



Cleaning the Air

Subjects

Engineering Earth Science

Topics

Sustainability Engineering Process

Key Words

Air Air filter Air Quality
Environmental Engineer Particulate Matter
Pollution Aerosols Model Cars

3 GOOD HEALTH AND WELL-BEING



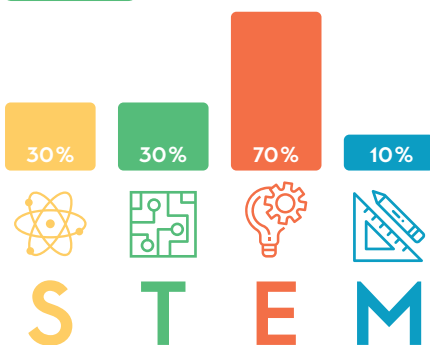
11 SUSTAINABLE CITIES AND COMMUNITIES



15 LIFE ON LAND



STEM Chart



Time for Activity

2–3 hours

Short Introduction

In this activity, students undertake an engineering challenge as they design and build a filter without blocking more than 50% of the air.

Introduction

Air pollution is caused by solid and liquid particles and certain gases that are suspended in the air. These particles and gases can come from car and truck exhaust, factories, dust, pollen, mold spores, volcanoes and wildfires. The solid and liquid particles suspended in our air are called aerosols.

Certain gases in the atmosphere can cause air pollution. For example, in cities, a gas called ozone is a major cause of air pollution. Ozone is also a greenhouse gas that can be both good and bad for our environment. It all depends where it is in Earth's atmosphere. Ozone high up in our atmosphere is a good thing. It helps block harmful energy from the Sun, called radiation. But, when ozone is closer to the ground, it can be really bad for our health. Ground level ozone is created when sunlight reacts with certain chemicals that come from sources of burning fossil fuels, such as factories or car exhaust. When particles in the air combine with ozone, they create smog. Smog is a type of air pollution that looks like smoky fog and makes it difficult to see.

Engineers design methods of removing particulate matter from industrial sources to minimize negative effects of air pollution. One of the biggest challenges engineers face is devising new techniques to prevent industrial air pollution. Engineers are creative in designing modern pollutant recovery methods and industrial technologies that remove particulate matter from industrial sources to minimize negative effects of air pollution. Mechanical and environmental engineers develop new technologies to control the problems old technologies have created. For example, engineers create air filtration systems that are commonly used in homes and businesses. In this activity, students undertake a similar engineering challenge as they design and build a filter to remove pepper from an air stream without blocking more than 50% of the air.



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Key Objectives

- 1 To be able to describe several causes and health effects of air pollution.
- 2 To be able to use the engineering design/test/build process to create a model indoor air filter.
- 3 To be able to count and calculate the average number of particles collected in one area.
- 4 To understand how engineers construct air filters to clean air pollution.

Materials

Each group should have:

- 1 2–3 index cards or construction paper
- 2 Clear packaging tape
- 3 Scissors
- 4 A variety of filter-making supplies (i.e., pipe cleaners, cotton balls, cloth, tape, tissue paper, etc.)
- 5 2–3 copies of the Cleaning the Air Worksheet (one per student)

For the classroom to share:

- 1 Shoebox
- 2 Tape
- 3 String
- 4 Aluminum foil
- 5 4 index cards
- 6 Black pepper, sand or similar small particles
- 7 Large container (such as a trash can or cardboard box)
- 8 Protractor
- 9 Hair dryer

Safety

- 1 Remind students not to touch the metal screen at the tip of the hairdryer, as it may be very hot. For best results (and for continued use of the hairdryer), make sure the hair dryer does not overheat.





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Guiding Questions

- 1 What are the different types of pollution?
- 2 What are the major causes of pollution?
- 3 What can we do to prevent pollution?

Task

Before the Activity

The facilitator should construct the testing apparatus as follows:

- 1 Cut a hole in the end of a shoebox. The hole should be sized so that the narrow end of a hairdryer fits into it.
- 2 Cut out the opposite end of the shoebox so it is completely open.
- 3 Tape a piece of string so that it extends horizontally across the top of the cut out end.
- 4 Fold a piece of aluminum foil in half and hang it over the string. The deflection of the foil when the hairdryer is on will be used to indicate the amount of air flow. This will be measured with a protractor.
- 5 Fold four index cards into an "I" (L) shape. Tape these halfway down the length of the shoebox on the inside to hold the students' filters.
- 6 Set up the testing apparatus in a location to which students have easy access. Position the hairdryer through the first hole cut in the shoebox (a ring stand may be useful for holding the hairdryer). Set a large container on its side at other end of apparatus to catch particles. If you are using a long container, such as a trash can, you may need to place the entire apparatus inside the container so that students will be able to capture particles with a pollution collector.
- 7 Make enough copies of the Cleaning the Air Worksheet so that each student has one.

