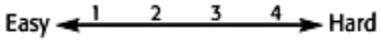
ENGINEERING LAB

Designing Climate Change Solutions

TIME REQUIRED Two 45-minute sessions

LAB RATINGS



Teacher Prep–1
Student Setup–1
Concept Level–3
Cleanup–1

3D LEARNING

- **SEP Asking Questions and Defining Problems; Developing and Using Models**
- **DCI ETS1.B Developing Possible Solutions; ETS1.C Optimizing the Design Solutions**
- **CCC Influence of Science, Engineering, and Technology on Society and the Natural World**

OBJECTIVE

Students use a computer simulation to design and test solutions that will lessen the negative effects of climate change on biodiversity.

SAFETY INFORMATION

- Make sure students exercise appropriate caution and do not share personal information online.

SETUP AND PROCEDURE

- Students may need extra guidance to find and recognize functional climate modeling simulations that run on the available equipment.
- Suggested search terms: climate modeling software, simple climate change model, climate modeling activity, climate model simulation

COLLABORATE

Organize students into groups of three or four to research climate change simulations online. Encourage each group to locate different simulations by using different sets of search terms/keywords, scrolling to different pages of search results, or another method. The goal is to locate functional, grade-appropriate simulations that meet requirements for the investigation and are compatible with available classroom equipment. Have each group locate a few different simulations and note the following information for each one:

- Title and URL
- Publisher/Organization
- Use online, download and install, or either
- If download: PC, Mac, or both

- Variables included (for example, CO_2, greenhouse gas emissions, sea level, and global temperature)
- Brief description of what the simulation does
- Any other notes (for example, intended audience/age range, ease of use, and last update)

When groups have finished, use a gallery walk approach to allow students to review each other's findings. Have each group lay their notes on a desk. One student in the group stays with the notes to answer questions while the other students walk around to see the other groups' notes and learn about other simulations. Each student group then chooses one simulation to start with. If any group needs to change simulations partway through, they can refer to the collection of notes taken by the whole class to identify alternatives.

ANSWER KEY

Conduct Research

1. Sources will vary. **Sample answer:** About 5.67×10^{20} joules, or about 18.0 terawatts; this is equivalent to 90 billion barrels of oil or 18 billion tons of coal

2. Values vary each year. **Sample answer:**

CO_2 equivalent emissions per year: 49 Gt (gigatons) (all greenhouse gases)

By source:

Energy: 36 Gt

Agriculture: 5.2 Gt

Industry: 3.2 Gt

Forest clearing: 3.2 Gt

Waste: 1.5 Gt

Ocean vessel fuels 1.1 Gt

3. **Sample answer:** Warming ocean water and cutting forests increases CO_2 concentrations in the atmosphere. Warming ocean water could be modeled by using a simulation that allows us to increase ocean water temperature over time and analyze how those changes affect CO_2 concentrations in the atmosphere.

4. Student answers will vary. Many simulations are available on research and university sites, as well as on NASA's site.

5. Student answers will vary but should identify an appropriate simulation or program.

Define the Problem

Student problem statements will vary but should focus on a specific approach to reducing atmospheric CO_2 and include measurable criteria and specific constraints that will guide solutions.

Design Solutions

Student solutions will vary depending on the approach chosen.

Test

Evidence Notebook answers should identify the simulation software used and include data from simulation tests, descriptions of changes made to optimize the solution, and additional data from tests of the optimized solution.

Optimize

Evidence Notebook answers should include a description of how well the solution met criteria while working within constraints, data from tests of optimized solutions, and consideration of the boundaries of the system used in the simulation software used for testing.

Communicate

Student explanations will vary. Explanations should address the questions listed under the Communicate head and be supported with evidence from the simulation and test results.

Name Date

ENGINEERING LAB

Designing Climate Change Solutions

Climate change has negative impacts on Earth's aquatic and terrestrial ecosystems. As a result, many scientists and engineers are trying to develop solutions to this problem. Scientists often use computer models to investigate the effects of interacting factors, such as carbon dioxide emissions and deforestation, on climate change.

