FUEL OUR FUTURE NOW

Family Activity

GRADE LEVELS: 3-5, 6-8

BE A BIKE ENGINEER

What factors affect vehicle efficiency?

<u>Introduction</u>

Wouldn't it be great to have your child become a vehicle efficiency engineer for a day, collecting some actual data, organizing and analyzing this data, then drawing some conclusions? This activity will engage you and your child in a series of investigations with your child's bicycle to model some of the factors professional engineers must consider when designing a vehicle for efficiency.

This activity assumes your child has access to a proper fitting bicycle and a safe operating environment, wears a bicycle helmet, and is careful in conducting these investigations. **Be sure to stress and monitor safety**. But also stress the fun and excitement of scientific investigation. This activity is not CSI, but it is a real hands-on investigation!

<u>Materials</u>

bicycle
helmet
playground, sidewalk, or safe street (supervision required)
bike pump
tire gauge (optional)
bike rack (attached to rear of bike if possible)
weights (sand, gravel, books, etc.)
scale (optional)
pencil
course markers (blocks of wood, chalk, cones, toys)
course measuring tool such as yardstick or tape measure (optional)
"Bike Engineer Data Log" (found at the end of this activity)

Discussion

To begin this activity, ask your child what things or factors he or she thinks affect the *gas mileage* or *fuel efficiency* of the family car. If either term is not a familiar concept, offer appropriate definitions, making reference to filling the car's gas tank at a gas station, how much that costs, and how far you can drive before you need to refill the gas tank. In this discussion, bring up the idea that people called *engineers* who work at automobile companies initially came up with a design for a particular car before it was actually made by other people at a factory. These engineers had to consider the car's aerodynamics, tire design, and the engine/transmission size, design and efficiency. Other factors like how you choose to drive (driving habits) and how you maintain the car can also affect gas mileage.

Next, ask your child to pretend to be an engineer who is interested in finding out what things affect the efficiency of his or her bicycle. Since there is no gas needed for riding a bicycle, efficiency can't be measured by gas mileage. What will be easy to observe and even measure, however, is the distance your child can coast on his or her bicycle, which we'll call the coasting distance. In this exercise, coasting distance is the *dependent variable*. You and your child will be observing how changing different factors—tire pressure, load, and aerodynamics (the *independent variables*)—affects coasting distance. Data tables to record this information can be found at the end of the activity.

The Investigation

Maintaining fairness and consistency for each test will ensure that the measurements taken are as accurate as possible. You can help your child understand and appreciate this concept by comparing the need for fairness and consistency in scientific experiments with the need for fairness in sports—for example, no head starts, extra pushes, or pedaling when you should be coasting. For this investigation, you will change the suggested factors one at a time in order to obtain accurate data for comparison.

This activity will work best if you have access to an area of hard surface that is slightly sloped. This could be a school playground, a sidewalk, or a low-traffic street. **Be sure to consider safety for your child when choosing a location for these investigations.** This area will be referred to as the course. The need for a surface that slopes slightly downward is so your child can coast on the bike as far as possible from an initial starting location. This starting location could be marked with a block of wood, chalk, or a natural crack in the surface. The distance needed for coasting will depend on factors such as condition of the bike, angle of slope, and factors you change in the investigation. You'll have to determine this distance with some trial and error. It could range anywhere from 50 to 150 yards.

If you want to incorporate math into this activity, you could choose to measure the coasting distance with an available tool: tape measure, yardstick, pole, or even by counting paces. Otherwise, you could simply indicate the coasting distance with markers (cones, blocks of wood, toys, etc.) and use descriptive terms to record the distance (e.g. “short,” “medium,” “long,” or “very long”). Feel free to modify or even make your own data tables to adapt them to your particular needs.

To record data during the investigation, provide your child with a copy of the “Bike Engineer Data Log” found at the end of this activity.

