Learning Cycle Three

3

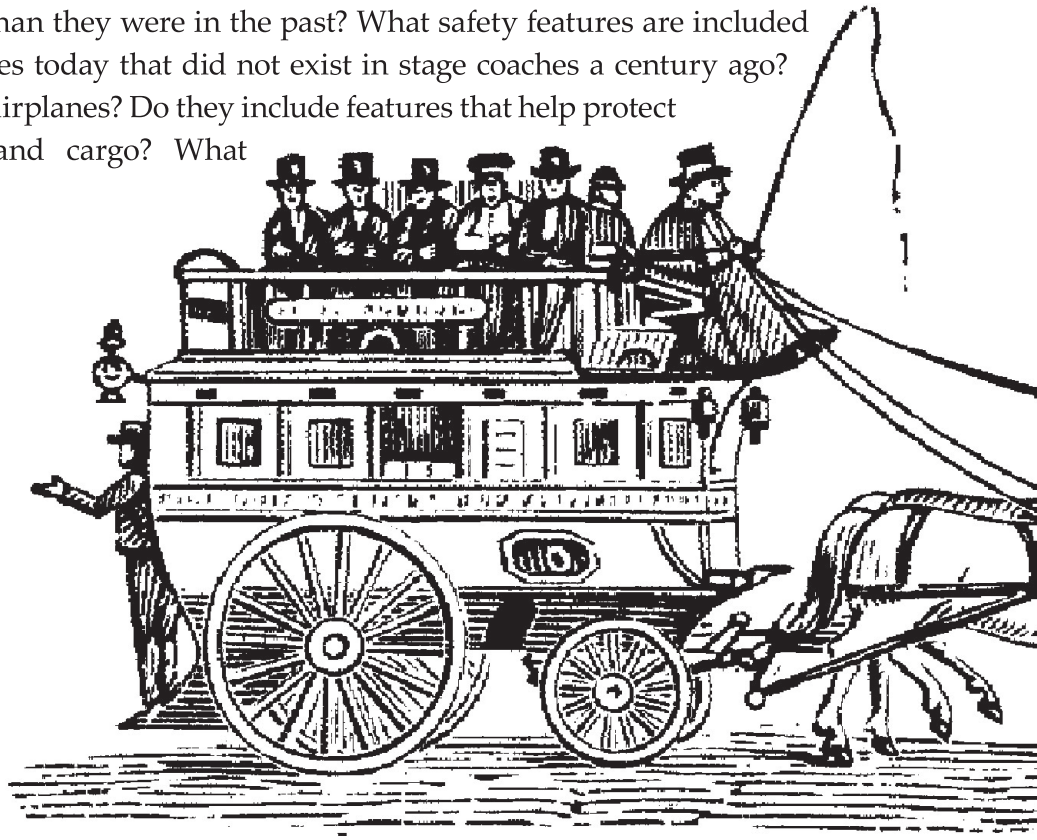
Safety First

3

Introduction

HAVE YOU EVER PURCHASED a bag of potato chips only to get home and realize that there are more crumbs than chips? Have you felt the force of being thrown forward when the car in which you are traveling stops suddenly? Getting people and cargo from one place to another safely requires understanding how to protect them in the event that things go wrong. In transportation systems, the safety features for passengers or cargo are built into both the structure and the suspension of the system. The suspension system works together to cushion and protect the cargo through a flexible connection between the wheels and the body of the transportation device.

Consider how vehicles have evolved over the past century. Are passengers safer today than they were in the past? What safety features are included in automobiles today that did not exist in stage coaches a century ago? What about airplanes? Do they include features that help protect passengers and cargo? What are they?