MATERIALS

- computer with Internet access

In this lab, your task is to use a computer simulation to test solutions that could reduce the negative impacts of climate change on ecosystems and thereby reduce loss of biodiversity. The solution you propose should suggest a specific and measurable set of actions that could be taken to help solve this problem. The simulation you select and use should do the following:

- model multiple variables, such as forest cover and fossil fuel use, and their effects on Earth's climate
- produce quantitative data (such as numbers and graphs) showing the relationship between the variables you choose to model and climate parameters (such as carbon dioxide concentration)
- be based on scientifically accurate models and assumptions

Refer to the Engineering Design Process flow chart on page 3 as you design and test your climate change solution.

DESIGN CHALLENGE Use a computer simulation to design and test solutions that will reduce the negative effects of climate change on biodiversity.

CONDUCT RESEARCH

On your own or with a small team, research possible ways to reduce CO_2 emissions. At the same time, look for computer simulations you can use to model the effects of implementing these solutions. Some of these simulations also provide data about CO_2 emissions. To inform your thinking, take notes based on the following questions:

1. **Obtain Information** How much energy, from any source, does the world population consume each year?

2. What are the main sources of CO_2 emissions, and how much CO_2 does each source add to the atmosphere per year?

3. What are some factors other than energy that influence CO_2 concentrations in the atmosphere? How will you model these factors in the simulation?

4. What simulations exist to help you test possible solutions for reducing CO_2 emissions?

5. **Use a Model** Which simulation will you be using or, if you are making your own simulation, what program will you use to design it?

DEFINE THE PROBLEM

On your own or with your engineering team, define a specific problem related to reducing CO_2 emissions and then brainstorm possible solutions to this problem. For example, you may define the problem as "Reduce CO_2 emissions from power plants that burn fossil fuels" or "Increase forested land to store more CO_2 in trees." On the lines below, state your problem and then, using data from your research, list criteria and constraints for a successful solution. You may need to redefine the problem or think of new solutions based on the data you collected.

