

# FUEL OUR FUTURE NOW

G6–8

## LESSON 4 — A Weighty Decision

### MODULE OVERVIEW

**Module Title:** Designing a Vehicle for the Year 2020

**Module Description:** Students learn about natural resources, human effect on the environment and engineering design through this brief module on vehicle transportation. They study how vehicles of today are designed and how vehicles could be improved for the future. Using real world scientific data and science reasoning skills, they investigate existing energy sources and designs for vehicles as well as emerging alternative energy sources and designs for vehicles. They take a realistic look at existing energy and fuel infrastructure and consider how that infrastructure will change, or need to change, by 2020. Students conduct investigations into vehicle design, and use content from videos and online resources. Finally, they apply this knowledge to realistically design their own “vehicles of the future” and to create multimedia presentations of their ideas for classmates.

**Module Project:** Students consider how fuel-efficient and environmentally friendly technologies will impact the kinds of vehicles available in the year 2020. They use videos, multimedia presentations, or pamphlets to design and advertise their “cars of the future.”

### LESSON OVERVIEW

**Lesson Time:** Three 45-minute classes

Another way to improve a vehicle’s fuel efficiency is to decrease its weight. This can be done simply by removing excess weight from the vehicle—for example, boxes or luggage currently being stored in a car can be stored elsewhere. The greater challenge, however, is to continue to improve and to develop new lightweight materials to use in the manufacturing of vehicles. In Lesson 4, students will experiment with a variety of lightweight materials in order to determine how different materials affect a vehicle’s fuel efficiency. They will then apply this knowledge to their own vehicle designs for the year 2020.

## BACKGROUND FOR TEACHERS

Generally, as a vehicle's weight decreases, its fuel efficiency improves. This is because less power is needed to move a lighter vehicle than to move a heavier vehicle.

Using lightweight materials to replace more traditional metals such as steel, manufacturers today can build more fuel-efficient vehicles without sacrificing safety, durability, and comfort. Common lightweight materials include aluminum, plastics, magnesium, carbon fiber, and metal matrix composites (composite materials consisting of both metal and nonmetal components). For every 10% of weight eliminated from a vehicle's total weight, fuel economy improves by 7%. A major focus of researchers affiliated with the Partnership for a New Generation of Vehicles is to develop new lightweight, high-strength materials. Researchers are aiming to cut vehicle weight by up to 40%—about 1,200 pounds—compared to today's average mid-sized sedan. Research must also find cost-effective ways to mass-produce vehicles constructed with lightweight materials.

Current aluminum technology can cut half the weight out of a conventional body structure, and many manufacturers are already using it extensively. (See site below for examples.)

Source:

FuelEconomy.gov - Lightweight Materials: <http://www.fueleconomy.gov/feg/lightweight.shtml>

**Teacher Preparation:** As a reminder: throughout the module, students should check in with fellow design team members (teams of 3-4 identified at the end of Lesson 1). In addition, each student should continue to take individual notes in his or her Engineering Notebook that might apply to the final team idea. You may wish to meet with students at different points throughout the module to check on their progress and remind them of the final project.

## LESSON OBJECTIVES

By the end of this lesson, students should be able to:

- Explain the relationship between a vehicle's weight, fuel efficiency, and safety.
- Demonstrate the relationship between weight and fuel efficiency by constructing a model vehicle and conducting an experiment.
- Compare and contrast different lightweight materials that might be incorporated into vehicles.

Please see *Standards Addressed in G6-8* for a list of the applicable science, technology, engineering, and math standards, as well as the 21<sup>st</sup> Century Skills.

### **Lesson Essential Questions:**

1. How does a vehicle's weight affect its fuel efficiency and safety?
2. How can the relationship between a vehicle's weight and fuel efficiency be tested?
3. What are some lightweight materials, and how do they differ from each other?

### **Key Vocabulary (appropriate for a word wall):**

*lightweight, modify/modification, trial*

## RESOURCES

### **Materials needed:**

- Materials for balloon-powered cars (per team):

<u>Design 1</u>	<u>Design 2</u>
– Polystyrene foam tray	– 4 plastic lids
– Scissors	– Hand drill (check local safety guidelines on use)
– Compass	– Corrugated cardboard (15 cm x 10 cm)
– Balloon	– 2 straws (straight and bendable)
– Flexible straw	– 2 bamboo skewers
– Tape	– Balloon
– 4 pushpins	– Rubber band
	– Masking tape
	– Scissors
	– Adhesive (check local safety guidelines for acceptable adhesives)
- Chalkboard and chalk, or whiteboard (or interactive whiteboard, if available)
- Computer with Internet access linked to a projector or TV (for whole class to view at once), PLUS additional computers with Internet access (one per student or student pair)
- Assorted metal washers or other small masses
- Meter sticks
- Various alternate materials (e.g., aluminum foil, plastic wrap, balsa wood, poster board)
- Triple beam balance
- Graph paper (ideally, projected as a transparency on an overhead or displayed on an interactive whiteboard)
- Index cards for *Wrap-up* activity (one per student)
- Engineering Notebook for each student

