Learning Cycle Four

Out of Control!

4

Out of Control!

Introduction

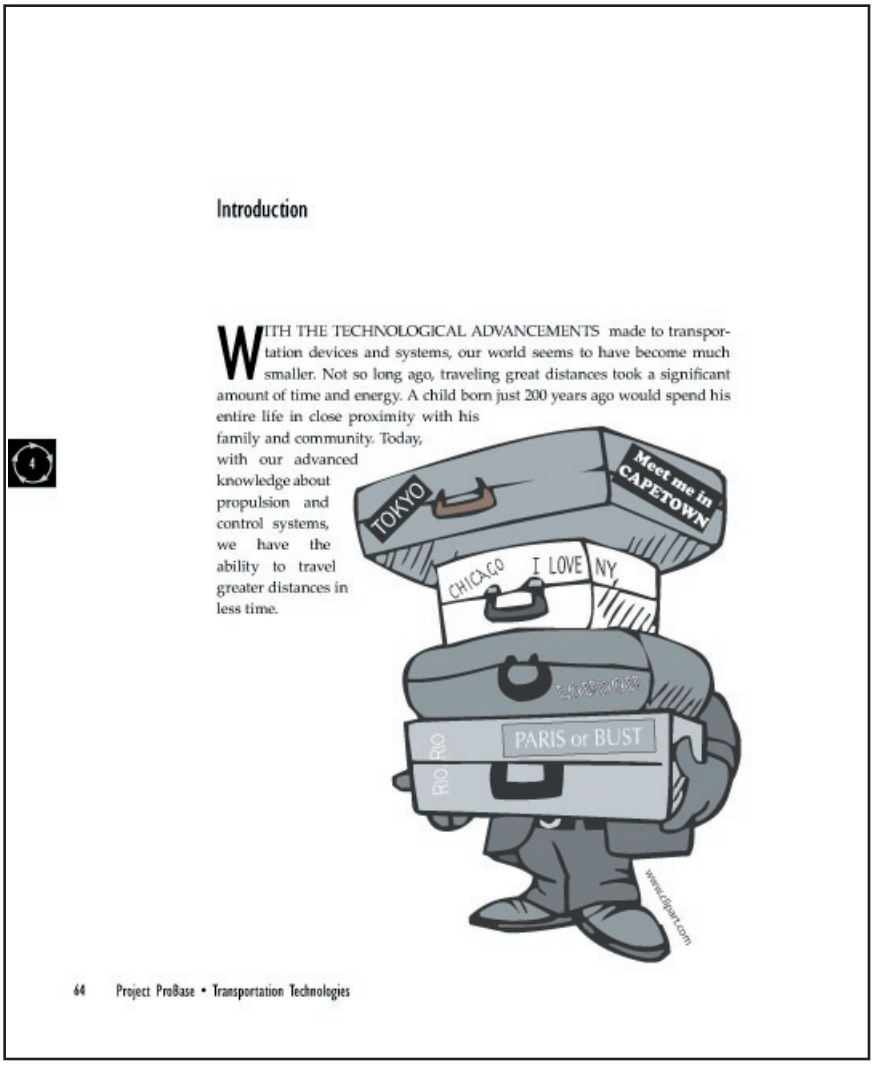
The primary goal for this learning cycle is to have students explore the technical concept of control, and to begin to understand how these controls are applied to transportation systems. After completing this learning cycle, students will be able to identify different methods of controlling movement and apply this knowledge to their *Primary Challenge* solution.

Objectives and Essential Questions

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

1. Utilize a variety of systems for controlling distance and direction of a vehicle.

Essential Question 9b: How is technology used to control devices and systems and provide information to humans?



Introduction

WITH THE TECHNOLOGICAL ADVANCEMENTS made to transportation devices and systems, our world seems to have become much smaller. Not so long ago, traveling great distances took a significant amount of time and energy. A child born just 200 years ago would spend his entire life in close proximity with his family and community. Today, with our advanced knowledge about propulsion and control systems, we have the ability to travel greater distances in less time.

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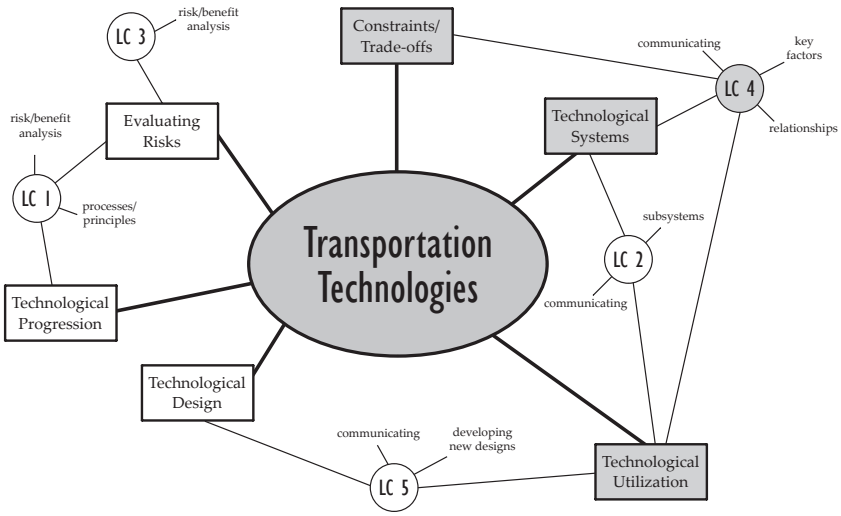
Transportation Technologies
Learning Cycle Four Concept Map



Most of us have experienced the discomfort of pedaling a bicycle up a hill or swerving around an object in the road. Have you ever considered the technology that allows us to accomplish these movements using less energy and with more control? How can we transfer energy in order to do work? How can we control and direct the output of that energy?

In this learning cycle, you will be exploring the technical concept of control. You will learn how various controls are applied to transportation systems to allow them to move from one place to another. After completing this learning cycle, you will be able to start identifying different methods of controlling the movement of your solution to the *Primary Challenge*.

Objectives

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

1. Utilize a variety of systems for controlling distance and direction of a vehicle.
2. Analyze the relationship between force and distance using mechanical systems.
3. Select appropriate control systems for a given application.

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2. Analyze the relationship between force and distance, using mechanical systems.

Essential Question 4b: What are the key elements of the various technological systems and what are the relationships between these systems?

3. Select appropriate control systems for a given application.

Essential Question 6b: What are the key factors that cause designers to make decisions about trade-offs, limitations, and constraints when designing new products and systems?

Facility Requirements

Exploration I will require access to the Internet and other resources. *Exploration II* works best in a classroom with tables large enough to allow students to work in pairs. The *Engagement* activity works best in a general laboratory equipped with basic tools and equipment; such as hand tools, drill press, table saw, band saw, etc.

