Car Rail Challenge

Students will design and construct a balanced weight system that will allow a toy car to roll down a narrow rail without falling off.

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**TIME REQUIRED**

- Advance Preparation: 25 minutes
- Set Up: 5 minutes
- Activity: 45 minutes
- Clean Up: 20 minutes

**SUPPLIES**

Each student or pair of students will need:
- 1 toy car such as a Matchbox or a Hotwheels Car Rail Setup
- 1 hoola hoop cut in half to make a semi-circle
- 2 Ring stand
- 4 C-clamps, about 2 1/2”
- Hacksaw or similar saw for cutting the hula hoop

Materials to photocopy:
- Student project worksheet, 1 per student

Suggested supplies for the class to have access to for car rail designs:
- toilet paper tubes
- beads
- popsicle sticks
- straws
- an assortment of nuts and bolts
- yarn
- hard pastas (macaroni)
- pipe cleaners (cut into assorted lengths)
- paper clips
- twisty ties
- wire
- scissors
- masking tape

**ADVANCE PREPARATION**

- Copy of project sheet, one per student
- Gather toy cars, 1 for each pair of students
- Gather car rail design supplies (suggested supplies listed above). It is suggested to have 1 supply station for every 4 groups of students.
- Cut 1 hula hoop in half using a hacksaw. Wear safety glasses and use C-clamps to hold it in place while cutting.
- Set up Car Rail Stations. Attach one end of the hula hoop to a ring stand with a C-clamp and set it on the floor. Attach the other end of the hula hoop to a desk or counter with another C-clamp (See Diagrams).

**SET UP**

- Have two areas in the classroom that will serve as “testing areas” for the toy cars. Set up one car rail in each of these areas.
INTRODUCING THE ACTIVITY

Using a yard stick, demonstrate the concept of balance. Ask the students to brainstorm their own definitions of balance.

What makes an object balanced?
When it stops tilting. When the weight is equal on both sides.

How can you find the “balance point” of an object?
The center of gravity. The center of the object. Point where the mass is evenly distributed.

Pass out rulers to each student and have them try to find the balance point of the ruler. Ask them to come up with rules to follow to find the balance point of an object.

Demonstrate how to find the balance point of the ruler by slowly moving your fingers from the ends of the ruler to the center.

What kinds of factors may affect balance?

CLASSROOM ACTIVITY

Divide the students into pairs or teams. Explain that their task is to design an amusement park ride that can successfully “drive” down a narrow rail without falling off. They have materials to develop a prototype of their design. You may want to suggest they consider factors such as balance, weight and friction during their design process.

- Inform the class of basic supplies
- Demonstrate the car rail setup
- Go over activity rules such as:
  - 1 toy car per a pair
  - The design cannot wrap fully around the tube, the teacher must be able to take it on and off without changing the design significantly. A successful model must drive down the entire tube.
  - Cars must drive the entire length of the tube
  - Teams are limited to 12 inches of tape (optional)
  - Draw every design you try. Write down what worked and what didn’t.
CLASS DISCUSSION

What other kinds of situations in the real world could this design challenge be used?
*Transportation, driving in mountain regions, construction, car design etc.*

Were there any common features you noticed between car rail designs that were successful?
*Weight distribution, they were balanced, they were simple in design etc.*

Were there any designs that worked really well?

What was the hardest part of solving this problem?
*Students may say that the limits on their materials or the amount of time they had to build were a challenge*

EXPLANATION

In-depth background information for teachers and interested students.

When designing structures such as bridges, airplanes and buildings, engineers have to keep in mind how the structure stays in balance and what makes them fall out of balance. Another word for balance is equilibrium. Equilibrium is a very important concept for engineers to consider because it is necessary to design safe structures. Equilibrium is important for everyday safety. If something is out of equilibrium, then it could fall over.

Center of gravity is a term used by many engineers, especially those involved with the design and construction of airplanes and other modes of transportation. The center of gravity of an object is the point around which the mass of an object is equally distributed.

In the example of the Car Rail, the center of gravity of the car begins above the hula hoop, and the car immediately flips over to the ground. By designing something that lowers the center of gravity below the hula hoop, the vehicle is able to stay on. The lower an object’s center of gravity, the more stable it is.
A. Working on a Budget
This activity works very well with the budget extension in Appendix A.

B. Center of Gravity
“All objects have a center of gravity including ourselves! Where is your center of gravity?”

“Your body has a center of gravity. It is located just behind your belly button. In order for you to stand upright, your center of gravity must be supported. To demonstrate this try standing against a wall with your right shoulder and right foot placed firmly against the wall. Now try lifting your left foot. What happens? Why?”

CROSS-CURRICULAR CONNECTIONS

Physics
For 7th and 8th grade: Introduce the concept of vectors and types of vectors such as velocity vectors. Vectors are composed of two main components: magnitude and direction. Have the students determine the types of vectors and direction of the vectors involved with the car rail challenge.

Math
Grades 2–5: Work with the students to measure the amount of masking tape used and the distances traveled. Grades 6 – 8: Introduce the concept of proportions. Have the students determined the weight of the objects attached to either side of their car? What is the proportion of one side to the other? Compare successful cars with unsuccessful cars.
C-Clamp
Weight
Toy Car
Car Rail
Half of a Hula-Hoop
What’s the Problem?
- What are the criteria for success?

What are the constraints?
- The car cannot wrap around the tube
- The design is limited to 12 inches of tape
- The car must drive down the tube completely from the top to the bottom
- The car design needs to be successful more than once
- Limits on materials

Develop a solution
- What will your design look like? Make sure to sketch your design on the proposal worksheet.
- What materials will you use?
- What kind of factors could affect how successful your car drives down the rail?

Test and Refine
- What parts of your design worked? What parts didn’t?
- What did you change in your prototype?
- How well did your design work?