### **Resources from FuelOurFutureNow.com:**

- Video: [Green Gadgets: Smart<sup>®</sup> Car](#) (3:07)

### **Resources from other Web sites:**

- <http://quest.nasa.gov/space/teachers/rockets/act2ws1.html> – *How to Build a Rocket Car*
- [http://sciencesquad.questacon.edu.au/squad\\_activities/balloon\\_powered\\_car.html](http://sciencesquad.questacon.edu.au/squad_activities/balloon_powered_car.html) – *Balloon-powered Car*

### **Student Worksheets Required:**

- *Data Table 1: Balloon-Powered Cars* (one copy per team)
- *Data Table 2: Modified Cars* (one copy per team)

### **What skills do students need for this lesson?**

- Follow directions to construct a model vehicle
- Gather and record experimental data
- Use experimental data to make and confirm predictions
- Use experimental data to modify designs
- Use the Internet safely and appropriately to search for specific data
- Communicate information to peers

## **TEACH**

### **Engage**

- Review what students learned about fuel efficiency. Review the data from the chart the class made in Lesson 1 that indicates how many vehicles were in a particular mpg range on the chart. Ask students if, in the work they've done, they noticed what, if anything, vehicles that got low gas mileage had in common. In most cases, these vehicles tend to be larger and heavier than those that get high gas mileage.
- Recall the video on the [Smart Car](#) (from *Green Gadgets*). What did they first notice about this highly efficient vehicle's size?
- Ask students if they would prefer to carry home a backpack full of textbooks or one that is empty. The empty one is far lighter (has less mass) and takes less effort to carry. Explain that it's the same with vehicles.
- Guide students to understand that lighter vehicles require less power to move, which means that a specific quantity of energy will move them farther than that same quantity of energy will move a heavier car.
- Have students work in their teams to brainstorm a list of all the different ways they can think of to reduce the weight of a car. Students should think not only about replacing heavier materials with lighter materials in the body of the car, but also about making various car parts lighter. Encourage students to use sketches or diagrams to represent their ideas in their Engineering Notebooks.
- Have teams share their ideas with the class, and compile a class list of possible solutions.

## Explore

- Each team will need time to construct a balloon-powered car with which to experiment. Depending on available materials, one of the following designs should suffice:
  - <http://quest.nasa.gov/space/teachers/rockets/act2ws1.html> – *How to Build a Rocket Car*
  - [http://sciencesquad.questacon.edu.au/squad\\_activities/balloon\\_powered\\_car.html](http://sciencesquad.questacon.edu.au/squad_activities/balloon_powered_car.html) – *Balloon-powered Car*
- When teams have completed their cars, distribute the *Data Table 1: Balloon-Powered Cars* worksheet and assign each team to a flat surface in the classroom, such as a lab table, that will serve as a track for the team’s car. Teams should line several meter sticks along the length of their tracks.
  - Explain that teams will be loading their cars with three different quantities of metal washers—a light quantity, a medium quantity, and a heavy quantity—and then running them along the track to determine the effect of weight on the distance the car travels. (You will need to determine ahead of time the mass of each quantity and how many washers are necessary to achieve each mass; the specific numbers aren’t important, so long as each team is using the same masses.)
  - Each team will run 10 trials for each quantity of washers, using the meter sticks to determine the distance the car travels for each trial, and then calculate the average distance traveled for each mass. Emphasize that students should blow up the balloon to the same size for each trial to ensure that the same amount of “energy” powers the car each time.
  - Teams should record their data from each trial on their *Data Table 1* worksheets and then answer the questions at the bottom. Students should realize based on their data that lighter cars are more “fuel efficient”—that is, the same amount of energy (i.e., breath) moves them farther.

## Explain

- Have teams regroup and share their results with the rest of the class. If any groups achieved different results, discuss the possible reasons why. (Most likely, they did not perform the experiment correctly—for example, they may not have been consistent in blowing up the balloon to the same size for each trial.)
- Ask students whether they can think of any possible downsides to reducing vehicle weight. Students may recognize that lighter vehicles may suffer greater damage (and thus put their passengers in greater danger) in a crash. Write the following information on the board, explaining that this data comes from the Insurance Institute for Highway Safety, and concerns cars and vans made between 1993 and 1996<sup>1</sup>:

---

<sup>1</sup> <http://www.safecarguide.com/exp/deathrate/deathrate.htm>

- Mini- and compact vehicles: less than 2,500 lb
  - 200+ deaths per million vehicles
- Small vehicles: 2,500–2,999 lb
  - Approx. 150 deaths per million vehicles
- Medium vehicles: 3,000–3,499 lb
  - Approx. 100 deaths per million vehicles
- Large vehicles: 3,500–4,499 lb
  - Approx. 125 deaths per million vehicles
- Ask students if they can explain the reason for the pattern in these figures. Guide students to understand that as cars get larger, they generally become less dangerous to their occupants in a crash, but more dangerous to the occupants of other vehicles; as cars get smaller, they generally become more dangerous to their occupants in a crash, but less dangerous to the occupants of other vehicles. Thus, reducing vehicle weight requires balancing the desire for improved fuel efficiency with the desire for safety. Emphasize that students must strike this balance as they consider ways to make their vehicles lighter.

