

BUILDING A
DEVICE THAT
CONVERTS ENERGY
FROM ONE FORM
TO ANOTHER
TO SOLVE A
PROBLEM



STUDENT HANDOUT

Utah SEEd Standard PHYS.2.4
Next Generation Science Standard HS-PS3-3
Grade and Topic: High School Physics


THE UNIVERSITY OF UTAH
College of Education


U.S. Department of Energy

Building a Device that Converts Energy from One Form to Another to Solve a Problem

To meet the objective of this lesson, you are going to need to engage in the engineering process. While there are many ways of envisioning the engineering process, in this lesson we are going to include the following steps:

1. Define the problem: What problem do you want to solve? This needs to be specific:
 - What is the problem?
 - Who is the solution for?
2. Identify criteria and constraints:
 - The criteria are “what does this solution need to do.” In this lesson, it needs to convert one form of energy to another
 - The constraints are the limits to your solution, these are often based on cost, but also on societal needs, or others. In this lesson, your constraints are “can you build this in the time allowed using the materials provided.”
 - There may be other criteria and constraints discussed as a class.
3. Research the problem: You need to find out:
 - What are the needs of the people you are creating this solution for?
 - What have others already done to solve this problem?
4. Develop possible solutions using models:
 - This can be a drawing, computer model, or prototype.
 - It needs to be detailed enough that you can build a prototype from the model.
 - This is the place where you can try out lots of different possible solutions before building them.
5. Analyze data to make improvements from iteratively testing solutions:
 - Iteratively testing means that we make small systematic changes to reach the optimal solution.
 - How to iteratively test a solution:
 1. Build your prototype
 - a. Record what you did
 - b. Make measurements of how it works
 - c. Record the results
 2. Make one small change to the prototype
 - a. Record the change
 - b. Make measurements of how it works
 - c. Record the results
 3. Change the same thing you changed last time, but a little bit more
 - a. Record the change
 - b. Make measurements of how it works
 - c. Record the results
 4. Repeat step 3 until results are satisfactory
 5. Make a different small change to the prototype
 - a. Record what you did
 - b. Make measurements of how it works
 - c. Record the results

6. Repeat step 3 until results are satisfactory
7. Repeat steps 5-6 until the results are satisfactory
6. Optimize a solution: This is what you've been doing the whole time!
 - Now pick the solution you made that
 - works best
 - within the criteria and constraints.
7. Communicate your results: Tell everyone what you did!
 - In this lesson, you will be doing a presentation for the class.
 - Make your presentation

Step 1: Define the problem and Step 2: Identify criteria and constraints

Group Name _____

Group Members _____

Instructions:

1. Spend 5-10 minutes brainstorming problems and possible solutions to these problems.
2. Select 2-3 of these problems to research.
3. Write the problems so they are well-defined. What is the problem? Why is it important? Who is this solution for?
4. Make sure your possible solutions fit within the criteria and constraints. Can this problem be solved with a device that converts one form of energy to another? Is this a device that you can build with the materials available in the time allowed? What other criteria and constraints do you have?
5. Get approval from your teacher to begin researching the problems.

Brainstorming problems:

In the space below, write as many problems and possible solutions as you can. Use additional pages if needed.

Selecting problems:

Circle 2-3 problems that you would like to research.

Defining the problems:

In the space below, write the problems you want to research. Make sure you word them in a way that is well defined. In defining the problems, make sure they address these questions: What is the problem? Why is it important? Who is this solution for? Use additional pages if needed.

Criteria and Constraints:

For each problem above, answer the following questions: How will a device that converts one form of energy to another solve this problem? Can you build this device with the materials you have in the time allowed? Does it meet any additional criteria and constraints? Use additional pages if needed.

Teacher approval _____

Get teacher approval before beginning the next step.

Step 3: Research the problem

Group Name _____

Names _____

Instructions:

1. As a group, decide which problem each person/pair will research.
2. Individually or in pairs, research your problem.
3. You need to answer the questions below. Your teacher may instruct you to answer additional questions as well.

Problem:

In the space below, write the problem you are researching: Make sure you include: What is the problem? Why is it important? Who is this solution for?

Research:

In the space below list 2-3 websites that address the problem. Describe the information available on the webpage. (For example, you might have a page about why the problem is important. You might have a page with instructions for how to build the device you want to make. You might have a page about a commercially available device that already solves this problem.)

Questions:

From your research answer these questions:

What are the needs of the people you are creating this solution for?

What have others already done to solve this problem?

What will your solution do that will improve on what others have already done?

Selecting a Problem through Consensus

Because you will be working as a group to build your device, you need to all agree on the problem you are trying to solve. In this process, you are going to give an initial proposal for which problem your group should work on solving. Next, you will discuss the proposals. After this, you will vote on the proposals. If you have consensus, you can move to the next phase. If you do not have consensus, you will return to discussing the proposals.

Initial Proposal

Each group member should begin their proposal with this statement:

I propose that we work on _____ problem. This problem is important because _____. This solution will benefit _____ type of people. This problem is solvable by building a device that converts energy from one form to another. This problem can be solved in the time we have with the resources we have.

