Force & Motion Lesson 3: *The Engineer*

Student Handout

Your Challenge: When two objects collide, different results can occur depending upon the mass, speed, and direction of the collision. In a store, shopping cart collisions can damage groceries and even people. In fact, shopping cart accidents account for more than 20,000 injuries per year.

So today, you have an opportunity to develop, design, *and pitch* a new shopping cart design that would fix those problems. Your new shopping cart can withstand impact, thereby protecting kids and fragile groceries inside.

Directions

1. Research and explore the science of collisions.
2. Relate what you noticed about collisions to Newton's Laws of Motion.
3. Design, test, and present an enhanced shopping cart that is capable of withstanding impact while protecting fragile goods stored inside.

Planning Organizer

Remember that in any collision, there is an **equal and opposite force exerted on the object**. This means that if a water balloon is thrown at a wall, it hits the wall with a certain force. In return, the wall hits the water balloon with an equal amount of force, which causes it to explode.

You have been hired to help Ms. Newton redesign shopping carts for her grocery store to protect precious cargo from the forces experienced during a collision. The newly designed shopping cart must be able to:

- ❏ Hold and protect fragile groceries **(represented by an egg**) during a collision so that groceries don't break and fly out of the cart. In your *Engineering* experiment, fragile groceries will be represented by a raw egg.
- ❏ Travel along a classroom ramp provided by your teacher
- ❏ Withstand multiple and repeated collisions without falling apart

Planning Guide

1. Understand the Problem: Restate the problem you are addressing in your own words. *What is the challenge you are focusing on?*

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2. Research: What happens to the motion of objects inside a vehicle during a collision? **Explore the links related to collision science below:** a. Crash Course Physics b. Air Bags and Seat Belts c. Physics of a Car Crash d. Guide to Car Safety Features
Analyze: 1. Explain the motion of passengers inside a vehicle during a collision. 2. How does Newton's First Law of Motion relate to passengers during collisions? 3. What safety devices have been installed to protect passengers and the car

body during a collision? Explain how each works to protect the passenger.

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3a. Brainstorm: How can vehicle collision research inspire shopping cart design for Ms. Newton's store? Brainstorm and sketch your ideas below.

From your brainstorm ideas, choose the idea that you think will work best to develop further. This will become your final product. On the sketch, label the function of the product's key features as well as the dimensions and materials.

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3b. Materials: Identify the materials you will need for your prototype. If you don't have access to the real-world materials, explain what you'll be using to represent these materials. *For example, you might use aluminum foil to represent steel in your build.*
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Teacher Approval Stamp

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4. Prototype Construction: With the above plan in mind, now it is time to create your solution. Using the approved materials, and being conscientious of others' materials needs, build your device.	
How will your design protect valuable groceries during and after a collision?	

5. Test
When your prototype is ready, test your design. Your teacher will provide you with a classroom test ramp and "wall" into which your shopping cart, loaded with a raw egg, must collide.

Data Table 1: Shopping Cart Dimensions

Length of cart	**(cm)**
Width of cart	**(cm)**
Mass of cart (without egg)	**(g)**

Data Table 2: Collision Data

Crash Test #	**Time until impact (s)**	**Distance traveled (m)**	**Speed (m/s)**	**Egg survival rating** *Rating Scale of 1-3 with 1 being death and 3 being unharmed*	**Shopping cart rating** *Rating Scale of 1-3 with 1 being total destruction and 3 being no damage*
1					
2					
3					

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6. Reflect: Complete this section after building and testing your design. Based on your collected data, answer the reflection question below.	
What worked well in your design during testing? Explain.	
Did the egg survive after the crash test? Did your cart survive after collision testing? Explain your test results.	
What revisions can you make to your prototype in order to improve your design for final test day?	

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7. Refine and Retest: Modify your design based on your test data above for final competition day. How can you make your shopping cart withstand multiple impacts and protect precious goods?

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Shopping Cart Investment Pitch
Your design is complete. Now it's time to pitch your prototype to Ms. Newton, who is looking to invest in the best design. So your team must create a "New Shopping Cart Investment Pitch." The pitch can be created either on poster board or in Google Slides/Docs, but it must include the following:

- ❏ Name of product
- ❏ Name of your company advertising product
- ❏ Picture of your prototype (drawn or captured via digital photography)
- ❏ Dimensions of your prototype
- ❏ Mass of your prototype
- ❏ Explanation of how the shopping cart design will effectively protect precious cargo during a collision based on your knowledge of forces and motion
- ❏ A convincing argument to make Ms. Newton invest in your design

Assessment
Use the Checklist and Cognitive Skills Rubric to ensure you have addressed all aspects of *The Engineer* with quality work.

<u>Shopping Cart Engineering Design Checklist</u>
Your Challenge: Redesign a supermarket shopping cart capable of protecting precious cargo during a collision.

Project Completeness:
- ❏ All aspects of *The Engineer* planning organizer are complete
- ❏ Shopping cart prototype:
  - ❏ Prototype is constructed from approved materials
  - ❏ Data and testing is completed for prototype design
  - ❏ Prototype design is revised based on testing data
- ❏ Shopping Cart Investment Pitch:
  - ❏ Includes product name
  - ❏ Includes student company name

- ❏ Includes photo/sketch of prototype with dimensions and mass
- ❏ Explains how shopping cart design will effectively protect precious cargo during a collision based on your knowledge of forces and motion
- ❏ Provides convincing argument to make Ms. Newton invest in design

DCI Standards Checklist:

- ❏ Research accurately describes and specifically references:
  - ❏ How Newton's First Law of Motion applies to the motion of passengers inside of a vehicle during a collision
  - ❏ Safety devices that have been installed and utilized in car design to reduce the impact of collisions
- ❏ Shopping Cart Prototype:
  - ❏ Accurately constructed according to brainstorm sketch and approved materials
  - ❏ Safely protects precious cargo inside of the cart during collision
  - ❏ Withstands multiple and repeated collisions without falling apart

Science & Engineering Practices Rubric

	Emerging (1)	**Developing (2)**	**Proficient (3)**	**Advanced (4)**
Developing and Using Models	Drawings, diagrams, or visual models include major misconceptions or have missing parts. Explanation of the model is minimal or not present.	Drawings, diagrams, or visual models include minor misconceptions or have missing parts. Explanation of the model is minimal.	Drawings, diagrams, or visual models are complete, but contain a minor misconception. Explanation of the model is complete but lacking complexity.	Drawings, diagrams, or visual models have no misconceptions and contain all details. Explanation of the model is complete and complex.
Designing Solutions	Applies no scientific principles and/or data to design, construct, and/or test a design of an object, tool, process, or system.	Applies minimal scientific principles and/or data to design, construct, and/or test a design of an object, tool, process, or system.	Applies adequate scientific principles and/or data to design, construct, and/or test a design of an object, tool, process, or system.	Applies complete scientific principles and/or data to design, construct, and/or test a design of an object, tool, process, or system.
Communicating Findings/Design (Oral Presentation)	Findings/design are incompletely and inaccurately communicated. Or no evidence of using appropriate eye contact, adequate volume, or clear pronunciation.	Findings/design are completely communicated with some misconceptions. Or uses minimal eye contact, inappropriate volume, or inconsistent pronunciation.	Findings/design are completely communicated but lacking depth and complexity. Or often uses eye contact and engaging and appropriate volume and pronunciation, but is inconsistent.	Findings/design are completely communicated with depth and complexity. Or mostly uses eye contact and engaging and appropriate volume and pronunciation.