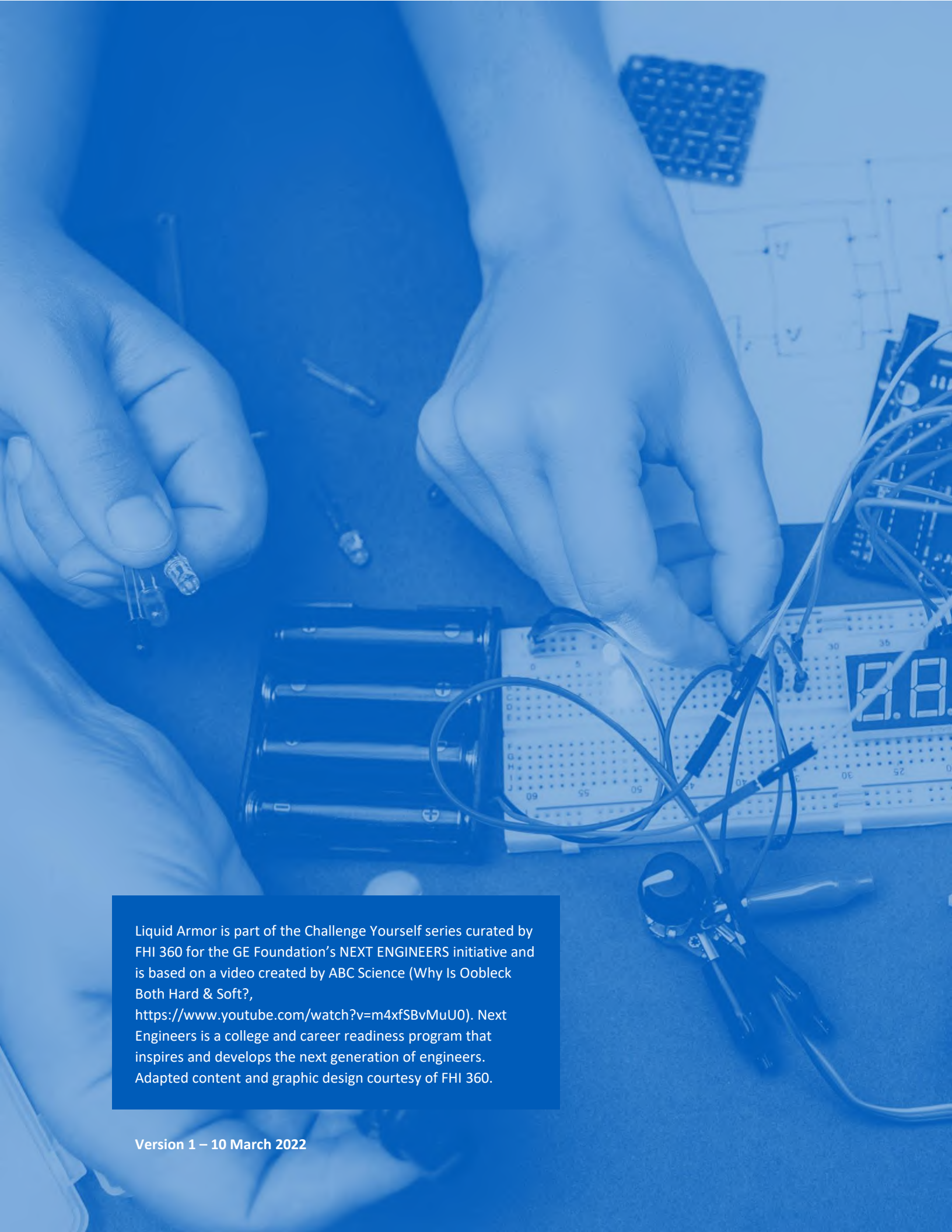
NEXT ENGINEERS

CHALLENGE YOURSELF

Liquid Armor

Chemical Engineering
Mechanical Engineering

GE Foundation



Liquid Armor is part of the Challenge Yourself series curated by FHI 360 for the GE Foundation's NEXT ENGINEERS initiative and is based on a video created by ABC Science (Why Is Oobleck Both Hard & Soft?, https://www.youtube.com/watch?v=m4xfSBvMuU0). Next Engineers is a college and career readiness program that inspires and develops the next generation of engineers. Adapted content and graphic design courtesy of FHI 360.

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Liquid Armor

EXPERIMENT & EXPLORE

Ages	Cost	Time
8+	Low - Medium	60 minutes (or more)
Engineering Areas		
• Chemical Engineering	• Mechanical Engineering	

Introduction

Imagine a liquid that was also a solid. Weird right! Imagine what you could do with such a strange substance. In this experiment and explore activity you will discover if just such a substance exists, experiment with its properties and explore ways engineers might put it to work to solve real-world problems.