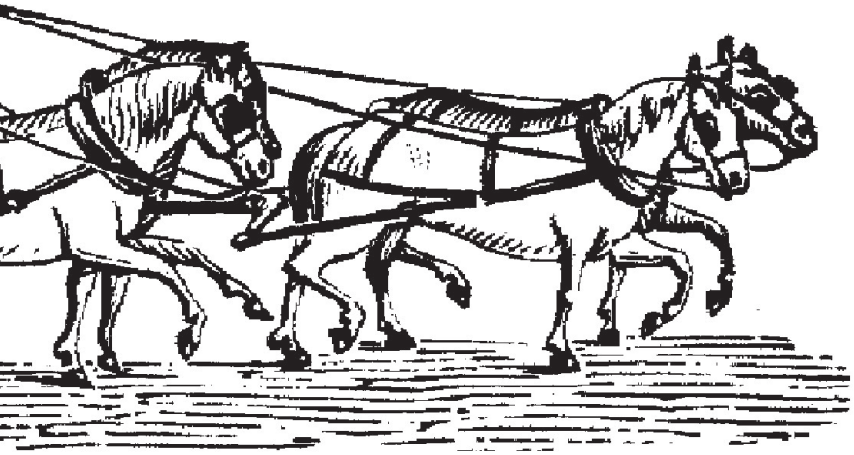
While completing the activities in this learning cycle, you will explore the various components of structural and suspension sub-systems within a transportation system. You will also spend some time thinking about how these components work together to protect cargo in transit. After completing this learning cycle, you will be able to begin designing a solution for transporting your cargo safely as a part of the *Primary Challenge.*

Objectives

After completing this learning cycle, you will be able to:

1. Describe how structural systems in a personal vehicle affect passenger and cargo safety.

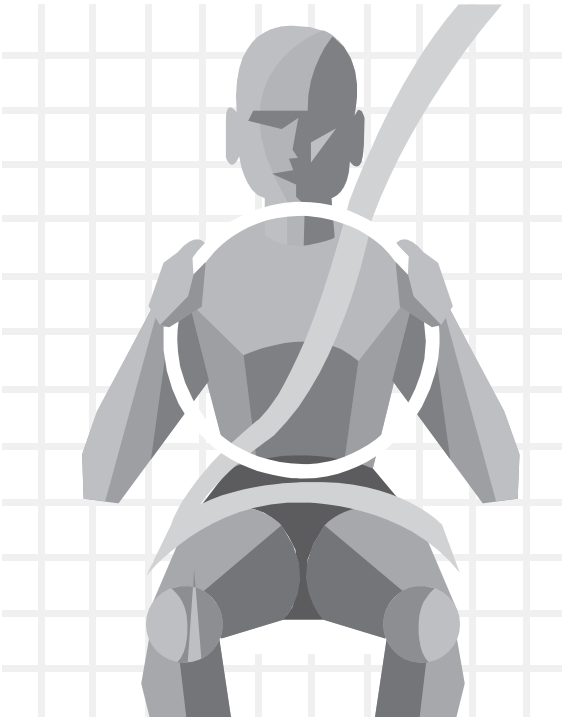
2. Describe how suspension systems in a personal vehicle affect passenger and cargo safety.



What types of technology have been developed for the purpose of protecting passengers in the event of a collision?

Exploration 1

Vehicle engineers can help to ensure that passengers and cargo are transported safely if they understand how the structural and suspension sub-systems work together to provide protection to the vehicle's contents. These sub-systems are integral to the vehicle's ability to protect cargo and include such things as crumple zones, air bags, and roll cages.



Some of these features are more effective at protecting specific types of cargo or passengers than others. The structural system must adequately and safely contain all of the elements of the vehicle and all of its passengers and cargo while traveling from one point to the next.

Your instructor will randomly assign you a research topic related to vehicle safety in an effort to cover the necessary information (without replication) in the shortest time possible. You are required to gather as much information as possible about your assigned topic before the next class meeting, and be prepared to discuss your findings with the class. Some of the questions that will initiate your class discussion are listed below to help guide your research and prepare your discussion points. You should also complete the Inventor's Logbook entries in the spaces provided.

Potential Discussion Questions

1. How can members of the public, politicians, or the state of the economy influence the design of new products and systems in the transportation industry?
2. What safety features are included in transportation structural sub-systems?
3. How and why have structural safety features changed since the first vehicles were created? What events caused these changes?
4 How can we minimize the impact force on a passenger or cargo within a vehicle?

