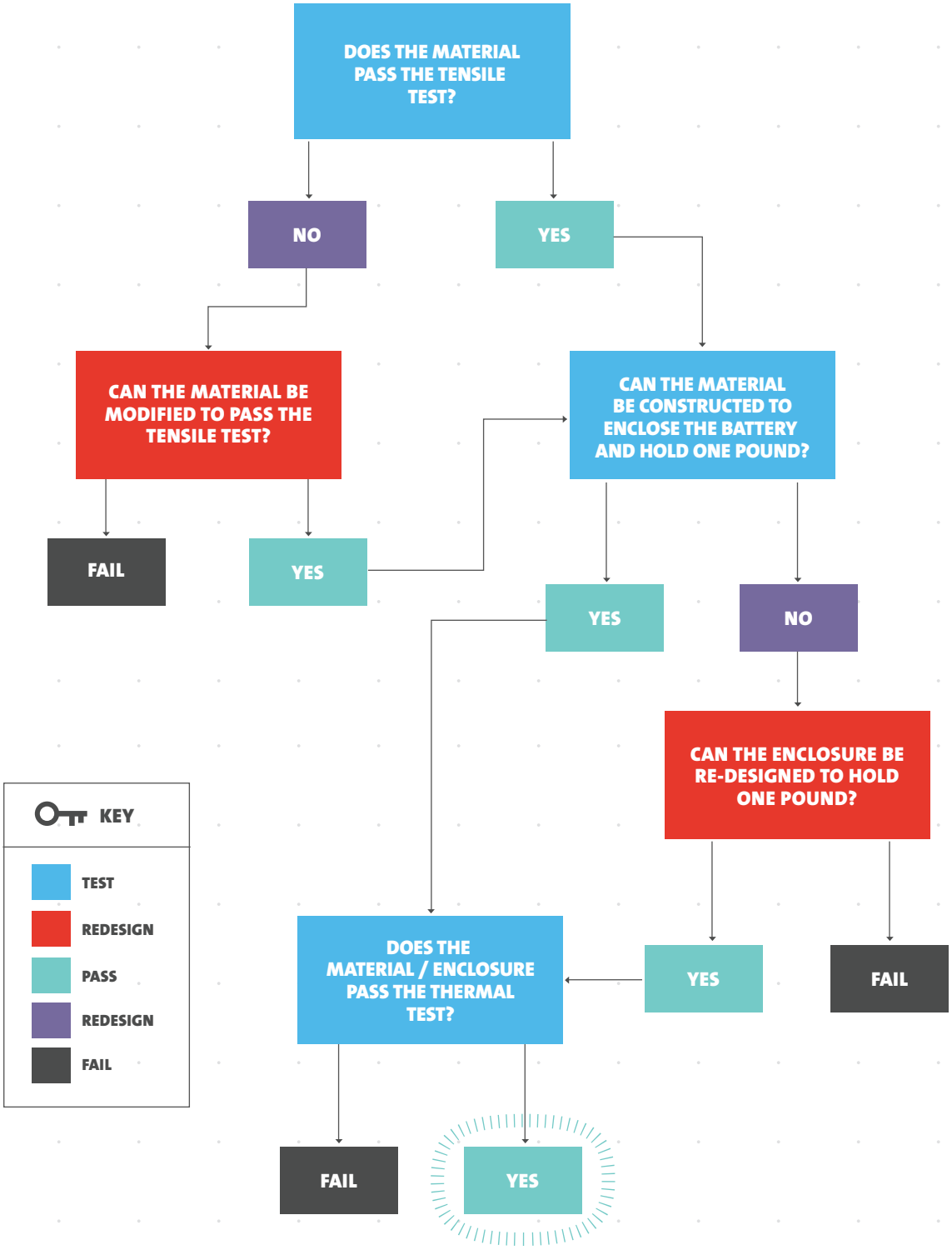
Outcome - Students will do...	Ask questions and define problems Define engineering problems to be solved Observe phenomenon Construct, use, and present arguments based on evidence Work in cooperative groups	Ask questions and define problems Develop and construct a model to generate data and test ideas Analyze and interpret data and construct graphical displays of data Evaluate competing design solutions based on jointly developed and agreed-upon design criteria Apply scientific ideas or principles to design Construct, use, and present arguments based on evidence Work in cooperative groups		Construct, use, and present arguments based on evidence Work in cooperative groups

XPLORLABS: INVESTIGATIONS PROCESS



ROLES (REMEMBER TO ROTATE!)

THE STUFF SUPERVISOR

- Gathers necessary materials for lab when it is time
- Ensures group has everything to begin investigation
- Ensures materials are used properly and safely
- Sets time and manages stopwatch
- Helps with time management
- Puts materials away when group is finished

THE EXPERIMENT EXEC

- Sets up investigation with material
- Ensures safe and precise use of lab equipment
- Ensures all members of the group participate in investigation
- Takes down investigation when it is time
- Helps clean up

THE PRINCIPAL PRESENTER

- Communicates group questions with teacher or other groups
- Ensures all group members give ideas before asking for help
- Ensures everyone in group agrees on question to ask
- Presents findings/reasoning to the class
- Helps clean up

THE DIRECTOR OF DOCUMENTS

- Ensures proper procedure is being followed
- Ensures data is being collected in proper places (all members record data)
- Helps all voices in group be heard
- Provides positive and helpful feedback to the group
- Helps clean up