2.8 Explore

Investigate New Brake Designs

2.8: Part 1 of 4- Think about the Brake's Design

Earlier you noticed that when the truck traveled over different surfaces, each surface changed the stopping distance of the truck. You also found that the use of a brake shortened the stopping distance. Both of these effects were because of friction, but what if the friction in your brake wasn't enough to prevent an accident? The target vehicle (car) from your earlier tests was positioned well before the average impact location. As an engineer, you have tested one solution but now you must modify it based on the test results in order to improve it. How might you redesign the brake to improve the stopping distance? (We'll refer to the brake that you tested earlier as the "basic brake design".)

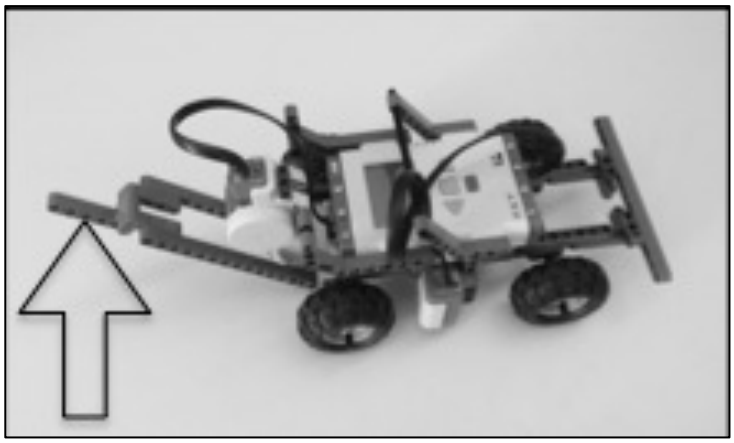
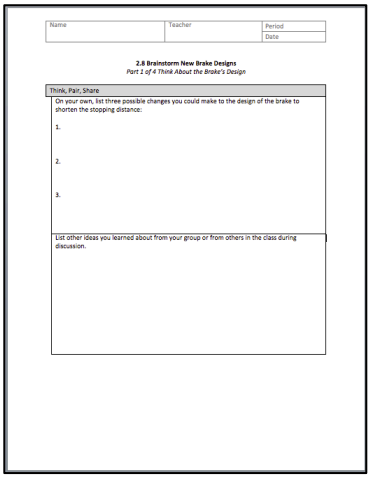


Figure 2.8.1 LEGO Truck Brake ("basic brake design")

GROUP

Think, Pair, Share: On your own brainstorm how we can further reduce the stopping distance of the brake. Consider the criteria and constraints for the challenge when you are brainstorming new ideas. Record your ideas on the *Brainstorm New Brake Designs* sheet. Afterwards, you will work with your group to discuss your ideas, and then share some of these ideas with your class. Your teacher will record these ideas on the board.

2.8 Explore



Name | Teacher | Period | Date

2.8 Brainstorm New Brake Designs
Part 1 of 4 Think About the Brake's Design

Think, Pair, Share

On your own, list three possible changes you could make to the design of the brake to shorten the stopping distance:

1.

2.

3.

List other ideas you learned about from your group or from others in the class during discussion.

2.8: Part 2 of 4- Investigate Different Brake Design Options

Now you will test a change to the brake design (that your class probably came up with) to see how it affects stopping distance. Your teacher will assign your group a variable (either a different material to attach to the basic brake or a new brake shoe design) to test. The new materials to test are: felt, plastic wrap and foil. The different brake shoe designs include: a large shoe (Figure 2.8.2), a small shoe (Figure 2.8.3) or a rake shoe (Figure 2.8.4). Your group will be assigned one of these designs to test and compare to the basic brake results. Iterative design is a cyclical process to help you achieve the best possible result for the problem you are working on. It involves testing a design, analyzing the results, modifying the design and then re-testing and possibly modifying the design again.