Equipment and Materials

Based on a class of 28 students:

(14) Tongue depressors

(7) Paper hole punches

(84) Brass paper fasteners

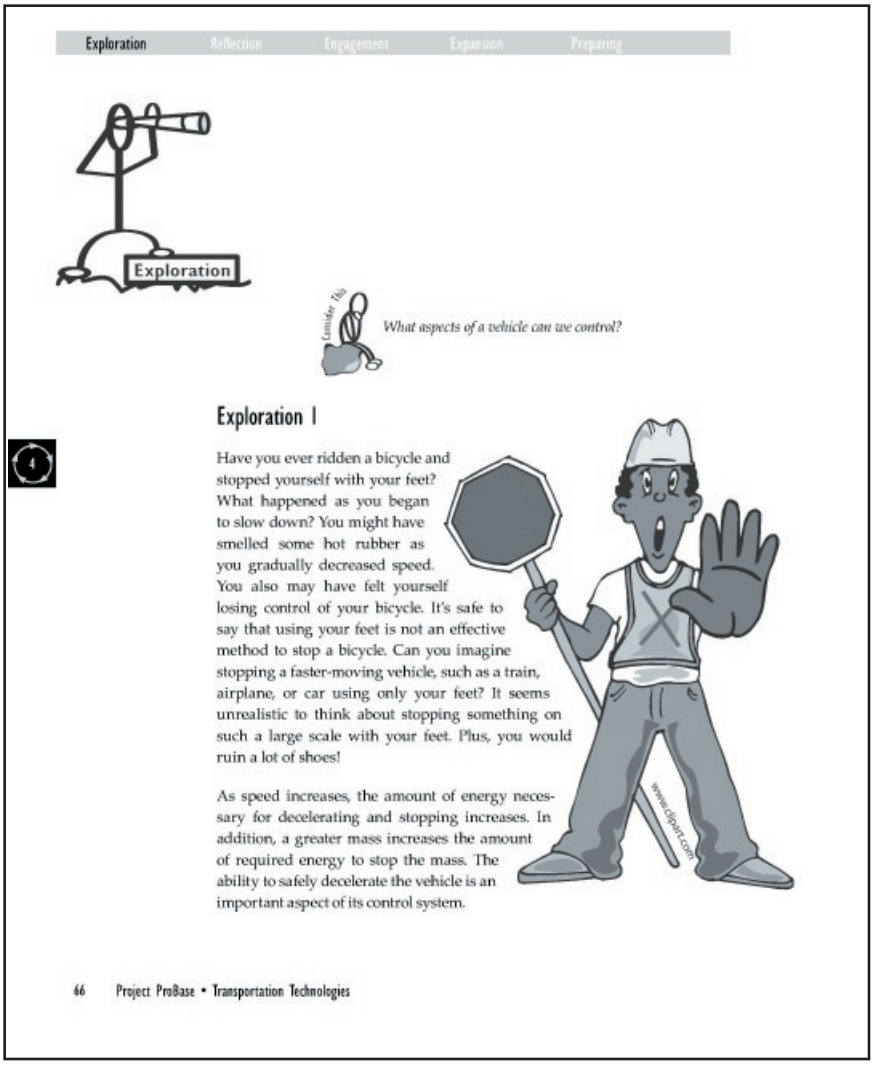
(14) 6" x 8" pegboards with ⅛" or ¼" holes

Various materials specified by solutions to the *Engagement* activity.

Estimated Number of 50-minute class periods: **7**

Suggested Daily Outline

Day One	Day Two
Introduction, *Exploration I*	*Exploration I* *Reflection I*
Day Three	**Day Four**
Exploration II	*Exploration II* *Reflection II*
Day Five	**Day Six**
Engagement	*Engagement*
Day Seven	
Engagement *Preparing for the Challenge*	



Exploration Reflection Engagement Expansion Preparing

Exploration

Consider This

What aspects of a vehicle can we control?

Exploration I

Have you ever ridden a bicycle and stopped yourself with your feet? What happened as you began to slow down? You might have smelled some hot rubber as you gradually decreased speed. You also may have felt yourself losing control of your bicycle. It's safe to say that using your feet is not an effective method to stop a bicycle. Can you imagine stopping a faster-moving vehicle, such as a train, airplane, or car using only your feet? It seems unrealistic to think about stopping something on such a large scale with your feet. Plus, you would ruin a lot of shoes!

As speed increases, the amount of energy necessary for decelerating and stopping increases. In addition, a greater mass increases the amount of required energy to stop the mass. The ability to safely decelerate the vehicle is an important aspect of its control system.

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Exploration I

Exploration I asks students to conduct research on the Internet or other available resources to discover the historical developments of one of the following types of braking systems: mechanical, hydraulic, pneumatic, or electrical. Students are also required to prepare a three- to five-minute presentation.

Constraints/Requirements

Braking Systems
mechanical
hydraulic
pneumatic
electrical

Your instructor will assign you to a two-person team. Each team is responsible for conducting research to better understand how braking systems work.

Each team must also present their findings to the class in a three- to five-minute presentation.

The research and presentation should answer the following questions:

- How is friction produced in this braking system?
- On what transportation vehicles is this type of braking system common?
- Where might this braking system be used in the future?
- How can climatic factors such as ice, snow, or rain affect the control of a vehicle when this type of braking system is utilized?
- What are some of the safety trade-offs of using this type of braking system (e.g., health, cost, disposal)?

Teaching Tips

You should assign your students to two-person teams for this activity. Internet access is helpful, but not essential for this research. There is a rubric at the end of this learning cycle for grading student presentations. It is recommended that you copy and distribute this rubric to your students before they begin their presentations.

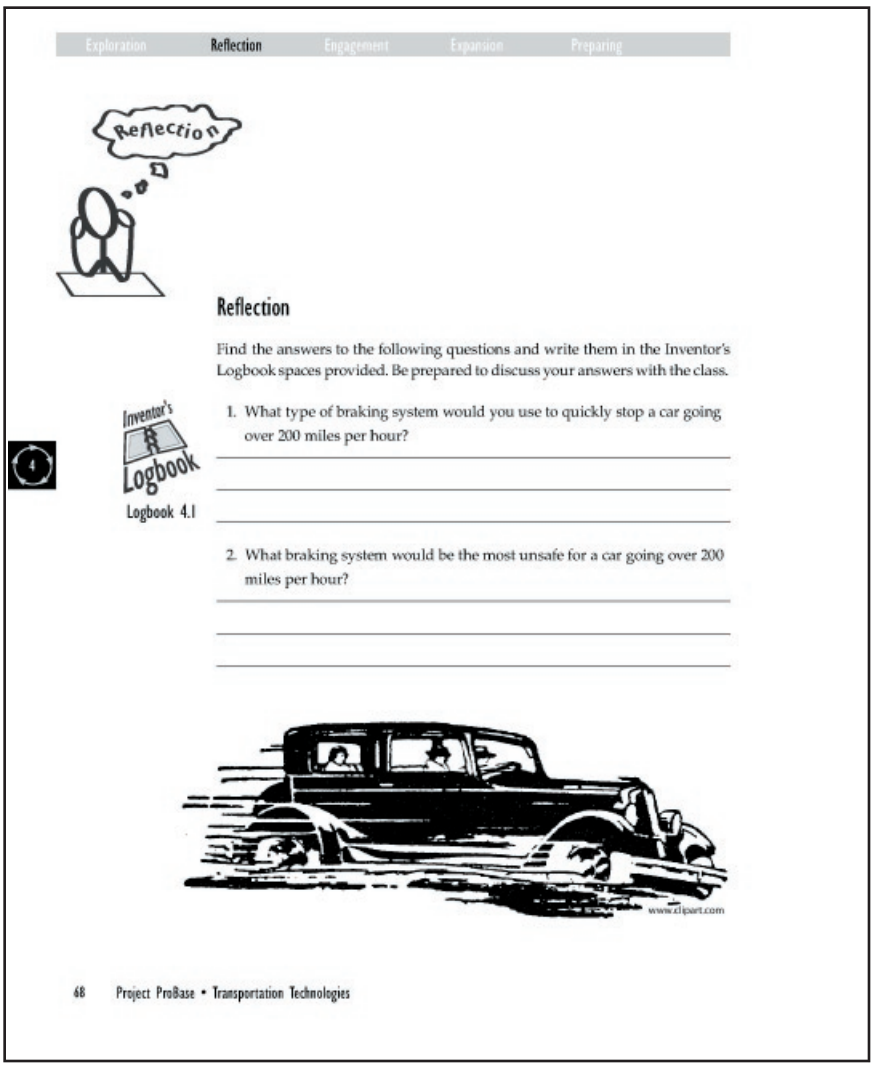
Teaching Tips

Remind students that their presentations should be engaging and should present the following information related to the specific type of braking system they were assigned:

- How is friction produced?
- What are the most common applications of this type of braking system?
- What are some future applications?
- How can climatic factors, such as ice, snow, or rain, affect the control of a vehicle using this type of braking system?
- What are some of the safety trade-offs of using this type of braking system (e.g., health, cost, disposal)?