Talk Moves to Come to Consensus

Next, as a group, you need to come to consensus about which problem to work on solving. Coming to a group consensus can be challenging. It is important that everyone's voice is heard and their opinions are respected. By listening to each other, it is possible for everyone to be able to agree on the final decision. Here are some talk moves to help you express your opinion and listen to your group members.

I agree with working on _____ problem because this problem is solvable by building a device that converts energy from one form to another.

I agree with working on _____ problem because this problem can be solved in the time we have with the resources we have.

I disagree with working on _____ problem because this problem is not solvable by building a device that converts energy from one form to another.

I disagree with working on _____ problem because this problem cannot be solved in the time we have with the resources we have.

I agree with working on _____ problem, because in addition to a solution to this problem meeting the criteria and constraints, this problem is important because _____.

I agree with working on _____ problem, because in addition to a solution to this problem meeting the criteria and constraints, this population is important because _____.

I disagree with working on _____ problem, because while a solution to this problem meets the criteria and constraints, this problem is less important than this other problem _____ because _____.

I am undecided about working on _____ problem and would like more information on why this would be a good problem for us to work on.

I am unsure about working on _____ problem because I have concerns about _____. How can we address my concerns?

Consensus Voting

In consensus voting, group members signal their vote with their thumbs.

- Thumbs-up indicates “yes, I want to do that!”
- Thumbs-down indicates “absolutely not! I will never do that!”
- Thumbs-sideways is “I’m not enthusiastic about that, can we talk about my concerns?”

If a vote has any thumbs-down or thumbs-sideways, the discussion must continue with students presenting their arguments.

Deciding on a Problem

Once the group has reached consensus, the teacher will sign off on the problem, and students continue onto the next step.

Step 4: Develop possible solutions using models

Group Name _____

Names _____

Instructions:

1. Individually or in pairs, brainstorm ideas for devices that will solve your problem by converting one form of energy to another.
2. Draw diagrammatic models of the ideas you think will work best.
3. Pick one to present to your group.
4. Use the consensus process from “selecting a problem” to select the model to prototype.

Problem:

In the space below, write the problem you are researching: Make sure you include: What is the problem? Why is it important? Who is this solution for?

Research:

Answer these questions:

What are the needs of the population this solution is designed for?

What have others done to solve this problem?

Diagrammatic Models:

In the space below, draw your designs for your engineering solution. Use additional pages as needed.

Selecting a model:

Identify your best design.

What are the advantages of this design?

What are the disadvantages of this design?

Initial Proposal:

Each group member should begin their proposal with this statement:

The model I am proposing is this one _____ . It solves _____ problem by converting _____ energy to _____ energy. I think this is my best model because it has these advantages _____. I also recognize that it has these disadvantages _____ which we should be able to address when we are testing it.

Selecting on a Model through Consensus:

Use the consensus process from “Selecting a Problem through Consensus” to choose which model to build the initial prototype. Below are some talk moves to help with this process.

I think we should build _____ model because it has _____ advantages.

I don't think we should build _____ model because it has _____ disadvantages.

I notice that both our models _____.

I notice that my model _____ while your model _____.

I like the way your model _____.

Could we make _____ change to _____ model to solve _____ disadvantage?

I agree with what you said and I also want to add that _____.

I disagree with what you said, and my reason is _____.

I think you said _____ is that what you meant?

Can you clarify what you meant by _____?

Could we make _____ change to your model to solve _____ disadvantage?

Deciding on a Model:

Once your group has reached consensus about which model to build as a prototype, the teacher will sign off on the problem, and students continue on the next step.

Step 5: Analyze data to make improvements from iteratively testing solutions and
Step 6: Optimize a solution

Group Name _____

Group Members _____

Instructions:

Once you have selected your model, you will begin the process of iteratively testing the solution.

- Which model did your group choose? Attach the relevant drawing to this page.
- What materials do you need to construct this model?
- Obtain these items from the supplies provided. If some supplies are not available, decide what you will use instead, or determine if there is a way to obtain these items and still meet the constraints of the solution.
- Work as a group to build the model.
- Iteratively test the model by making small changes to the model and recording the results of these changes. Record all the tests and results

1.0 -- Initial test: This is the test of your prototype.

Results:

1.1 -- First iteration: This is the first change you made to the prototype. Record the change here:

Results:

1.2 -- Second iteration: change the same thing as before, just a little bit more. Record the change here:

Results:

1.3 -- Third iteration: change the same thing as before, just a little bit more. Record the change here:

Results:

Repeat: Use additional pages as needed.

- When you are satisfied with that modification, select a different part of the prototype to test, and repeat the testing process. Use additional pages as needed.

2.1 -- First iteration of second modification: This is the first change you made to the modified prototype. Record the change here:

Results:

2.2 -- Second iteration: change the same thing as before, just a little bit more. Record the change here:

Results:

Third iteration: change the same thing as before, just a little bit more. Record the change here:

Results:

Repeat: Use additional pages as needed.

- When you are satisfied with all your changes, pick the solution you made that works best within the criteria and constraints. This is optimizing your solution.

Which solution did you choose?

