Gravity Separator

sead : stem

Subjects

Physics | Engineering | Scientific Inquiry | Engineering Design Process

Topics

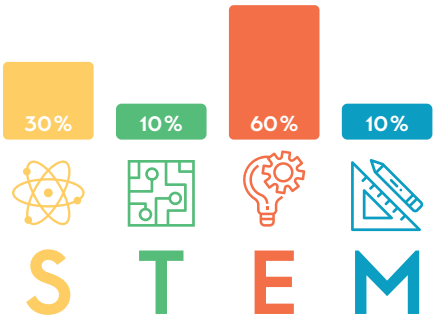
Physics | Engineering | Energy | Simple Machines

Key Words

Diameter | Force | Motion | Projectile Motion | Density | Gravity | Kinetic Energy | Energy Conversation | Simple Machines | Screening | Panning | Gravitational Potential Energy

Connection to SDG

STEM Chart



Time for Activity

2–3 hours

Introduction

Sorting machines come in all shapes and sizes, ranging from tiny toy coin sorters to huge industrial sifting machines used in food processing or mining. Regardless of what exactly they sort, they all have something in common: they automate a task that would be very difficult, or even impossible, for humans to do! It is not such a big deal to sort a few dollars' worth of change or to use a hand sifter for a cup of flour. But what if you worked at a bank and had to sort thousands of coins, or at a food processing factory dealing with thousands of pounds of flour? Then it would certainly help to have a machine do the work.

The same is true in the mining industry. Early miners would use a manual process, called panning, to separate gold nuggets from dirt and sand in a pan. Modern industrial mines use a variety of automated processes to separate valuable gems and minerals from dirt and other rocks. Some sorting systems use complex electrical sensors, for example to measure whether a metal is magnetic or how reflective it is, in order to sort them.

Others use mechanical methods like screening, where particles fall through screens with different-sized holes. Particles with a smaller diameter fall down through the screens, while larger particles stay on top. Some systems use bursts of compressed air to blow away lighter materials, while materials with a higher density remain in place. Many times, these mechanical sorters are powered by motors, but simple systems are powered only by gravity.

In this project, your goal is to build a gravity-powered marble sorting machine that can sort large and small plastic spheres (representing rocks and gems, respectively), like the ones shown in Figures 1 and 2. You will start out with a cup containing a mix of two different sizes of spheres, pour them into the machine, and the machine should sort them into two separate cups. Keep in mind that the machines in Figures 1 and 2 are just two examples of how you could approach the task. They are not necessarily the "best" methods, and you might come up with your own design that is more creative or works better.

Gravity Separator

sead : stem

Subjects

Physics | Engineering | Scientific Inquiry | Engineering Design Process

Topics

Physics | Engineering | Energy | Simple Machines

Key Words

Diameter | Force | Motion | Projectile Motion | Density | Gravity | Kinetic Energy | Energy Conversation | Simple Machines | Screening | Panning | Gravitational Potential Energy

Fig 1

An example of a gravity-powered marble machine. This machine is designed to separate spheres by diameter. Spheres are poured into the funnel at the top and then roll down the popsicle sticks. The smaller spheres fall through the gap between the popsicle sticks into the first cup, and the larger spheres continue rolling to the second cup.

Fig 2

Another example of a gravity-powered marble machine. This machine uses a lever to separate larger, heavier spheres from smaller, lighter spheres. The spheres are poured into a funnel and land on a lever when they fall out the bottom. The smaller, lighter spheres are not heavy enough to tilt the lever, so they roll to the right. The larger, heavier spheres weigh enough to tilt the lever, so they roll to the left.

Key Objectives

1. Building a gravity-powered sorting machine that can separate small and large plastic spheres.
2. Understanding that the force of gravity can be used to separate the mixture of different masses.
3. Understanding the concept of differences in mass, weight and density as a basis for the gravity separation method.
4. Understanding how gravity separation is used in mining industry.

Materials

1. Paper or plastic cups
2. Popsicle sticks
3. Cardboard to use as a base
4. Roll of tape
5. Glue

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!