Reflection

If time is limited, students could do this *Reflection* as homework. Students are asked to find the answers to the following questions and write them in the Inventor's Logbook spaces provided.



Exploration Reflection Engagement Expansion Preparing

Reflection

Reflection

Find the answers to the following questions and write them in the Inventor's Logbook spaces provided. Be prepared to discuss your answers with the class.

Inventor's Logbook

Logbook 4.1

1. What type of braking system would you use to quickly stop a car going over 200 miles per hour?

2. What braking system would be the most unsafe for a car going over 200 miles per hour?

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1. What type of braking system would you use to stop a car going over 200 miles per hour?
   A hydraulic system with disc brakes made from carbon materials would work best.

2. What braking system would be the most unsafe for a car going over 200 miles per hour?
   A pneumatic brake system would probably be the most unsafe because of the heat build up during braking.

3. How has the need or desire for speed affected or changed the technologies used for braking systems?
   Materials are being developed for braking systems that will withstand very high temperatures caused by friction, and engineers have created independent front and rear braking systems for high speed vehicles so that they can control the front and rear brake systems independently to account for the weight shifts that occur during high speed braking.

4. Beyond safety, how have braking systems improved transportation?
   Braking systems have allowed us to move faster.

5. Explain how stopping a car is more than just stepping on the brake pedal?
   Diagram what happens when the brake pedal is depressed.

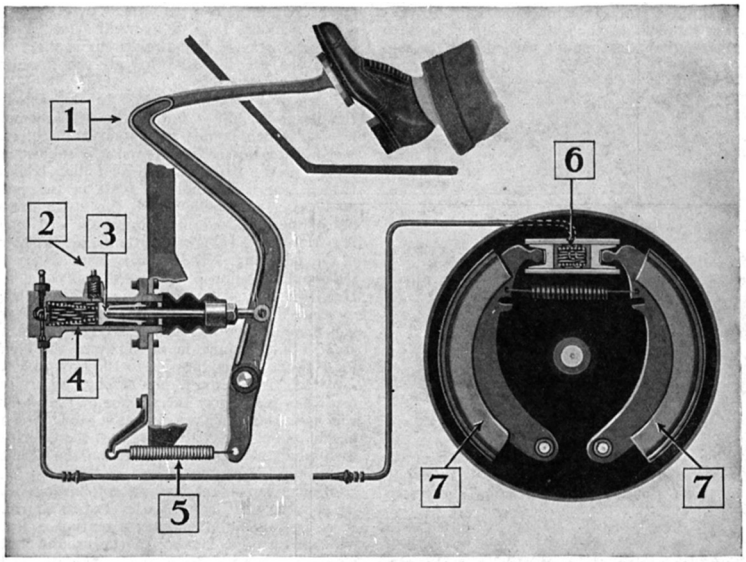
6. What causes a vehicle's brake pads to wear down?
   Friction causes the brake pads to wear down.

3. How has the need or desire for speed affected or changed the technologies used for braking systems?

4. Beyond safety, how have braking systems improved transportation?

5. Explain how stopping a car is more than just stepping on the brake pedal. Diagram what happens when the brake pedal is depressed.

6. What causes a vehicle's brake pads to wear down?



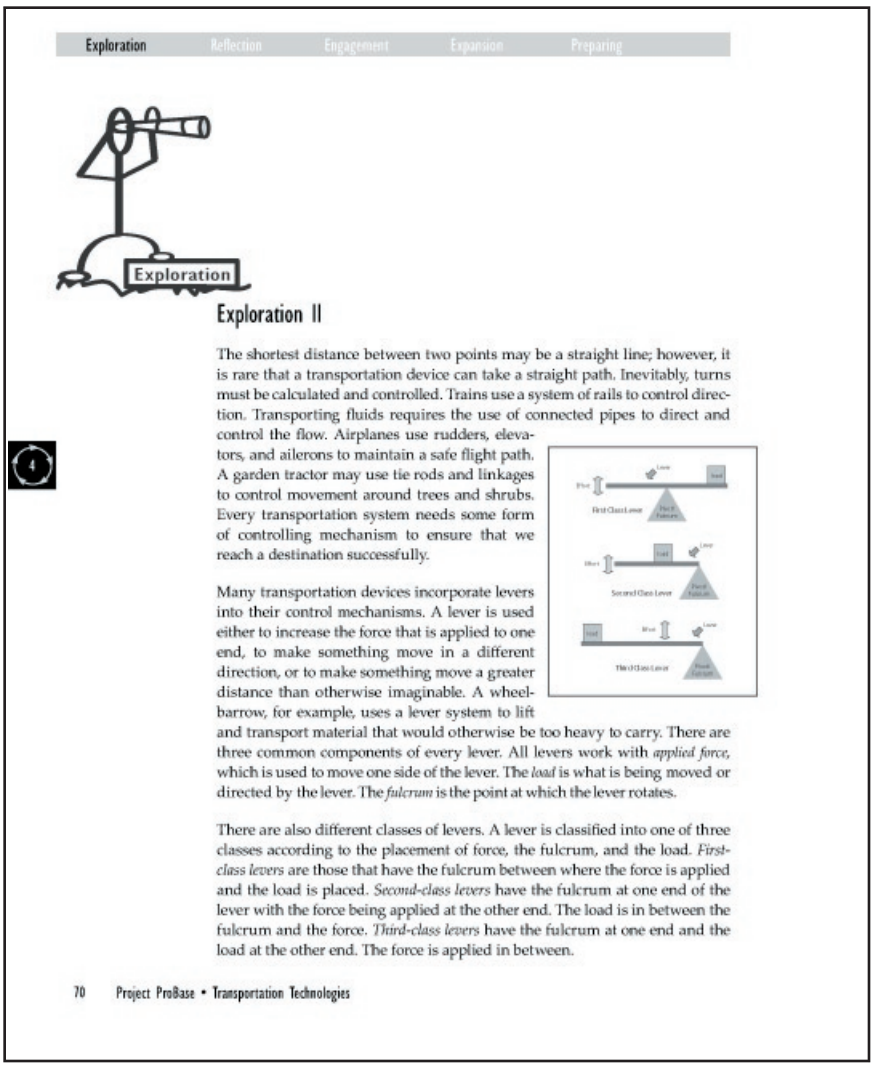
HYDRAULICS APPLIED TO THE AUTOMOBILE

The hydraulic brake for motor vehicles has supplanted mechanical brakes in many kinds of automobiles. The above illustration explains its action. (1) The foot brake pedal, where power is applied. (2) Master cylinder supply tube connection. (3) Piston. (4) Liquid. (5) Pedal return spring. (6) Wheel cylinder. (7) Brake shoes. The fluid is compressed, and the compression extends through pipes to the wheel cylinder, where expansion of the brake causes the necessary friction to stop the vehicle.