Provide your research topic here:

_____

List at least three interesting findings related to your assigned topic here:

_____

_____

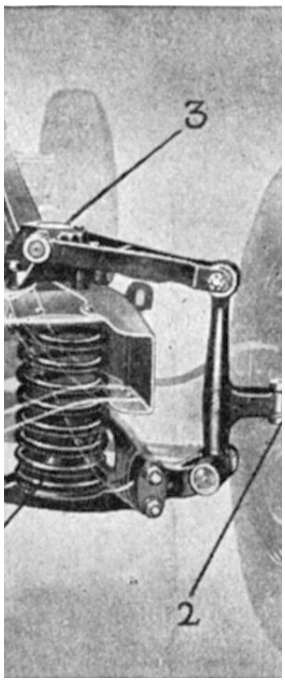
_____

Inventor's Logbook

Logbook 3.1

Exploration II

Suspension systems help keep transportation devices level. In passenger vehicles, the suspension system provides easy control of the vehicle and maximizes a smooth ride for the passenger. Components of the suspension system can be either independent or integrated into the surface design of the vehicle. Some of the components of a passenger vehicle's suspension system include shocks and struts, the padding in the seats, air in the tires, and springs.



Your instructor will assign you to a three-person team for this *Exploration* activity as you explore suspension systems. Each team will construct and test three different suspension systems (i.e., mechanical, fluid, and magnetic). Your instructor will provide the basic structure (a tube mounted to a board) that you will use to construct each suspension system. You will be required to remain within the following parameters:

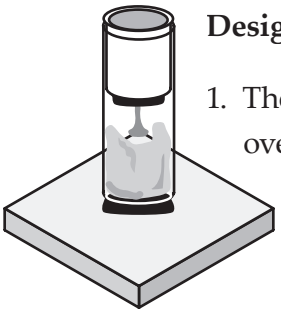


Figure 1. Fluid suspension

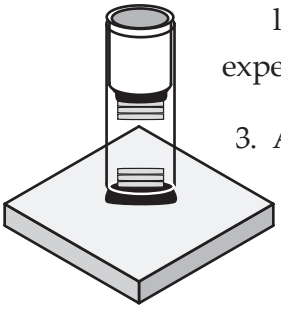


Figure 2. Magnetic suspension

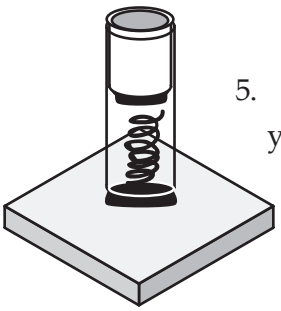


Figure 3. Mechanical suspension

Design Criteria/Constraints

1. The container will be filled with water and transported over rough terrain in a wagon.
2. Each team should construct each of the suspension systems, similar to the ones illustrated in Figures 1-3 at the left, using the materials provided. Experiment with different lengths of light shield to determine the best length for each system. Make small adjustments as you experiment.
3. After constructing each suspension system, transport the wagon over the designated course using the given suspension system.
4. Measure and record the amount of water lost during transit to determine the most effective suspension system.
5. Complete all three suspension systems and record your observations.
6. You will have two days to complete this assignment.

Reflection

Inventor's Logbook

Logbook 3.2

Answer the following questions in the Inventor's Logbook space provided. Be prepared to discuss your answers with the class.

1. Describe how mechanical, fluid, and magnetic suspension systems are designed to protect the cargo. How does each suspension system work?

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_____

_____

2. What are the limitations or flaws of each type of suspension system?

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3. Identify at least one example where each suspension system is used in real transportation devices.

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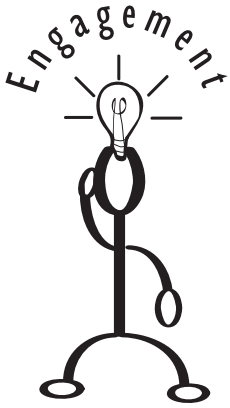

Engagement

Incorporating structural and suspension sub-systems into a transportation system to help protect passengers is a real problem for automobile manufacturers today. Crash tests allow us to analyze how effectively a vehicle's design can protect its passengers during a collision. Here is an opportunity for your team to design and construct a structural and suspension system and test how effectively it protects its passengers.

First, you will need to know how to analyze and determine the amount of force a vehicle can take (with or without a crumple zone), while still protecting its passengers. The amount of force the human body can take has been measured in *g*s. A *g* is a unit of acceleration equal to the acceleration caused by gravity. Gravity causes objects on the Earth to change their speeds when free-falling at about 10 meters per second (m/s). If an object is said to experience 3 *g*s of acceleration, then the object is changing its speed at a rate of about 30 m/s every second. About 30 *g*s (positive or negative) will break a person's ribs and about 70 *g*s will cause severe internal damage and death. Federal crash standards require that passenger vehicles not exceed accelerations of 60 *g*s for longer than 36 milliseconds.