<u>Changing Tire Pressure</u>

Start by changing the tire pressure to see what effect this has on coasting distance. It will be important to know how much air pressure is in the bike tires. At the end of this activity is a general guide to help you determine the air pressure. You can measure the air pressure in the tires in one of several ways:

1. If you have a bike pump with an integrated pressure gauge, or if you have a stand-alone tire gauge, simply read and record those values in the data table. This would quantify air pressure and add some math to this activity. The air pressures will be quite low, so the gauge will need to be able to measure small values (5 – 30 pounds per square inch or psi).
2. If a pressure gauge is not available, you could count the number of pumps of air you put in the tires. This would give you a relative measure of air pressure from one trial to the next (10 pumps and the bike coasted 40 yards; 20 pumps and it coasted 50 yards, etc.).
3. Another option if you do not have access to a pressure gauge would be squeezing the tire between your thumb and fingers to get a sense of how much it compresses. Even though a tire looks “full,” it can actually compress quite a bit, depending on how hard you squeeze it and how much air pressure is in the tire. Come up with a “scoring system” or term that you and your child can agree upon.
4. An alternative to squeezing the tire would be to push down on the handlebars and observe how much the front tire compresses. If the bike has a front brake, be sure to engage it so the bike can’t roll forward.

Begin with the tires at a very low pressure (somewhere between 5 and 10 psi). (Refer to the general guide to tire pressures that can be found at the end of this activity.) Depending on the method you use to measure the tire pressure, enter a number or term in the “Bike Engineer Data Log” also found at the end of the activity. With helmet in place and the course safely cleared, your child should get on his or her bike at the starting point and gently push off with just enough speed so he or she can stay balanced. The speeds should be slow enough that your child can coast down the course with feet extended to the side (and exercising caution while doing so). Try to maintain a consistent starting speed for all tests. As the bike slows to a stop, your child should be able to maintain control without tipping over and be able to put his or her feet on the ground when stopped. Measure or estimate this distance and record it in the data log.

Using the pump, have your child add a little air pressure to both tires. “A little” means about 5 psi or about five pumps of the bike pump. Repeat the procedure of testing the coasting distance on the course, doing everything the same as before. Observe and record this data in the data log. Add a little more air pressure to the tires and repeat the procedure a third time. You should be observing a difference in coasting distance as you increase the pressure in the tires. Once the tires are no longer “soft,” you won’t be able to detect much difference in coasting distance as you add more air pressure.

Changing the Load

Your child should start this part of the activity with the tires “soft,” in other words, very low air pressure. You’ll want about the same pressure as when you observed a short coasting distance. This part of the activity assumes you can attach some weight to the bike, so a rack on the back would be ideal. The weight (load) could be in the form of small bags of sand, gravel, or even books and should amount to about 25-50 pounds at most. **Take care not to place more weight on the rack than what your child can safely handle.** Try not to add the weight to the handlebars; this could have an adverse affect on the handling of the bike. If a scale is available, use it to measure the weight of the added load in pounds and record this numerical value instead of using the terms “none,” “some,” and “a lot.”

Begin with no added weight and using the same course, have your child push off and observe how far he or she can coast. Record this information in the data log. Next add about half the weight you have available to the bike, repeat the trial and record this data. Finally, add the remainder of the weight, repeat the trial and record this data.

Changing Aerodynamics

The effect of this factor is not as easy to observe as tire pressure or load because at low speeds, air resistance does not change noticeably with increased speed. It is usually only a factor at higher speeds. If your child would like to try to observe the effect of air resistance, they could try coasting on the course both sitting up and crouching down as low, and safely, as possible, much like professional cyclists do sometimes in a bike race. If you can't detect any noticeable difference in coasting distances, your child might try riding faster in a safe environment (accompanied by you on your bike perhaps). Get up to speed, stop pedaling, and while you sit upright and coast, try to get a sense of how quickly your child's bike slows down. After this, get up to the same speed again, stop pedaling and crouch down in a tucked position, coast, and observe any differences in slowing speed/time. There is a table to record these observations on the data log sheet.