Example brake system

Exploration II

Exploration II asks the students to predict the outcome of various linkage configurations and then test their predictions using simple linkages. This is shown as Figure 1 in the Student Guide and explained further here in the Instructor Guide.



Exploration Reflection Engagement Expansion Preparing

Exploration

Exploration II

The shortest distance between two points may be a straight line; however, it is rare that a transportation device can take a straight path. Inevitably, turns must be calculated and controlled. Trains use a system of rails to control direction. Transporting fluids requires the use of connected pipes to direct and control the flow. Airplanes use rudders, elevators, and ailerons to maintain a safe flight path. A garden tractor may use tie rods and linkages to control movement around trees and shrubs. Every transportation system needs some form of controlling mechanism to ensure that we reach a destination successfully.

Many transportation devices incorporate levers into their control mechanisms. A lever is used either to increase the force that is applied to one end, to make something move in a different direction, or to make something move a greater distance than otherwise imaginable. A wheelbarrow, for example, uses a lever system to lift and transport material that would otherwise be too heavy to carry. There are three common components of every lever. All levers work with *applied force*, which is used to move one side of the lever. The *load* is what is being moved or directed by the lever. The *fulcrum* is the point at which the lever rotates.

There are also different classes of levers. A lever is classified into one of three classes according to the placement of force, the fulcrum, and the load. *First-class levers* are those that have the fulcrum between where the force is applied and the load is placed. *Second-class levers* have the fulcrum at one end of the lever with the force being applied at the other end. The load is in between the fulcrum and the force. *Third-class levers* have the fulcrum at one end and the load at the other end. The force is applied in between.

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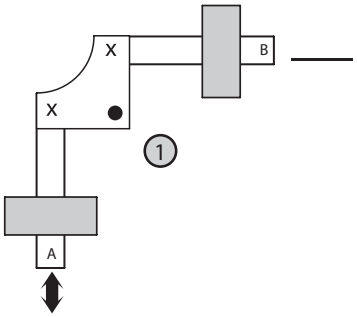
Teaching Tips

Assign your students to two-person teams. Lay out the necessary materials and allow each team to get the materials listed in their student text. Remind your students to write their predictions in the Inventor's Logbook spaces provided before constructing each of the linkage systems. Students should be able to punch the required holes in the tongue depressors using a paper punch. If preferred, a drill can be used to drill ¼" holes in the tongue depressors.

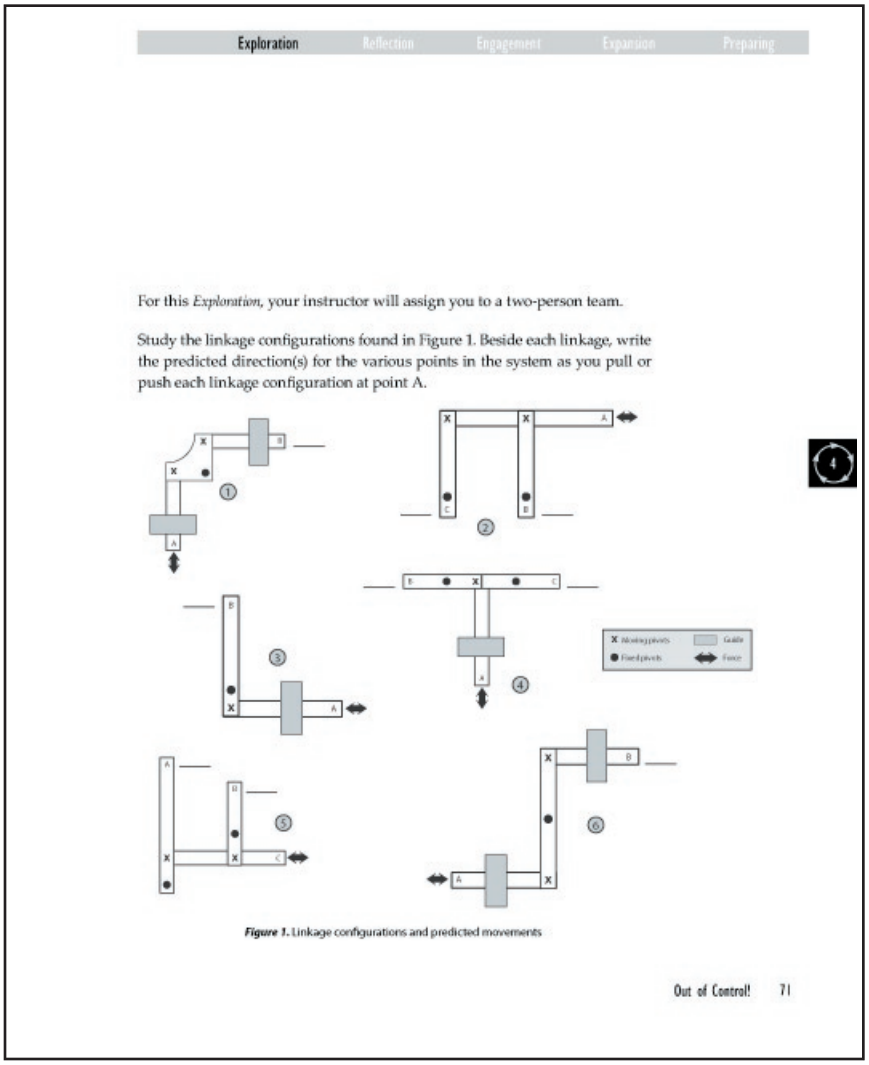
Safety

Remind students to punch or drill the holes near the center of the tongue depressors to prevent them from breaking or splintering.



When Point A is pulled down, B moves to the left. If A goes up, B moves to the right.

Legend



Exploration Reflection Engagement Expansion Preparing

For this *Exploration*, your instructor will assign you to a two-person team.

Study the linkage configurations found in Figure 1. Beside each linkage, write the predicted direction(s) for the various points in the system as you pull or push each linkage configuration at point A.

Figure 1. Linkage configurations and predicted movements

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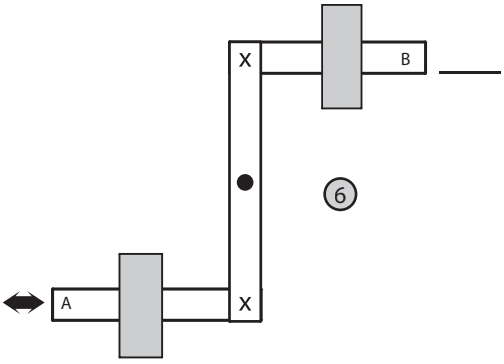
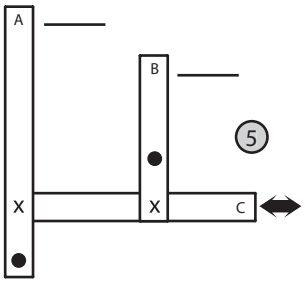
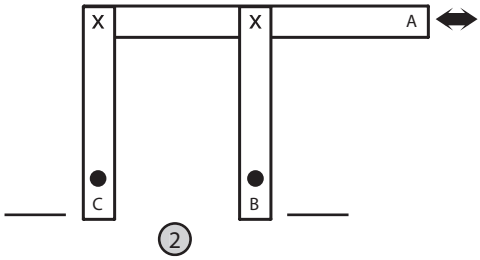


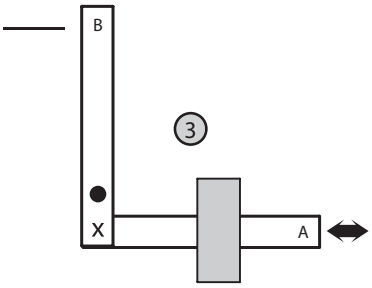
When Point A is pulled to the left, B will move to the right.