Work through the following two examples to better understand how to calculate force.

1. If a car that weighs 1,131 kilograms (kg) is traveling 60 miles per hour (26.82 m/sec) and hits a wall with no crumple zone, the impulse force of impact can be determined by using the following equation.

$$\text{Force} = \frac{\text{Mass x Change in Velocity}}{\text{Time}}$$

The mass of the car is 1,131 kg and the change in velocity was 26.2 meters per second. Time in the above equation is the measurement of the amount of time it takes for the vehicle to decelerate or hit the wall and stop. For this example, the deceleration time was .01 second (s). So, the amount of force is 3,033,342 newtons (N).

$$\text{Force} = \frac{1131 \text{ kg} \times 26.82 \text{ m/sec}}{.01 \text{ s}} = 3{,}033{,}342 \text{ N}$$

2. Now, what if the same car is traveling at the same rate and hits the same target, but with a 1.5 meter crumple zone? In this example, the deceleration time increased to .1119 second. Using the same equation F= (Mass x Change in Velocity)/Time, you can see that the impulse force of impact was drastically reduced:

$$\text{Force} = \frac{1131 \text{ kg} \times 26.82 \text{ m/sec}}{.1119} = 271{,}076 \text{ N}$$

Using the previous examples, would a passenger survive either of the impacts?

In the first example, the possible *g* force applied to a passenger can be found by using the equation below:

$$\text{Acceleration} = \frac{\text{Change in Velocity}}{\text{Change in Time}}$$

The change in velocity is found by subtracting the speed upon impact, which was 26.82 m/s from the starting speed of 0 m/s. That number is then divided by the amount of time it took for the vehicle to travel from the starting point to the point of impact to find the acceleration in *g*s. In the first example, the acceleration was -273 *g*s. This is well above the amount of *g*s that are considered safe! Remember, just 70 *g*s (positive or negative) can kill a passenger.

$$\text{Acceleration} = \frac{(0\text{ m/s}-26.82\text{ m/s})}{.01\text{ s}} = \frac{-26.82\text{ m/s}}{.01\text{ s}} = -2{,}682\text{ m/s}^2 \times \frac{1\,g}{9.8\text{ m/s}^2} = -273.7\,g$$

For the second example with the 1.5 m crumple zone, the acceleration was -24.46 *g*s. In this example, the crumple zone could have meant the difference between life and death for a passenger.

$$\text{Acceleration} = \frac{(0\text{m/s}-26.82\text{ m/s})}{.1119\text{ sec}} = \frac{-26.82\text{ m/s}}{.1119\text{ sec}} = -239.7\text{ m/s}^2 \times \frac{1\,g}{9.8\text{ m/s2}} = -24.46\,g$$

Obtain the following from your instructor:

- 1 sq. ft. of Cardboard
- Paper cup (12 oz.)
- Styrofoam block (3" x 3" x 3")
- Index card
- Foam peanut
- Block of wood (3" x 3" x 1")
- (10) Popsicle sticks
- (2) Rubber bands
- (4) Straws
- 10" masking tape
- (2) Eye hooks
- 12" string
- CO 2 cartridge

Design Challenge

Design and construct a vehicle to safely transport a passenger along a guided track. You will be required to remain within the following parameters during the completion of this activity:

Design Criteria/Constraints

1. Your team may only use the materials provided and may use no more than one square foot of cardboard.
2. You must incorporate structural and suspension systems to protect your passenger. Your passenger will be one Pringles® potato chip.
3. Your vehicle will be propelled along a guided track using a CO 2 cartridge as an energy source.
4. You will have two days to complete this activity: one day for designing and constructing, and one day for testing.
5. Your vehicle must travel the entire distance of the course (approximately 40 feet).

6. The vehicle must attach to the track (fishing line) using eye hooks and must accommodate a standard CO_2 cartridge. Be aware of the distance from the track to the CO_2 cartridge. Your vehicle's CO_2 cartridge must line up with the pin on the launching device.
7. Your team must provide an illustration for your design. This can be a pencil sketch or CAD drawing.
8. Your vehicle must weigh between 40 and 70 grams.
9. You must complete the mathematical analysis sheet provided by your instructor.
10. A rubric will be used to assess the effectiveness of your design. A cracked chip is considered a failure.
11. You will work in your *Primary Challenge* teams for this activity. Be sure to take advantage of the design work completed by each team.

