Go-with-the-flow

sead : stem

Subjects

Physics | Engineering | Scientific Inquiry | Engineering Design Process

Topics

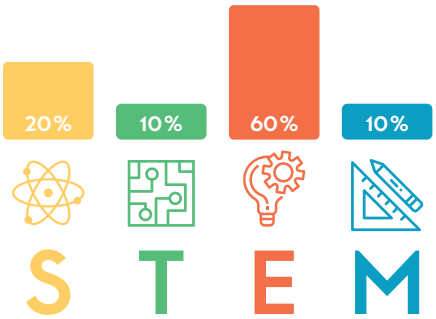
Physics | Engineering | Energy | Simple Machines

Key Words

Irrigation | Gravity | Floatability | Density | Viscosity | Friction | Fluid Dynamics

Connection to SDG

STEM Chart



Time for Activity

2–3 hours

Introduction

Water poured from a bucket will naturally flow towards the ground, just as water in general always flows downhill because of gravity.

Water coming out of a water pistol will travel fast. it is pushed out using force. The speed water travels at depends on the amount of force applied to it. When water is poured into a funnel, the wide part (cup) of the funnel will fill up quickly. That is because water can move faster in the wide area but slows down when it hits the narrow neck. It pushes harder on the sides of the funnel as it moves through the narrow bottom, because as water moves from a wider space to a narrower space the water pressure gets higher.

On the surface of a window, rain will move faster than on a wall. This is because running down a rough surface slows it down due to friction. Gravity affects the direction water flows in. Gravity, force and friction affect water pressure and how fast the water flows.

Water can flow in a number of different ways. The study of how water flows is part of a branch of physics called fluid dynamics. In this experiment, students will observe how water flows observing the motion of a plastic ball. Linking this experiment to a real-life application, students will understand the science behind terrace farming.

The Banaue rice terraces in the Philippines are flat layers carved into the sides of mountains, which allows farmers to grow rice on the otherwise incredibly steep mountain slopes. Amazingly, these structures are 2,000 years old—meaning they were made entirely by hand and without modern construction equipment!

The terraces were watered by an irrigation system (the artificial application of water to plants for agriculture purposes) that channeled water from mountain springs and streams down through the layers. This means the irrigation systems were powered entirely by gravity (the force that pulls things down towards the earth) as the water flowed down the mountainside.

In this project, our goal is to build a model of the Banaue Rice Terraces using some common household materials (Figure 2). The students will design a terrace structure so plastic or wooden beads will be carried down from the top layer by running water, simulating the irrigation system in the real rice terraces. The beads are buoyant, meaning they float in water, because their density (mass per unit volume) is lower than the density of water. They get

Fig 1

View of the Banaue rice terraces, an ancient engineering marvel in the Philippines.

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Fig 2

A model of the Banaue rice terraces.

dragged along because water is viscous, meaning it exerts friction (a force that resists motion) when it flows past or around an object.

Finally, we can use this project to demonstrate the engineering design process. It is unlikely that you will think of an idea for a device, sit down and build it, and have it work perfectly on the first try. Just encourage students to come up with their own designs, test the designs and modify the designs to improve them.

Professional engineers rarely get things right on the first try!

Key Objectives

1. Building a model of a terraced irrigation system that uses flowing water to transport plastic beads. Beads start in the top layer and must flow through each lower layer until they are retained in the bottom layer.
2. Understanding the properties and nature of water.
3. Understanding the type of flow used in and the science behind terrace farming.

Materials

1. Small and large plastic cups or paper cups
2. Aluminum foil
3. Popsicle sticks
4. Tape
5. Large shallow plastic tub to catch water if the project is done indoors, or an outdoor area where it is OK to spill water
6. Tap water
7. Approx. 12 mm or ½ inch diameter wooden or plastic beads. The beads can have holes in them. Do not use glass marbles or metal bearings as they will sink!

Safety

1. Be careful when using scissors, knifes or handsaws for cutting wood or metal strips!
2. Be careful when using the hot glue – it's really hot!