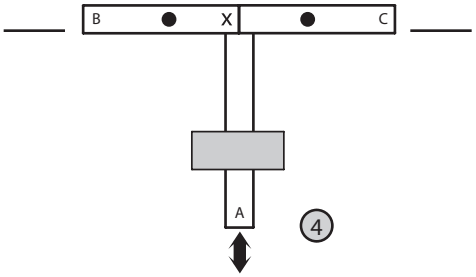
When Point C is pulled to the right, B and A will turn inward. If C goes to the left, B and A turn outward.



When Point A is pulled to the left, both B and C will move to the right.



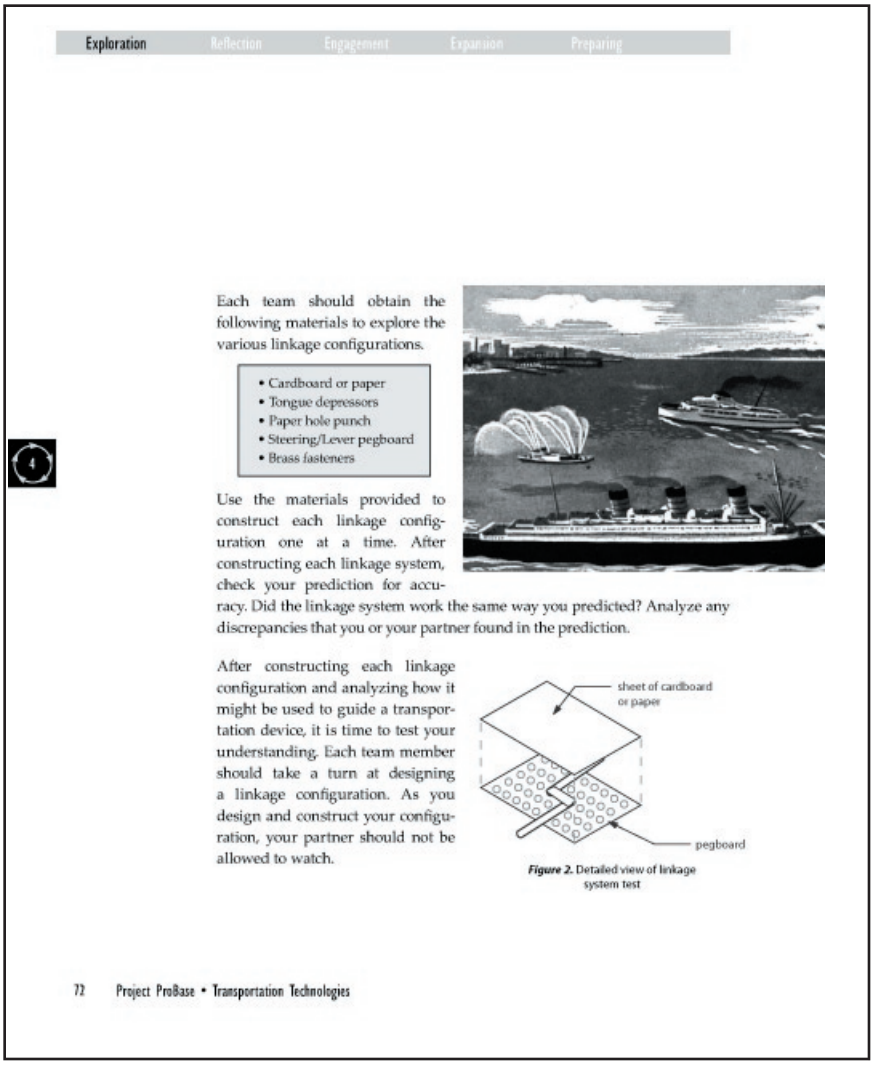
When Point A is pulled to the left, B will move to the left.



When Point A is pulled down, B and C will turn up. If A goes up, B and C turn down.

Teaching Tips

After students have constructed each linkage configuration and analyzed how it might be used to guide a transportation device, they should test their understanding. Each team member should take a turn at designing a different linkage configuration.



Exploration Reflection Engagement Expansion Preparing

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Each team should obtain the following materials to explore the various linkage configurations.

- Cardboard or paper
- Tongue depressors
- Paper hole punch
- Steering/Lever pegboard
- Brass fasteners

Use the materials provided to construct each linkage configuration one at a time. After constructing each linkage system, check your prediction for accuracy. Did the linkage system work the same way you predicted? Analyze any discrepancies that you or your partner found in the prediction.

After constructing each linkage configuration and analyzing how it might be used to guide a transportation device, it is time to test your understanding. Each team member should take a turn at designing a linkage configuration. As you design and construct your configuration, your partner should not be allowed to watch.

sheet of cardboard or paper

pegboard

Figure 2. Detailed view of linkage system test

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As students design and construct their configuration, the other member of the team should not be allowed to watch. After constructing the linkage configuration, they should cover the mechanism with paper, cardboard, or other opaque material so that their partner cannot see the configuration.

The moving points should stick beyond the cover so that each partner can observe the input and output movement (see diagram at left). Allow students enough time to test their knowledge of linkages, using two or three different configurations. After each demonstration, the student serving as the witness should attempt to sketch a plausible linkage system that represents the hidden linkage.

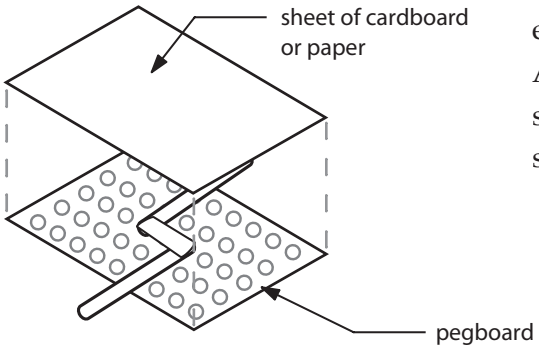
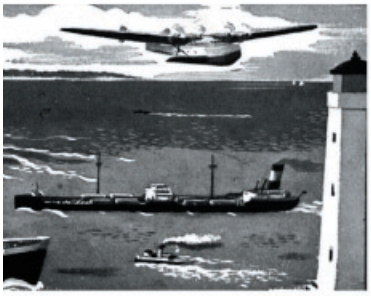


Figure 2. Detailed view of linkage system test



After constructing the linkage configuration, cover the board with paper, cardboard, or another opaque material so that your partner cannot see your configuration (as shown in Figure 2). The moving points should stick beyond the cover so that your partner can observe their movement.

Allow your partner to pull and/or push one of the points of your system and observe what happens to the other exposed point. After your partner observes your configuration, he or she should sketch a plausible linkage system that performs like yours.

After the sketch is completed, you should uncover your system and see how closely your partner's solution matches the configuration. If the solution is different, you should work together to construct the solution and observe how it works. You may find that there is more than one plausible solution to configuring the linkage system.

After one team member has completed this test, the other team member should take her or his turn. If time permits, this should be repeated using different configurations.