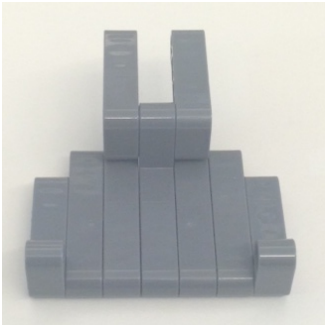


Figure 2.8.2 Large Brake Shoe

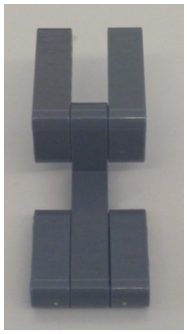


Figure 2.8.3 Small Brake Shoe

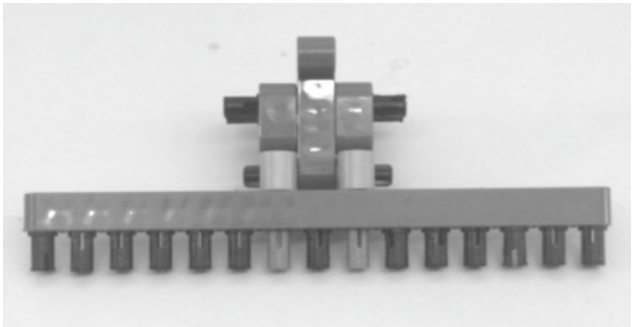


Figure 2.8.4 Rake Brake Shoe

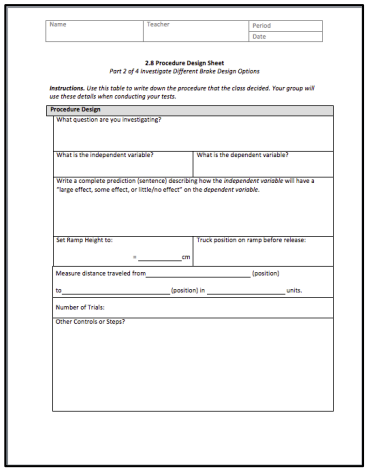
2.8 Explore

After you test this variable (the new design) you will be able to compare these results to the stopping distance results from your investigation of the basic brake design (Section 2.6). This will let you determine if the new design is more effective than the basic brake design.

It would take too long for each group to test every variable, so we will split the work and have different groups test different variables. Later, all of the groups will share and compare their test results and data. Therefore you will need to decide upon a class procedure and a set of controls for your test.

CLASS

Complete the *Procedure Design Sheet* to record your procedure and the details for your tests.



Name | Teacher | Period | Date

2.8 Procedure Design Sheet
Part 2 of 4 Investigate Different Brake Design Options

Instructions. *Use this table to write down the procedure that the class decided. Your group will use these details when conducting your tests.*

Procedure Design

What question are you investigating?

What is the independent variable? | What is the dependent variable?

Write a complete prediction (sentence) describing how the *independent variable* will have a "large effect, some effect, or little/no effect" on the *dependent variable*.

Set Ramp Height to: = _____ cm | Truck position on ramp before release:

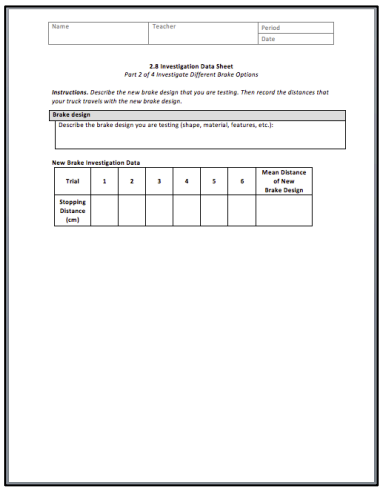
Measure distance traveled from _____ (position) to _____ (position) in _____ units.

Number of Trials:

Other Controls or Steps?

GROUP

Run your investigation following class procedure. Record your results on the *Investigation Data Sheet*.



Name | Teacher | Period | Date

2.8 Investigation Data Sheet
Part 2 of 4 Investigate Different Brake Options

Instructions. *Describe the new brake design that you are testing. Then record the distances that your truck travels with the new brake design.*

Brake design

Describe the brake design you are testing (shape, material, features, etc.):

New Brake Investigation Data

Trial	1	2	3	4	5	6	Mean Distance of New Brake Design
Stopping Distance (cm)							

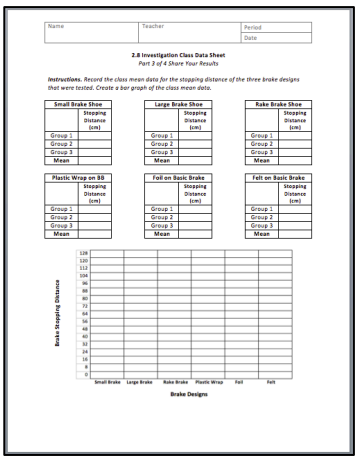
2.8 Explore

2.8: Part 3 of 4- Share your results

Now that your group has collected data testing modified brake designs, your teacher will ask each group to collaborate and share their data with the class. Your data will be added to a class data log so that it can be analyzed and compared to the data other groups collected.

CLASS

Record and graph the class data on the *Investigation Class Data Sheet*.