NOTE: This is a good place to break between class sessions. Remember to end the first part of the lesson with a quick review of what students have done so far, and to begin the second part of the lesson with a brief review of what students learned in the previous period.

This second part may require more than one class period since students will be undertaking engineering design, testing, and redesign.

### **Extend**

- Explain to students that they will now have an opportunity to modify their balloon cars by replacing the materials from which they were created with different materials. Students can also make modifications to the shape of their balloon cars. Their goal is to determine how different designs affect how far a vehicle can travel on a given amount of fuel (as before, the “fuel” is the students’ breath).
- To create their modified designs, students should follow the same basic plan as before. The primary difference is that they will be using different materials. To help them achieve this, provide students with a variety of alternative materials from which to construct new balloon cars or with which to modify their old ones. These materials may include the following:
  - Aluminum foil
  - Plastic wrap
  - Cardboard (if original designs called for polystyrene foam)
  - Polystyrene foam (if original designs called for cardboard)
  - Balsa wood
  - Poster board

- Students should sketch their modified designs in their Engineering Notebooks before they begin modifying their actual balloon cars. One modification should be lighter than the original car, and one modification should be heavier than the original car. (If time is an issue, you may wish to divide each team in half, so that some members work on the lighter modification while other members work on the heavier modification—this will require additional materials, since each team will be creating two new cars simultaneously.) You may wish to have each team run its designs by you so that you can approve them. Walk around during this work and observe and ask questions to determine if they understand the process and the content.
- Distribute the *Data Table 2: Modified Cars* worksheet to each team. Have students use the triple beam balance to find the mass of their original car. Then give each team time to modify its car twice, using the triple beam balance to find the mass of each modification and recording that data on the *Data Table 2* worksheet.
- As before, each team will run 10 trials for each modified car, using the meter sticks to determine the distance the car travels for each trial, and then calculate the average distance traveled for each modified car. Emphasize again that students should blow up the balloon to the same size for each trial to ensure that the same amount of “energy” powers the car each time.
- Teams should record their data from each trial in their data tables and then answer the questions at the bottom of the worksheet.
- Have teams share their results with the rest of the class. Work with the class to plot the data on a graph, with the mass of each car plotted on the x-axis and the average distance each car traveled plotted on the y-axis. See if students discern a pattern in the data—most likely, they will notice that lighter vehicles travel farther on average than heavier vehicles do.

### Evaluate

- In their teams, have students decide how to incorporate various lightweight materials into their vehicle designs. Explain that these designs may be incorporated into their final products.
- Have students enter their findings from this activity in their Engineering Notebooks. In particular, they should include plans—including sketches and diagrams—for incorporating lightweight materials into their final vehicle designs.

### Wrap-Up

- Have students recall what they did in Lesson 4. As this is the midway point in the module, you may wish to pass out index cards to each student to use as “exit” cards. Before students leave class, they should write down one thing they have learned about each of the following topics and explain how they plan to incorporate that knowledge into their vehicle designs:
  - Fuel efficiency
  - Eco-friendly design
  - Alternative energy sources
  - Vehicle emissions
  - Lightweight materials
- Briefly review the pros and cons of using various materials to reduce a vehicle’s weight.

- Preview Lesson 5. Explain that today they learned about how lightweight materials can be used to decrease a vehicle's weight and decided how to use these materials in the cars they wish to design. Tomorrow they will again study how vehicles of the future can be powered. They will be looking at the roads and fueling stations that make up our transportation system.

*Acknowledgment: This material is based upon work supported by the Department of Energy, National Energy Technology Laboratory under Award Number DE-FG26-08NT03077.*

*Disclaimer: This Curriculum was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express, or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.*





Data Table 1: Balloon-Powered Cars

<i>Weight of car</i>	<b>Distance</b>		
	<i>Light:</i>	<i>Medium:</i>	<i>Heavy:</i>
Trial 1			
Trial 2			
Trial 3			
Trial 4			
Trial 5			
Trial 6			
Trial 7			
Trial 8			
Trial 9			
Trial 10			
Average distance			

What is the effect of increasing the number of washers (i.e., the weight of your car) on the distance the car travels? How is this related to fuel efficiency?





Data Table 2: Modified Cars

	Distance	
<i>Mass of original car:</i>	<i>Mass of modification 1:</i>	<i>Mass of modification 2:</i>
Trial 1		
Trial 2		
Trial 3		
Trial 4		
Trial 5		
Trial 6		
Trial 7		
Trial 8		
Trial 9		
Trial 10		
Average distance		

What is the effect of decreasing the overall mass of your vehicle? What is the effect of increasing the overall mass of your vehicle?