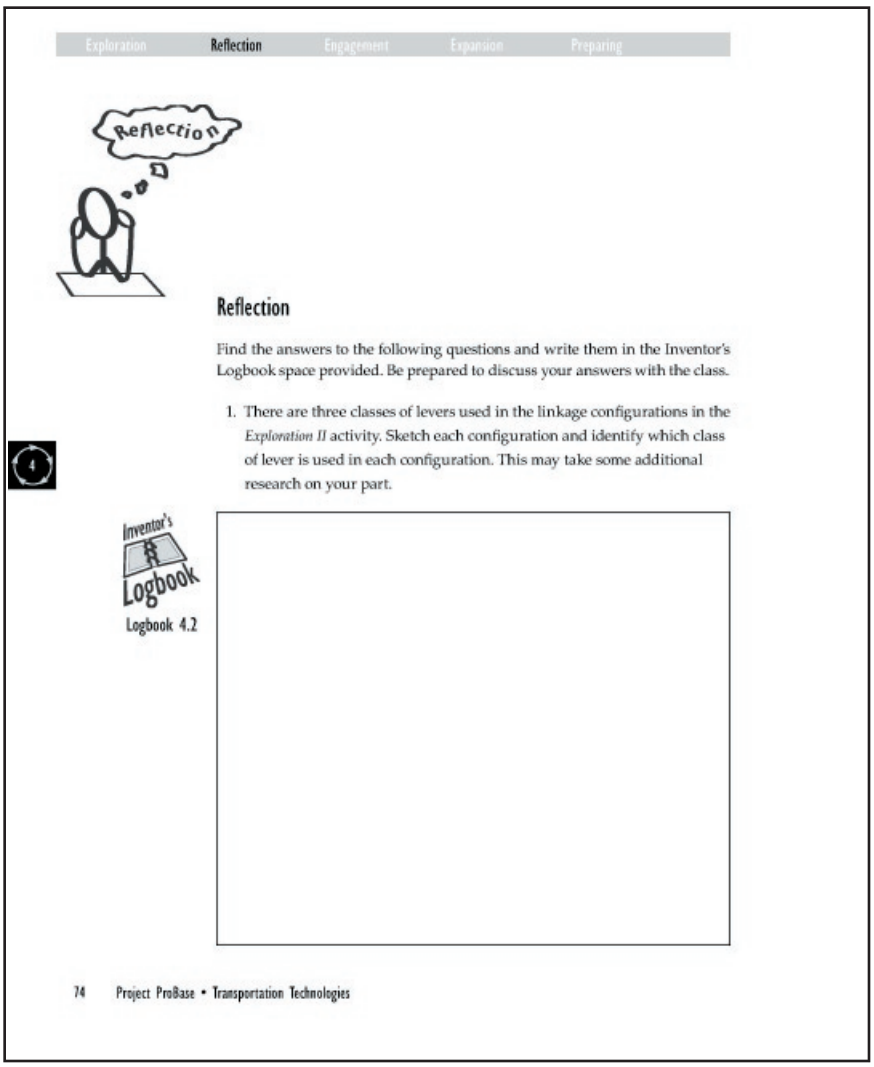
When both team members have tested their knowledge of linkage configurations, return all materials to your instructor and write the answers to the *Reflection* questions in the Inventor's Logbook spaces provided.

Remind the other students to sketch a plausible linkage system that performs like their partners'. If students develop solutions that move in the same way that their partners' did using a different configuration, they should construct their solution to be sure that it works like they think it does.

Reflection

Teaching tips

Students could do this as homework if time is limited. Some students may need to conduct additional research using the Internet or other available resources to find the answers to these questions.



Exploration Reflection Engagement Expansion Preparing

Reflection

Reflection

Find the answers to the following questions and write them in the Inventor's Logbook space provided. Be prepared to discuss your answers with the class.

1. There are three classes of levers used in the linkage configurations in the *Exploration II* activity. Sketch each configuration and identify which class of lever is used in each configuration. This may take some additional research on your part.

Inventor's Logbook

Logbook 4.2

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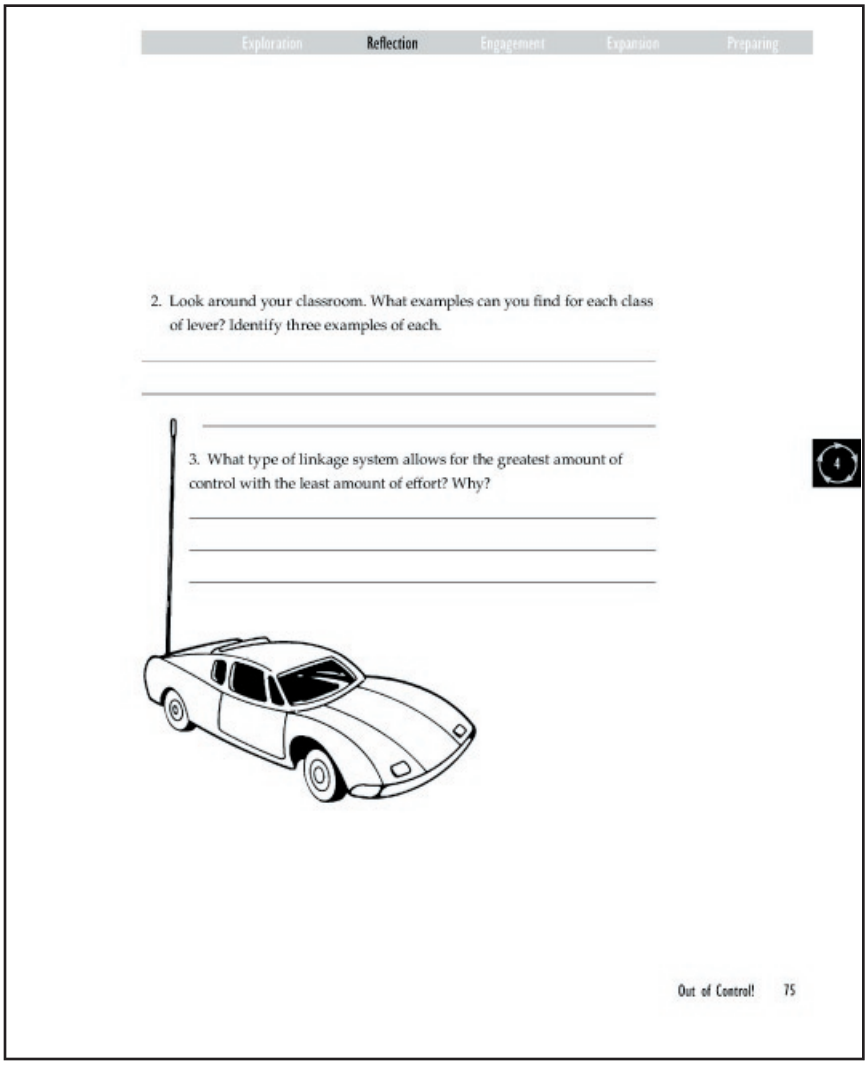
Students are asked to find the answers to the following questions and write them in the Inventor's Logbook spaces provided.

1. There are three classes of levers used in the linkage configurations in the *Exploration II* activity. Students are asked to identify which class of lever is used in each configuration. *See Table 1 for the classes of lever.*

Table 1.

Lever classes for *Exploration* configurations

Configuration	Class of Lever
1	1-1st class
2	2-2nd class
3	1-1st class
4	2-1st class
5	1-1st class; 1-3rd class
6	1-1st class



Exploration Reflection Engagement Expansion Preparing

2. Look around your classroom. What examples can you find for each class of lever? Identify three examples of each.

3. What type of linkage system allows for the greatest amount of control with the least amount of effort? Why?

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2. Look around your classroom. What examples can you find for each class of lever? Students are asked to identify three examples of each.
   Examples will come from your class and may include things like the door.