What you will need

- An apron
- Newspaper
- A large plastic bowl
- A wooden spoon
- 2 cups (about 250 g or 9 oz) cornstarch
- 1 cup (about 250 ml or 0.5 pints) water
- A measuring cup
- Food coloring (optional)

You will also need the following items to do some additional investigations.

- A bouncy ball
- An egg
- A Ziplock bag
- A large tub
- Another 30 - 50 cups (about 4 – 7 kg or 9 – 15 lbs) of cornstarch
- Another 20 – 30 cups (5 - 7.5 L or 10 - 16 pints) of water

TOP TIP

Things can get messy so don't wear your favorite clothes and try to do the activity outside.

What to do

1. Spread out a few sheets of newspaper on a desk or tabletop to work on.
2. Measure out 2 cups of cornstarch and add it to the bowl.
3. Now measure out 1 cup of water and add it to the bowl.
4. Mix the cornstarch and water together until well mixed. Your mixture should feel like watery slime. Add some food coloring to your mixture if you like.
5. Stir your mixture slowly. How does it feel? How does the mixture behave?
6. Stir your mixture quickly. How does it feel now? What is different?
7. Can you pick your mixture up in your hand and squeeze it?

8. Can you roll your mixture into a ball? What happens when you stop?
9. Make a fist and slowly push it into the mixture. Now try to punch the top of the mixture. Is there a difference? How would you describe this difference?

What's happening

You should have noticed that your mixture behaves differently if you handle it slowly with little force or quickly with more force. If you stir it slowly or move your hand through it slowly, it behaves more like a liquid. But if you stir it quickly or try to punch the surface, it behaves much more like a solid.

This is because the mixture you have created is no ordinary **Newtonian fluid**. It is a **non-Newtonian fluid** called **Oobleck**. Non-Newtonian fluids are fluids that change their **viscosity** (how easily they flow) under stress or force. The faster you stir or the more force you apply, the more viscous the mixture becomes.

But what is going on? There is still much that scientists and engineers don't understand, but this is what we do know. The tiny cornstarch particles are suspended in the water rather than dissolved in it. At low speeds or small forces, the water molecules can easily fill gaps between particles as they are moved around. At higher speeds or under greater forces the water is unable to fill these gaps and friction forces between the cornstarch particles becomes more important. As the friction increases, the viscosity increases!

If you want to learn more about Oobleck and non-Newtonian fluids watch the video called *Non-Newtonian Fluids* (4:43) (https://www.youtube.com/watch?v=DQoelYi6qfw).

Think about it

Knowing what you now know about Oobleck and non-Newtonian fluids, think about the following. Try these experiments yourself to see if your predictions are correct.

1. What do you think will happen if you bounce a bouncy ball on a bowl of Oobleck?
2. What do you think will happen if you throw the ball down hard as opposed to just letting it fall under its own weight?
3. What do you think will happen if you drop the ball from different heights? Will it sometimes bounce and sometimes sink? When will it bounce or sink? Why?
4. What do you think will happen if you place a raw egg inside a Ziplock bag filled with Oobleck and throw it against a wall? Try this, just make sure you do it outside! Does the egg survive? Why do you think this is? What role do you think the Oobleck plays?
5. Do you think you can jump on Oobleck? Get a large tub and make a bigger batch to find out. You can make as much Oobleck as you like. You just need to mix 1 part water with about 1.5 parts cornstarch (i.e. 1 cup water to about 1.5 cups cornstarch).
6. Can you make Oobleck that behaves even more like a solid when placed under stress? Experiment with different recipes to see how adding more or less cornstarch to a set quantity of water changes the properties of the mixture. How can you test and measure these properties? Make notes to keep track of your observations.

VISCOSITY

Viscosity is a measure of how easily a liquid flows. Water has a low viscosity and flows easily. Honey has a high viscosity and does not flow easily.

NEWTONIAN FLUID

A Newtonian fluid behaves as we expect normal liquids to behave. Their viscosity is constant irrespective of the amount of force applied to them.

NON-NEWTONIAN FLUID

A non-Newtonian fluid is one which changes its viscosity depending on how much force is applied to it. For fluids like Oobleck, the greater the force, the greater the viscosity.

LEARN MORE

Watch these videos to learn even more about Oobleck and its amazing properties.

- *How strong is Oobleck?* (6:16) https://www.youtube.com/watch?v=Sl0BHueSjvA
- *Fun with Non-Newtonian Fluid* (2:24) https://www.youtube.com/watch?v=RIUEZ3AhrVE

Links to the real-world

Oobleck sure is fun to play with, but do you think we can put its unusual properties to practical use? Consider these possibilities.

- How might you use Oobleck or a similar non-Newtonian fluid to design a mobile phone or tablet case?
- How might you use Oobleck or a similar non-Newtonian fluid to design body armor that was light and easy to wear but was able to protect the wearer from blows or even bullets?
- How else might you engineer a use for Oobleck or a similar non-Newtonian fluid to solve a real-world problem. Share your ideas at **#nextengineersdiy**.