Name | Teacher | Period | Date

2.8 Investigation Class Data Sheet
Part 3 of 4 Share Your Results

Instructions. *Record the class mean data for the stopping distance of the three brake designs that were tested. Create a bar graph of the class mean data.*

Small Brake Shoe	Stopping Distance (cm)
Group 1	
Group 2	
Group 3	
Mean	

Large Brake Shoe	Stopping Distance (cm)
Group 1	
Group 2	
Group 3	
Mean	

Rake Brake Shoe	Stopping Distance (cm)
Group 1	
Group 2	
Group 3	
Mean	

Plastic Wrap on BB	Stopping Distance (cm)
Group 1	
Group 2	
Group 3	
Mean	

Foil on Basic Brake	Stopping Distance (cm)
Group 1	
Group 2	
Group 3	
Mean	

Felt on Basic Brake	Stopping Distance (cm)
Group 1	
Group 2	
Group 3	
Mean	

Brake Stopping Distance

128 120 112 104 96 88 80 72 64 56 48 40 32 24 16 8 0

Small Brake | Large Brake | Rake Brake | Plastic Wrap | Foil | Felt

Brake Designs

2.8: Part 4 of 4- Reflect & Connect

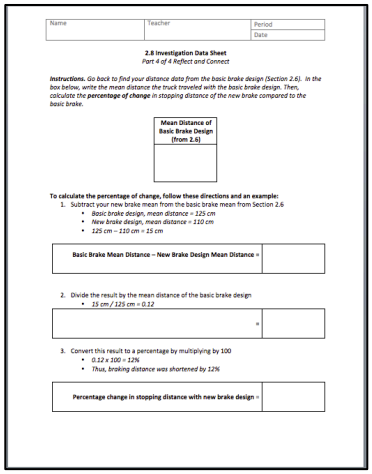
As a class, you will reflect on what you learned from the investigation. You can use the following questions to help start the discussion.

- How did your data compare to the basic brake design data?
- How did the data compare between the different brake designs?
- Does the data look consistent between the groups?
- Were any brakes effective? How do you know?

GROUP

Complete the *Investigation Data Sheet* to mathematically compute the percent change of the new brake design.

2.8 Explore



Name | Teacher | Period | Date

2.8 Investigation Data Sheet
Part 4 of 4 Reflect and Connect

Instructions. *Go back to find your distance data from the basic brake design (Section 2.6). In the box below, write the mean distance the truck traveled with the basic brake design. Then, calculate the* ***percentage of change*** *in stopping distance of the new brake compared to the basic brake.*

Mean Distance of Basic Brake Design (from 2.6)

To calculate the percentage of change, follow these directions and an example:

1. Subtract your new brake mean from the basic brake mean from Section 2.6
   - *Basic brake design, mean distance = 125 cm*
   - *New brake design, mean distance = 110 cm*
   - *125 cm – 110 cm = 15 cm*

Basic Brake Mean Distance – New Brake Design Mean Distance =	

2. Divide the result by the mean distance of the basic brake design
   - *15 cm / 125 cm = 0.12*

	=	

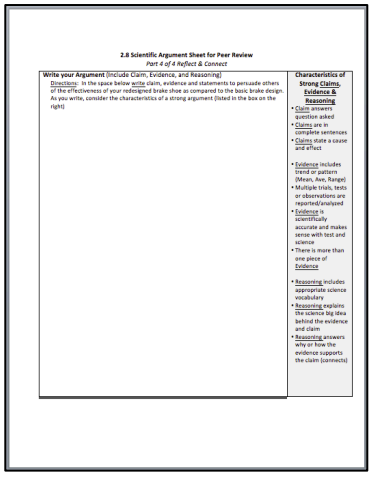
3. Convert this result to a percentage by multiplying by 100
   - *0.12 x 100 = 12%*
   - *Thus, braking distance was shortened by 12%*

Percentage change in stopping distance with new brake design =	

Now that you have collected and analyzed truck-braking data, you can communicate your findings to others by crafting an argument. Your communication will include a **claim** about the effectiveness of the brake design that you used (either different material attached to the basic brake or a new brake shoe structure) and how it compared to the basic brake design. Support your claim with the strong **evidence** that you collected and analyzed and science **reasoning** that you have learned. Recall that the criteria for strong claims and evidence can be found in Section 2.2, Part 3 and your rubric.

STUDENT

Complete the *Scientific Argument Sheet for Peer Review*. When writing your claims, evidence, and reasoning consider the characteristics of a strong argument. You will be sharing your argument with members of your class.