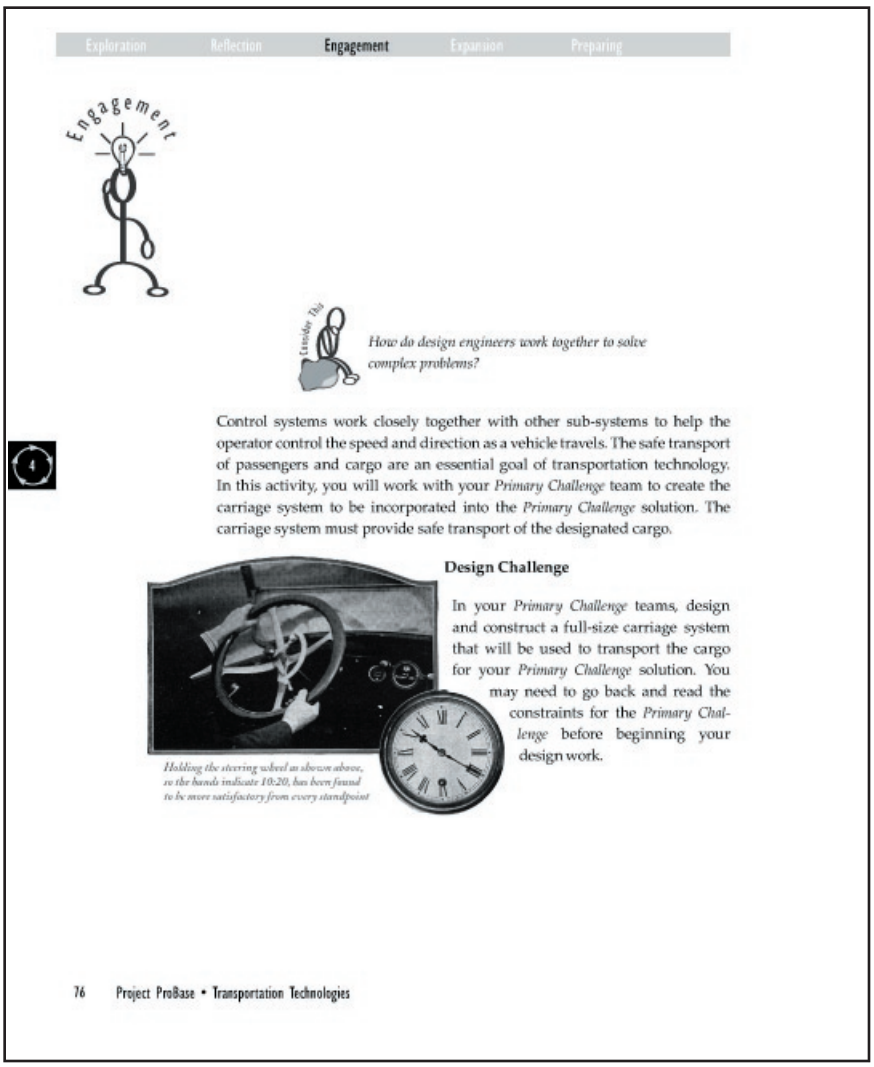
3. What type of linkage system allows for the greatest amount of control with the least amount of effort? Why?
   A first-class lever, because the fulcrum can be changed to various positions to adjust the amount of control necessary and the amount of effort used.

Engagement

The *Engagement* phase of this learning cycle allows students to apply what they have explored about linkage systems as they design and construct a prototype carriage system. This carriage system may be used to provide the safe transit of the cargo for the *Primary Challenge.*

Teaching tips

Allow students to work in their *Primary Challenge* teams for this activity. Students are asked to design a carriage system. Encourage your students to read the constraints for the *Primary Challenge* before beginning this task. Their systems may be separate from the vehicle design (i.e., a trailer or side car) or incorporated into a uni-body vehicle design.



Exploration Reflection **Engagement** Expansion Preparing

Engagement

Consider This

How do design engineers work together to solve complex problems?

Control systems work closely together with other sub-systems to help the operator control the speed and direction as a vehicle travels. The safe transport of passengers and cargo are an essential goal of transportation technology. In this activity, you will work with your *Primary Challenge* team to create the carriage system to be incorporated into the *Primary Challenge* solution. The carriage system must provide safe transport of the designated cargo.

Design Challenge

In your *Primary Challenge* teams, design and construct a full-size carriage system that will be used to transport the cargo for your *Primary Challenge* solution. You may need to go back and read the constraints for the *Primary Challenge* before beginning your design work.

Holding the steering wheel as shown above, so the hands indicate 10:20, has been found to be more satisfactory from every standpoint

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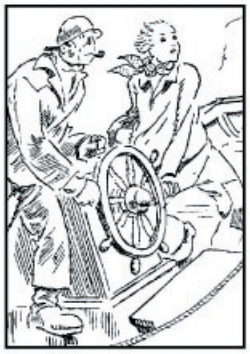
Student teams should work under the following criteria/ constraints as stated in the student text:

Criteria/Constraints

1. Your carriage system must be full size.
2. You must have a way to attach this carriage system to the final vehicle.



Criteria/Constraints

1. Your carriage system must be full size.
2. You must have a way to attach the carriage system to the final vehicle.
3. Your team will need to present your carriage system to the rest of the class and explain how it works.
4. To get started:
   a. Sketch two to three different designs on a separate sheet of paper.
   b. Select a design.
   c. Create a materials list and submit the list to your instructor.
   d. Begin construction.

Teaching Tips

Students may not have enough time to actually construct their carriage systems. They should at least present their designs and turn in a materials list. This will help prepare them for the *Primary Challenge* solution.

3. Your team will need to present the carriage system to the rest of the class and explain how it works.

4. To get started:
   a. Sketch two to three different designs on a separate sheet of paper.
   b. Select a design.
   c. Create a materials list and submit the list to your instructor.
   d. Begin construction.