With the Students

- 1 Divide students into groups of two or three depending on how your class works best.
- 2 Pass out the Cleaning the Air Worksheets to the students.
- 3 Review particulate matter with students. It is all the small particles like fly ash, dust and pollen that pollute the air. Challenge students to design an air filter that will filter out the most particulate matter without blocking the air flow. Tell them that black pepper will be used as the particulate matter, and show them the apparatus you will use for testing.
- 4 Write the following challenge on the board: Design an air filter that filters out the most particulate matter without blocking the air flow.



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- 5 Show students the testing apparatus. Explain to students that there are two slots that will hold a filter and so students can design two filters if they want, but it must fit into the testing apparatus' filter slots.
- 6 Ask students if they know what an ammeter is? **(Answer: An ammeter is a device that is used to measure air flow.)**
 Show students the ammeter on the testing apparatus — the aluminum foil. Turn the hair dryer on and tell students this is full air flow. Put an index card into the testing apparatus that fully blocks the air flow. This is no air flow.
- 7 Explain to the students that their air filters cannot block more than 50% of the air flow. Ask students what the ammeter will look like when 50% of the air is blocked.
(Answer: the ammeter — i.e., the foil — will come up to half of the angle it was at when air blew through the box with no filter installed.)
- 8 Explain that there are four criteria for the air filters that the students build.
 - 1 They can only use materials that are provided by the teacher.
 - 2 The filter cannot block more than 50% of the air.
 - 3 The filter must be designed to fit into the testing apparatus filter slots.
 - 4 All students must test the filter at least once.
- 9 Review the Cleaning the Air Worksheet with the students. Make sure students understand their challenge and the four filter criteria; ask students to copy the four criteria and challenge down on their worksheets.
- 10 Give the students time to work in groups and design their filter. They should initially just list their ideas and draw a picture of their filter design.
- 11 Give the groups time to build their air filters and time to test them at least once. Students will probably have to test them several times to optimize and adjust the filter, so use two class periods to build if necessary. If needed, students are allowed to redesign their filter. Remind them that engineers often redesign something several times before they test and finally use the finished product.
- 12 After everyone has optimized their filters, begin final testing. Explain to students how to make the pollution collector and how to analyze the data. Tell students that they must put a piece of graph paper under the pollution collector and count how many particles are in 4 squares and then take the average.
- 13 The pollution collector is placed outside of the air pollution apparatus just beyond the ammeter. It is best to tape the collector to the bin that is being used to contain the escaping pepper.
- 14 After all groups have tested their filters, compare the results and filter designs. Ask students what was the most challenging part of the design process. Ask them if they would do it differently a second time.



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Assessment

Pre-Activity Assessment

Group Discussion: Review air pollution causes and filters that engineers use to clean the air by asking the following questions.

- 1** What are the different types of pollution?
(Answer: particulate matter, such as fly ash; toxic gases like sulfur oxides (SO_x), nitrogen dioxide (NO₂) and carbon monoxide (CO); and secondary pollutants, such as ozone (O₃)).
- 2** What are the major causes of pollution?
(Answer: The major man made sources of pollution are automobiles and burning coal; the major natural sources are forest fires.)
- 3** What can environmental engineers do to prevent pollution?
(Answer: The best way to stop air pollution is by not creating it in the first place. In addition, environmental engineers can engineer filters such as gravity settlers, cyclones, electrostatic precipitators, scrubbers and fabric or fiber filters.)
- 4** What's the relationship between human populations and per-capita consumption of natural resources and the resulting negative impacts on Earth?
(Optional: use this link as a resource: <http://www.nationalgeographic.com/environment/global-warming/pollution/>)

Activity Embedded Assessment

Cleaning the Air Worksheet:

Have the students record measurements and follow along with the activity on their worksheet. After students have finished their worksheet, have them compare answers with their peers.

Post-Activity Assessment

Sales Pitch:

Have the students pretend to be salespeople who are trying to sell their indoor air filter to a manufacturer or a consumer. Have student teams create a persuasive poster or flyer, as well as a 10-minute sales pitch of their filter design for presentation during the next class. Have them incorporate into their sales pitch particulate matter count, the parts and features of the filter and how it works.

Authors

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