Gravity Separator

sead : stem

Subjects

Physics | Engineering | Scientific Inquiry | Engineering Design Process

Topics

Physics | Engineering | Energy | Simple Machines

Key Words

Diameter | Force | Motion | Projectile Motion | Density | Gravity | Kinetic Energy | Energy Conversation | Simple Machines | Screening | Panning | Gravitational Potential Energy

Guiding Questions

1. What is gravity separation based upon?
2. What are the differences between gravity separation and panning?
3. Where can you see gravity separation in real-life situations?
4. What is the difference between weight and mass?
5. Why is weight and mass used synonymously on Earth?
6. How is mass related to weight?
7. Why are weight and mass often confused?

Procedure

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

The objective of this project is to build a gravity-powered sphere-sorting machine that can separate 6 mm and 12 mm-diameter spheres using a specific list of materials. Following the guidelines, you will calculate a score for your machine based on how quickly it can properly sort spheres and the amount of materials you use.

1. **Your machine can only be built from items listed in the Materials section.**
2. **Your machine must be entirely gravity-powered. This means that you cannot touch the machine during operation and the machine cannot have any electrical or motorized parts.**
3. **Your machine must fit on a 60 cm by 60 cm piece of cardboard. This piece of cardboard can only serve as a base and must remain flat. You cannot fold the cardboard or cut off smaller pieces and use them as parts of your machine. You are allowed to tape your machine to the cardboard.**
4. **The machine must collect the plastic spheres in two separate plastic or paper cups. These cups must be removable so you can easily count the spheres. They cannot act as structural supports for your machine or otherwise be permanently attached to the machine.**
5. **You must start the test with a single plastic or paper cup containing a mixture of 25 spheres of 6 mm and 12 mm each. While you can pour the spheres into the machine as slowly or as quickly as you would like, you must pour them in one continuous motion. You cannot pause during pouring.**

Engage (5 minutes)

Introduce the challenge to students. Explain that the main goal is to build a gravity-powered sphere-sorting machine and test it.

Design

Before you start building anything, it is a good idea to brainstorm some 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.

Gravity Separator

sead : stem

Subjects

Physics | Engineering | Scientific Inquiry | Engineering Design Process

Topics

Physics | Engineering | Energy | Simple Machines

Key Words

Diameter | Force | Motion | Projectile Motion | Density | Gravity | Kinetic Energy | Energy Conversation | Simple Machines | Screening | Panning | Gravitational Potential Energy

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 machine. The machines within the class can be different from each other.**
3. **The machine must be freestanding. It cannot be taped to the ground or supported by a person.**

Test

Once you have the machine, 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.

Rules for Testing a Machine

You must start the test with a single plastic or paper cup containing a mixture of 25 spheres of 6 mm and 12 mm each. While you can pour the spheres into the machine as slowly or as quickly as you would like, you must pour them in one continuous motion. You cannot pause during pouring.

Assessment

1. **What are some examples of sorting, screening, or sifting objects or materials from your every-day life?**
2. **What are some large-scale or industrial examples of sorting, sifting or screening?**
3. **Search the web for videos of different sorting machines. How do they work?**
4. **Build a larger sphere-sorting machine, for example one that can sort tennis balls and ping pong balls.**
5. **Make a coin sorter instead of a sphere sorter.**

Gravity Separator

sead : stem

Subjects

Physics | Engineering | Scientific Inquiry | Engineering Design Process

Topics

Physics | Engineering | Energy | Simple Machines

Key Words

Diameter | Force | Motion | Projectile Motion | Density | Gravity | Kinetic Energy | Energy Conversation | Simple Machines | Screening | Panning | Gravitational Potential Energy

Related Pictures

Fig 3

Fig 4

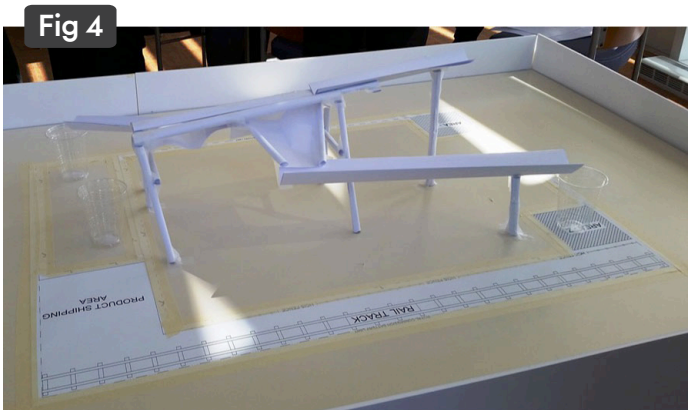


Fig 5