Analyzing the Data

Now that your child has collected some data as a bike engineer, the two of you can look at this data, the results, and try to make sense of it. In looking at the results, pose some of the following suggested questions, but try not to answer for your child. Let him or her go through the process of analyzing the data, thinking about the mechanics of how a bike works, and drawing his or her own conclusions.

What was the effect of changing the tire pressure? How would your child describe the relationship between tire pressure and coasting distance? If your child has graphing skills, ask him or her to make a graph that would show this relationship to a friend. What scientific principles can explain why a given change in tire pressure resulted in a given change in coasting distance? Do the results suggest any guidelines for operating an automobile in a more efficient way so it gets better gas mileage? Remember, you are expecting your child to work like an engineer in this activity.

What effect did adding weight to the bike have on coasting distance and why? Again, what are the implications for driving an automobile?

If your child investigated aerodynamics with the bike, what did he or she discover? How could these results be applied to other objects that move through air or water? What has your child learned that could apply to improving automobile design?

Another thing for your child to consider is the presence of other extraneous factors or conditions that could have affected the accuracy of the experiment. How might weather conditions have affected the data? Was your child able to get precise readings every time for weight, tire pressure or other data points?

Drawing Conclusions

Now that you and your child have talked about the results of these investigations, what conclusions can your child make? There is space on the data log sheet to compose a written conclusion. How would your child summarize the results and implications to share with another member of the family? Get your child to think about how the investigations were carried out. What might your child consider doing differently if he or she were to do this activity a second time? What factors might automobile engineers consider as they design cars of the future for improved fuel efficiency?

Resources on the Internet

The U.S. Department of Energy has several excellent Web sites about fuel economy that you and your child might want to look at now that you've completed this activity. "Gas Mileage Tips" talks about several of the factors you investigated in this activity and can be found at: http://www.fueleconomy.gov/feg/drive.shtml. Be sure to watch the short video entitled "MotorWeek Video" that can be found on that site. "Driving More Efficiently" can be found at: http://www.fueleconomy.gov/feg/driveHabits.shtml. This site offers practical advice for improving gas mileage.

For more resources, visit www.FuelOurFutureNow.com.

A General Guide to Air Pressure in Bike Tires

(Pressure values, appearance, and firmness will all vary depending on the type of tire and may be quite different from those listed below. The number of pumps to increase air pressure will depend on the type of tire and the particular bike pump you use.)

Air pressure (psi)	Appearance of tire	Compression of front tire	Approximate number of pumps required
5	flat	some with just the weight of the bike	5
10	soft	slight with just the weight of the bike	8
15	low	none with just the weight of the bike but some with a slight downward force on the handlebars	11
20	looks full	some with a moderate downward force on the handlebars	15
25	looks full	some with great downward force on the handlebars	19
30	looks full	minimal with great downward force on the handlebars	23

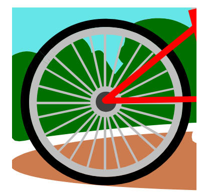
For more resources, visit www.FuelOurFutureNow.com.

Bike Engineer Data Log

Directions:
Your parent is going to help you do an experiment to find out if changing certain features about your bike has any effect on how easy it is to pedal. This relates to what's called *efficiency*. Use the data tables below to record the data you collect during these investigations.

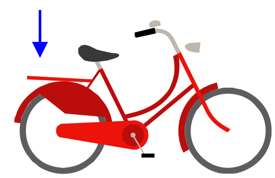
Change: ***tire pressure***

Tire pressure	Coasting Distance



Change: ***load***

Added Load	Coasting Distance
none	
some	
a lot	



Change: ***aerodynamics***

Ride position	Coasting distance or degree of slowing
high or normal	
crouched down	

After analyzing my results, my conclusions are:

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