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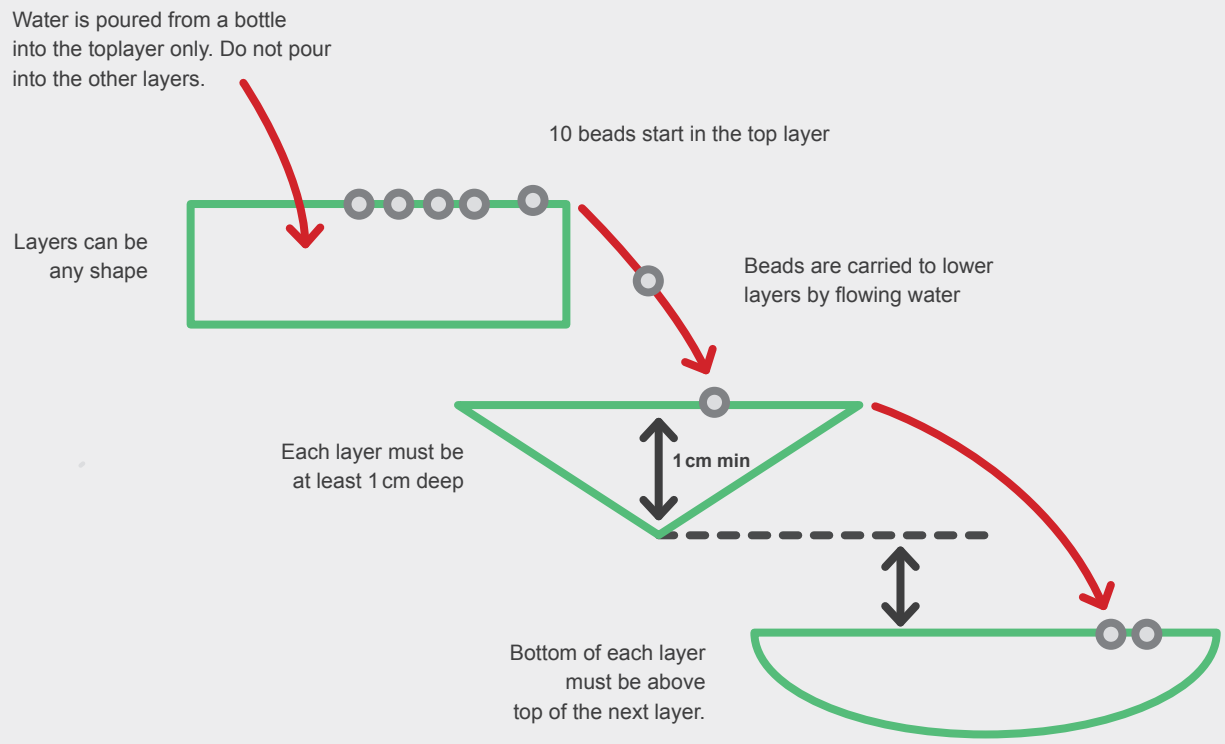
Guiding Questions

1. What determines if an object will float in water?
2. How were rice terraces irrigated without the use of electricity or modern equipment?
3. Why does water stay liquid over a large temperature range? How does it help living things?
4. Does floating ice help animals in nature? If so, how does it help?
5. What does laminar flow mean?
6. What purpose did the terrace farming system serve?
7. What is terrace farming and what are its benefits?
8. How does terrace farming reduce erosion?
9. What are the disadvantages of terrace farming?
10. What is the importance of terrace farming?

Procedure

(Experimental Procedure or How It Works and How to Design)

Fig 3



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The objective of this project is to build a gravity-powered irrigation system modeled after the Banaue rice terraces in the Philippines.

1. **Your model can only be built from items listed in the Materials section.**
2. **There are no restrictions on the shape of your layers, and layers do not have to be the same shape. However, each layer must hold at least 1 cm of water at its deepest point (see Figure 3).**
3. **Your model must have a minimum of 2 and a maximum of 10 layers.**
4. **The bottom of each layer must be higher than the top of the next layer down (see Figure 3).**
5. **All ten beads must start from rest in the top layer, with no water in the model.**
6. **You can only pour water into the topmost layer. There are no limits as to how quickly or slowly you pour the water.**
7. **You cannot touch the model or any of the beads during operation. However, there is no limit to the number of attempts you can use to try and get a high score. If your model breaks or does not behave as expected, you can reset it (pour out all the water and put the ten beads back in the top layer) and start again.**

Engage (5 minutes)

Introduce the challenge to students. Explain that the main goal is to build a model of a terrace structure and test it.

Design

Before you start building anything, it is a good idea to brainstorm different designs. Try sketching your designs on paper. Which designs will work best given the rules and materials you are allowed to use? Which design do you think will be the most reliable? Think about these questions and select a design to move forward with.

Build

Once you have decided on designs, it is time to start building them. You might find out that your designs “on paper” do not work as planned when you try to build them in the real world. That is OK! You do not have to stick to your original plan. You can make modifications to your design, or even start over with something completely new.

Rules for Building a Machine

1. **Only use items listed in the Materials section.**
2. **Build one model. The models within the class can differ from each other.**
3. **The model must be freestanding. It cannot be taped to the ground or supported by a person.**
4. **Your model has to prove that it generates electricity by lighting up a 3V LED.**

Test

Once you have the model, put it on a table and try it out. This is your opportunity to identify weak spots in your designs and things that can be improved. Here are some things to consider:

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Rules for Testing a Machine

1. Drain all the water from your model.
2. Place ten plastic beads in the top layer of your model. Make sure they are not moving or rolling around at all before you continue.
3. Fill a 1-liter (or 32 oz) plastic bottle with water.
4. Pour the water into the top layer of your model.
   1. There are no limits as to how quickly or slowly you must pour the water.
   2. You can only pour water into the top layer. Do not pour water into any of the other layers.
   3. You do not have to use all of the water, but you cannot refill the bottle.
5. Wait until the water has stopped flowing and all of the beads have stopped moving.
6. If need to make repairs, you must start over counting the number of failed attempts.

Assessment

Can you use your model to show how sediments are transported down the mountainside?
What happens if you fill the top layer with dirt instead of using plastic beads?
Can you see why erosion might be a problem for the rice terraces?

Test your design by pouring the water slowly / quickly and observe how many beads move from the top layer to the bottom layer without falling out of the model.