2.8 Scientific Argument Sheet for Peer Review
Part 4 of 4 Reflect & Connect

Write your Argument (Include Claim, Evidence, and Reasoning)

Directions: In the space below write claim, evidence and statements to persuade others of the effectiveness of your redesigned brake shoe as compared to the basic brake design. As you write, consider the characteristics of a strong argument (listed in the box on the right)

Characteristics of Strong Claims, Evidence & Reasoning

- Claim answers question asked
- Claims are in complete sentences
- Claims state a cause and effect
- Evidence includes trend or pattern (Mean, Ave, Range)
- Multiple trials, tests or observations are reported/analyzed
- Evidence is scientifically accurate and makes sense with test and science
- There is more than one piece of Evidence
- Reasoning includes appropriate science vocabulary
- Reasoning explains the science big idea behind the evidence and claim
- Reasoning answers why or how the evidence supports the claim (connects)

2.8 Explore

Two key components of scientific communication are 1) written and oral arguments and 2) peer-review of investigations, results, and conclusions. Peer-reviewed science work provides a trusted form of scientific communication because other scientists are independently evaluating the work. Even if you are unfamiliar with a science topic you can trust peer-reviewed work to meet certain standards of quality. Since scientific knowledge builds on itself, this trust is particularly important.

It can be difficult to imagine how the peer review process occurs in science and/or even in school. To help you feel more comfortable with this important skill you will watch a video to see it in action. Afterwards, discuss the following questions with your class:

- How did the two individuals interact? Was it respectful or was it adversarial?
- What was the purpose of the interaction?
- What were some comments that they made?

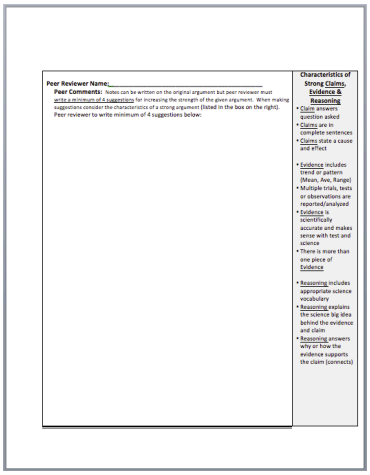
Watch Tutorial
Video 7

Like in the video, you are now going engage in the peer-review process. You will trade papers with a partner to assess each other's scientific argument. When finished you will discuss your assessment with your partner and make suggestions for how the argument could be improved.

STUDENT

Swap your *Scientific Argument Sheet* with your partner. Evaluate your partner's argument using the reminders for strong claim, evidence and reasoning statements. When finished, discuss the argument with your partner and make suggestions on the back for how your partner could strengthen it.

2.8 Explore



Peer Reviewer Name:_____

Peer Comments: Notes can be written on the original argument but peer reviewer must write a minimum of 4 suggestions for increasing the strength of the given argument. When making suggestions consider the characteristics of a strong argument (listed in the box on the right). Peer reviewer to write minimum of 4 suggestions below:

Characteristics of Strong Claims, Evidence & Reasoning

- Claim answers question asked
- Claims are in complete sentences
- Claims state a cause and effect

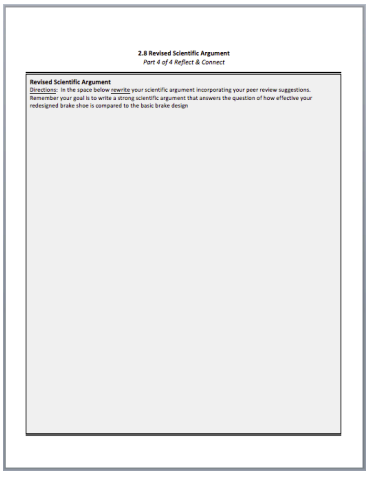
- Evidence includes trend or pattern (Mean, Ave, Range)
- Multiple trials, tests or observations are reported/analyzed
- Evidence is scientifically accurate and makes sense with test and science
- There is more than one piece of Evidence

- Reasoning includes appropriate science vocabulary
- Reasoning explains the science big idea behind the evidence and claim
- Reasoning answers why or how the evidence supports the claim (connects)

Consider your partner's comments and re-evaluate your claim, evidence, and reasoning statements. How strong were your statements when your partner evaluated them? Were they as appropriate, reliable and relevant as you thought? What could be improved? Revise and rewrite them on the *Revised Scientific Argument* sheet.

STUDENT

Revise and rewrite your argument statement on the *Revised Scientific Argument* sheet.



2.8 Revised Scientific Argument

Part 4 of 4 Reflect & Connect

Revised Scientific Argument

Directions: In the space below rewrite your scientific argument incorporating your peer review suggestions. Remember your goal is to write a strong scientific argument that answers the question of how effective your redesigned brake shoe is compared to the basic brake design