Safety

Vehicles will be suspended on a fishing line and travel at high speeds. All components should be secure and checked by your instructor before launching each vehicle. All spectators should stand a safe distance from the test track. No one should be allowed to stand near the end of the track because vehicle parts may fly on impact.

Inventor's Logbook

Logbook 3.3

While other teams are testing their solutions, record your observations below. What worked best? What designs should be avoided?

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When your team has completed this activity, answer the following questions in your Inventor's Logbook:

Inventor's Logbook

Logbook 3.4

1. What structural features were most effective in protecting the passenger?

_____

_____

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2. What suspension features were most effective in protecting the passenger?

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3. How does size of the cargo affect the design of the vehicle?

_____

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_____

Select one of the following *Expansion* activities in which to engage, and follow the directions.

1. Identify additional political and social decisions that have affected passenger safety that were not identified in the learning cycle and describe the impact(s) of those decisions. Present your findings to the rest of the class.

2. Conduct research and develop a report or presentation about the latest safety features that appear in your favorite automobile. Choose one of these features and follow its history and development from conception to its presence in your favorite car.

3. Restraining devices such as seat belts and children's car seats have not always been used in automobiles. Conduct research on the historical developments of child-restraining devices. Write a report or prepare a presentation on the historical developments of child-restraining devices. Make use of all possible resources such as your parents and grandparents. Many of them may remember when restraining devices were not available.

Career Connections

Industrial Safety Engineer
Packager
Cargo Handling Supervisor
Transportation Inspector

Here are some careers related to this learning cycle. For more information, visit the United States Department of Labor's Occupational Outlook Handbook at: www.bls.gov/oco

Preparing for the Challenge

How does the knowledge you have gained during this learning cycle relate to the *Primary Challenge*? What structural and suspension system ideas can your team incorporate into your *Primary Challenge* solution to help ensure the safe transport of the water? Sketch at least three different potential structural and suspension solutions for the *Primary Challenge* in the space provided in the Inventor's Logbook section. Share your solutions with members from your *Primary Challenge* team. As a team, select the best potential design and incorporate it into your team's solution.

Be sure to consider questions such as the ones shown below:

- What materials will you use?
- How will you protect your cargo?
- How will all of the pieces fit together?
- What else do you need to know in order to complete the *Primary Challenge?*

Inventor's Logbook

Logbook 3.5

Safety First!

Name: Date:

Element	Criteria				Points
	4	3	2	1	
Presentation and Communication Preparation	Exceptional preparation of presentation with strong visual aids/handouts/ appropriate technology.	Above average preparation of presentation with good visual aids/handouts/ appropriate technology.	Average preparation of presentation; basic visual aids/handouts/ appropriate technology.	Below average preparation of presentation.	
Effectiveness	Presentation was exceptionally effective, clear, and accurate.	Presentation effectiveness, clarity, and accuracy were above average.	Presentation effectiveness, clarity, and accuracy were average.	Presentation effectiveness, clarity, and accuracy were below average.	
Informative and Interesting	Presentation was exceptionally informative and interesting.	Presentation was highly informative and interesting.	Presentation was informative and interesting.	Presentation was neither informative nor interesting.	
Suspension Testing Apparatus Construction	Construction is of exceptional quality.	Construction is above average quality.	Construction is average quality.	Construction is below average quality.	
Safety Vehicle Design and Documentation Design	Exceptional creativity and innovation in design.	Above average creativity and innovation in design.	Average creativity and innovation in design.	Below average creativity and innovation in design.	
Mathematical Analysis	Exceptional documentation of research and design.	Above average documentation of research and design.	Average documentation or research and design.	Below average documentation of research and design.	
Functionality and Construction	Vehicle works well and is constructed well.	Vehicle works well; construction is average.	Vehicle works average; construction is below average.	Vehicle doesn't work; construction is below average.	
Inventor's Logbook Suspension	Fully comprehends suspension.	Comprehends suspension.	Comprehends suspension somewhat.	Does not comprehend suspension.	
Structure	Fully comprehends structure.	Comprehends structure.	Comprehends structure somewhat.	Does not comprehend structure.	
				Total Points	