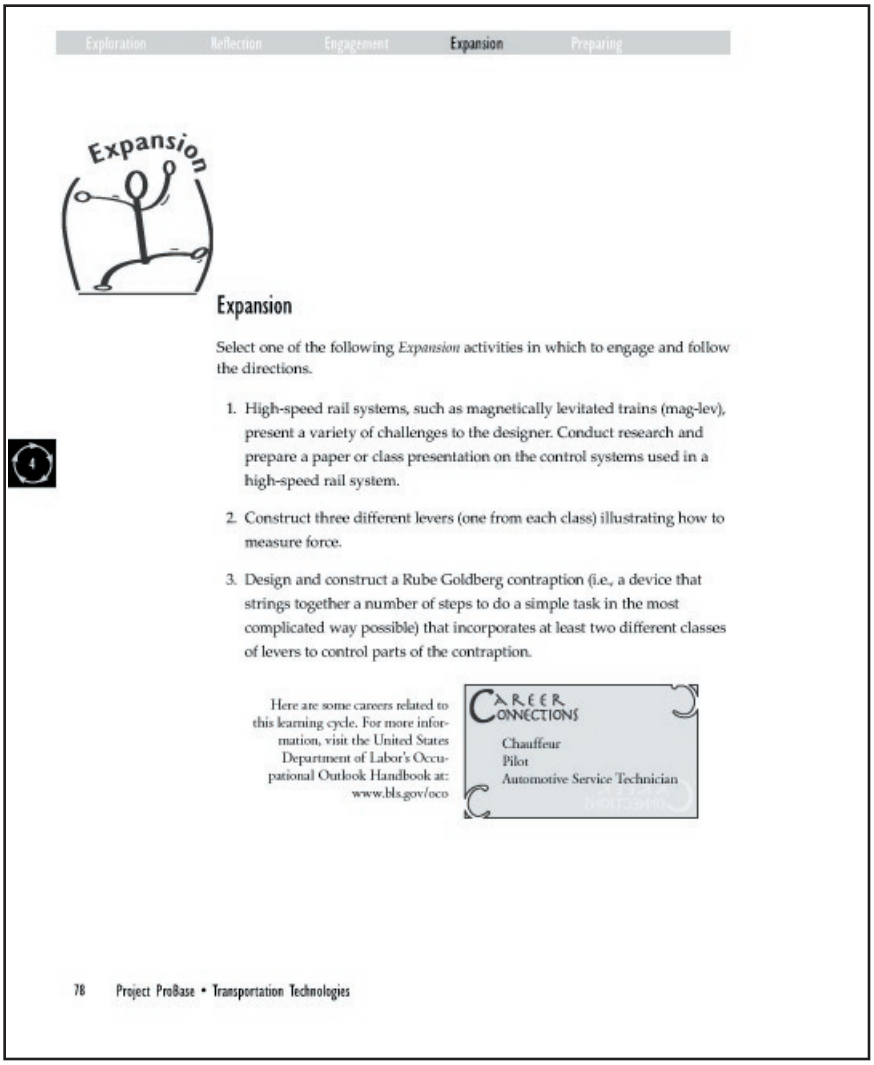
Expansion

Although not required, these *Expansion* activities are designed to cause teams to delve deeper into the concepts explained in this learning cycle.

1. High-speed rail systems, such as magnetically levitated trains (mag-lev), present a variety of challenges to the designer. Conduct research and prepare a paper or class presentation on the control systems in a high-speed rail system.

2. Construct three different levers (one from each class) illustrating how to measure force.

3. Design and construct a Rube Goldberg contraption (i.e., a device that strings together a number of steps to do a simple task in the most complicated way possible) that incorporates at least two different classes of levers to control parts of the contraption.



Exploration Reflection Engagement Expansion Preparing

Expansion

Expansion

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

1. High-speed rail systems, such as magnetically levitated trains (mag-lev), present a variety of challenges to the designer. Conduct research and prepare a paper or class presentation on the control systems used in a high-speed rail system.
2. Construct three different levers (one from each class) illustrating how to measure force.
3. Design and construct a Rube Goldberg contraption (i.e., a device that strings together a number of steps to do a simple task in the most complicated way possible) that incorporates at least two different classes of levers to control parts of the contraption.

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

Career Connections
Chauffeur
Pilot
Automotive Service Technician

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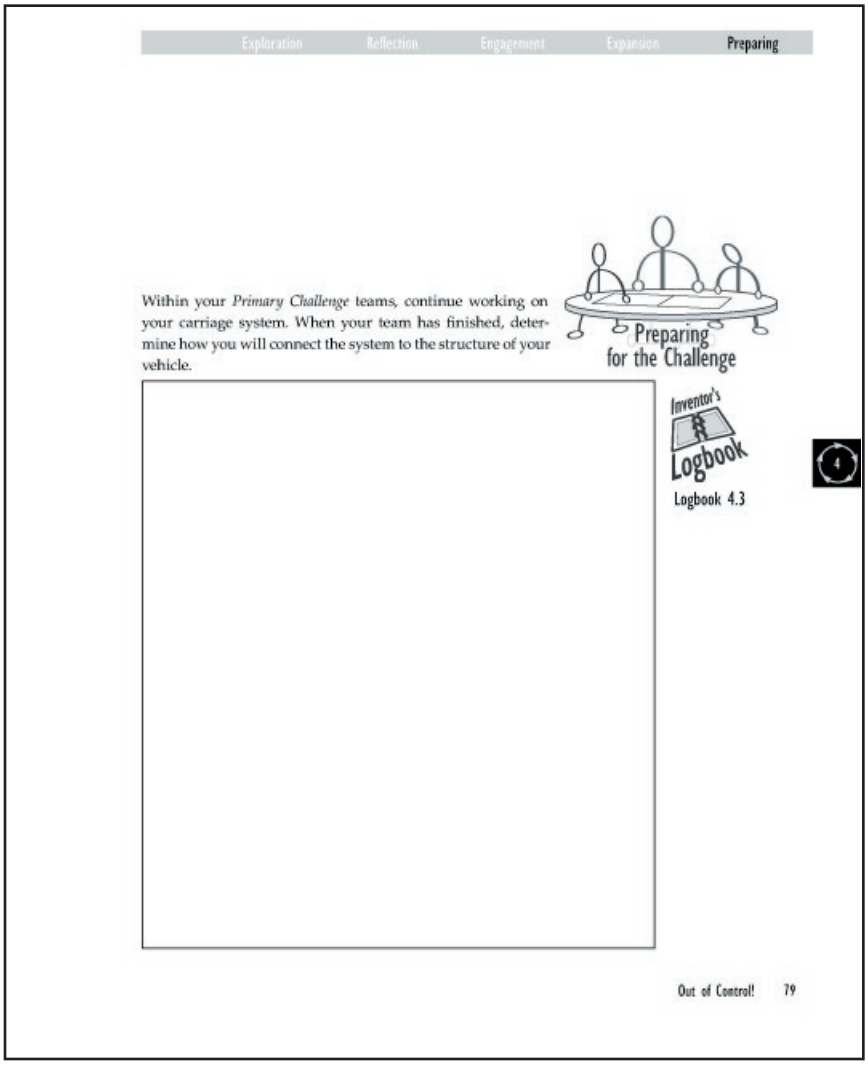

Exploration Reflection Engagement Expansion **Preparing**

Within your *Primary Challenge* teams, continue working on your carriage system. When your team has finished, determine how you will connect the system to the structure of your vehicle.

Preparing for the Challenge

Inventor's Logbook

Logbook 4.3

Out of Control! 79

Preparing for the Challenge

Students are asked to meet with their *Primary Challenge* team to continue working on their steering system. If some groups have completed their system, they should be directed to determine how they will connect it to the structure of their vehicle.

Student Assessment

An assessment rubric has been developed for the *Exploration* and *Engagement* activities. Feel free to change this rubric to better suit your particular needs.

Out of Control!

Name: Date:

Element	Criteria				Points
	4	3	2	1	
Research Research	Exceptional amount of research conducted about historical developments of brake system.	Above average amount of research conducted about historical developments of brake system.	Average amount of research conducted about historical developments of brake system.	Limited research conducted on brake system.	
Documentation	Exceptional documentation of research; more than 10 logbook entries/ sketches.	Above average documentation of research; 7-9 logbook entries/ sketches.	Average documentation of research; 4-6 logbook entries/ sketches.	Below average documentation of research; 1-3 logbook entries/ sketches.	
Presentation and Communication Preparation	Exceptional preparation of presentation with strong visual aids/ appropriate technology.	Above average preparation of presentation with good visual aids/ appropriate technology.	Average preparation of presentation with basic visual aids/ appropriate technology.	Below average preparation of presentation.	
Effectiveness	Presentation was exceptionally effective, clear, and accurate.	Presentation was effective, clear, and accurate.	Presentation's effectiveness, clarity, and accuracy were average.	Presentation's 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.	
Design Carriage system	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.	
Inventor's Logbook Entries	Fully answered all entries and provided good examples.	Answered 80% of the entries and provided some examples.	Answered 70% of the entries and provided few examples.	Did not answer entries and did not provide examples.	
				Total Points	