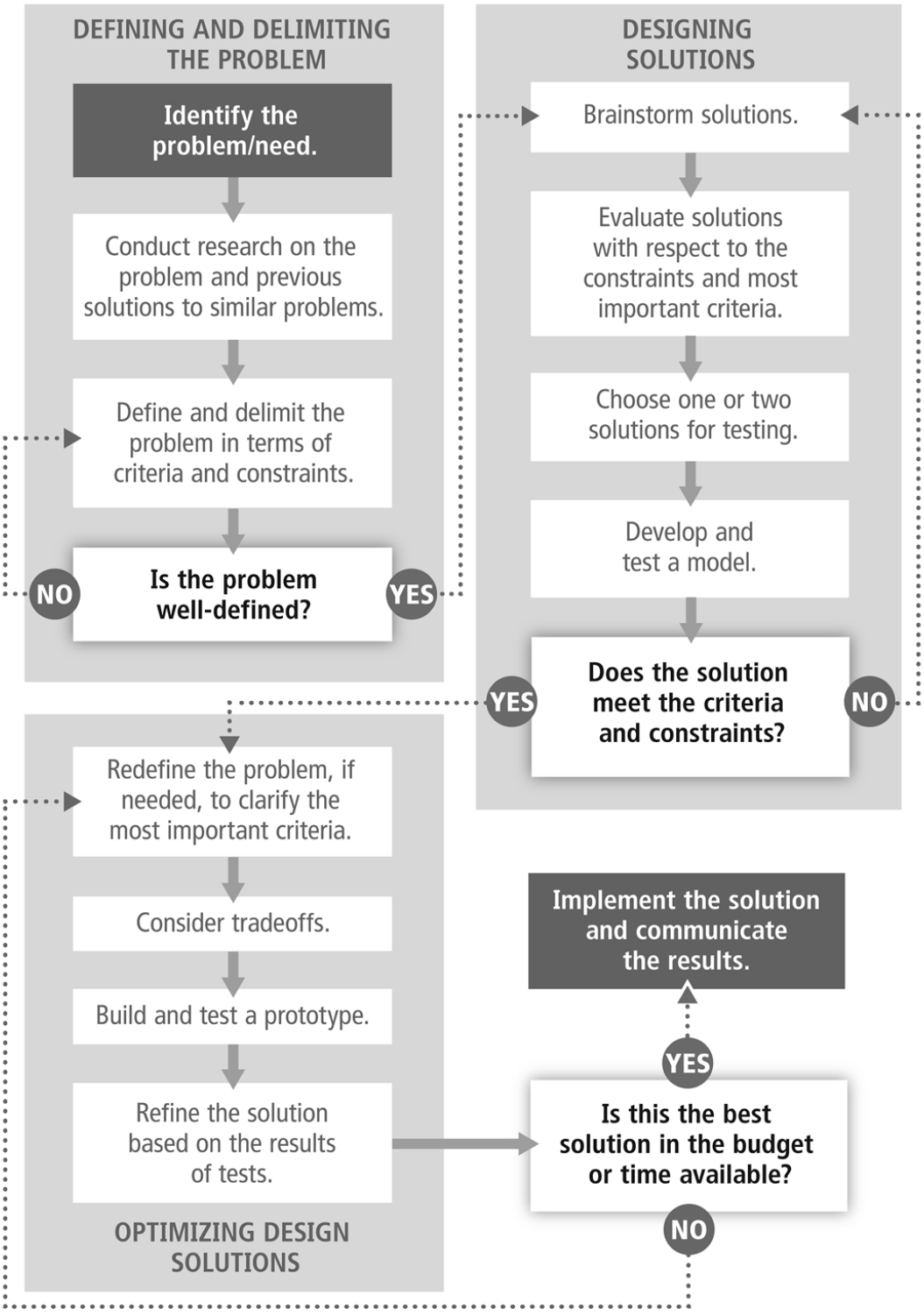
DESIGN SOLUTIONS

Based on your criteria and constraints, design a solution that can lessen the effects of climate change on ecosystems and biodiversity by reducing CO_2 emissions. You and your team may wish to research some of the designs engineers are currently considering to achieve these goals and then modify such solutions to meet your criteria and constraints. For example, "clean" coal technologies reduce CO_2 emissions, but mining coal still has negative impacts on ecosystems and biodiversity. Tradeoffs such as this must be considered in your final solution. Describe your design below.

TEST

Use a Model Once you have designed a solution, use a simulation or make your own simulation to test your design. You may be able to use the same simulation from which you gathered your initial data during research, or you may need to find a new simulation that is more specific to your design solution. For example, if your solution includes increasing the use of renewable energy and decreasing the use of fossil fuels, you may need to find a simulation that can test these variables while determining if those energy sources can still meet the energy needs of the world population. Record all necessary data in your Evidence Notebook, and perform calculations as needed. Continue testing solutions until you are certain that your solution meets the criteria and constraints.

Engineering Design Process



OPTIMIZE

Analyze your design's success in solving the problem you defined, using data to support your conclusions. Consider the following questions:

- Did your solution meet the most important criteria and the constraints?
- If your solution did not meet the criteria and constraints, how would you devise a new solution by modifying your design or redefining the problem?

- Can you think of any tradeoffs or potential problems introduced by your solution? How do those tradeoffs or problems affect the long-term success of your design?
- What are the boundaries of the system in the simulation? Are these boundaries realistic? Do you think they had an impact on the data you collected?

Record your analysis in your Evidence Notebook.

COMMUNICATE

Construct an Explanation Write an evidence-based explanation that communicates your results. What solution are you proposing, and how will it reduce climate change's negative impacts on ecosystems and biodiversity? How do the data you collected support your claim that this solution will be effective in reducing negative impacts? Are there any tradeoffs that should be considered further? How might social, cultural, and political factors influence the implementation of such a solution? Write your explanation in your Evidence Notebook.

EXTEND

Compare the costs and benefits of your solution with the costs and benefits of another group's solution. What impacts on society can you expect from implementing each solution? Will some people be more affected than others by the costs of implementing the solution? Will some people benefit more than others? Record your findings in your Evidence Notebook.