Build a Recycling-Sorting Machine
A sustainable science project from Science Buddies

Key Concepts
Material properties
Forces
Weight
Magnetism
Recycling
Engineering

Introduction
Does your community have single-stream recycling, which allows you to mix materials into one recycling container? Have you ever wondered how those materials all get separated so they can be recycled into new things? Try this activity to find out as you build your own recycling-sorting machine!

Background
Recycling allows our old plastics, glass, aluminum and papers to be broken down and turned into new things. For example, plastic bottles might be melted down and turned into park benches or playground equipment, and old paper can be turned into new paper towels or napkins.

That process presents a challenge, however. Before the materials can actually be recycled they need to be separated and sorted. You don't want bits of plastic or metal in your recycled paper towels! After recyclables are collected, they get transported by trucks to recycling plants called materials recovery facilities (MRFs). In MRFs, giant piles of mixed materials are fed through machines that separate them out into different categories and bundle them to be shipped off to processing plants. Much of the sorting is done automatically by machines that make clever use of different properties of the materials. Magnets, for example, can attract metal objects, and blowing air can separate lighter paper and cardboard from heavier objects such as glass bottles and metal cans.

This process is not without its downsides. Plastic bags can clog sorting machines, which is why they typically cannot be included in single-stream recycling. Many communities only accept certain types of plastic, and they require that food containers be rinsed thoroughly before being placed in the recycling. Ignoring these guidelines can result in contamination in the recycled materials, making them unusable—so they will still wind up in the trash! This is why it's very important to make sure you follow your community's recycling guidelines.

In this project you will focus on separating two materials: shreds of paper and paper clips. Can you build a machine to separate them efficiently? Try it and find out!

Materials

- At least two dozen paper clips
- Paper
- Scissors
- Magnets
- Flat workspace, such as a table top
- Cups or other small containers
- Construction materials such as cardboard, plastic bottles, tape and/or other craft supplies that you can use to build a recycling-sorting machine
- Additional items to sort, such as glass and plastic marbles or large and small plastic beads

Preparation

- Carefully cut a few dozen small pieces of paper, roughly 1-by-1 centimeter (they can be irregular shapes of this size). This will be quicker if you fold the paper first so you can cut multiple pieces at once.
- Put the paper pieces in a cup with the paper clips. Cover the top of the cup with your hand so nothing falls out, and shake the cup to mix them.

Procedure

- Dump the mixed paper clips and paper pieces into a pile onto your work surface. Try separating them manually. *How long does it take you to pick them apart by hand?*
- Remix the paper clips and paper pieces, then dump them back on the table. Try using air to separate them by blowing on them. *Is this method easier or harder than sorting by hand?*
- Remix and dump the materials again. This time try separating them using a magnet. *Can you completely separate them all using just a magnet?*
- Real recycling plants use a combination of different methods to separate materials. Using what you've learned from your tests, can you build a machine that will separate a mixed cup of paper clips and paper pieces into two different piles or cups? One method (but certainly not the only way!) is to build a ramp and/or a funnel that is lined with magnets on the outside. When you pour the mixed cup of paper clips and paper pieces into the machine, they all slide down. The paper clips should get stuck to the magnets in the walls, and the paper continues to fall. Try building this machine out of your construction materials. *How effective do you think it will be?*
- Test out your machine. *How effective was it? Do any paper clips fall through to the bottom, or do any shreds of paper get stuck by the magnets? How could you improve your machine?*
- Try making any changes to your machine that might help it be more effective, then redo the sorting test.
- **Extra:** Try this project with different materials. *Can you sort objects by weight or by size? For example, what about glass marbles and plastic marbles or large and small plastic beads?*

Observations and Results

You probably found moderate success if you built a ramp-and-funnel-style device with magnets to separate the paper clips and paper shreds. It might be difficult to build a device that can completely separate the materials without some manual sorting. Some paper clips may whiz by the magnets without getting stuck. As more paper clips start sticking to the magnets, they can create clogs where shreds of paper get trapped. This results in two sets of materials that are better than what you started with, but still not completely separated—it probably required some manual sorting to finish the job.

Real recycling plants have moving conveyor belts and powerful electromagnets that can be turned on and off. This lets them pull magnetic materials *up* off the conveyor belt and move them away, separating them from nonmagnetic materials such as plastic, glass and paper, and reducing their chances of getting stuck together.