Hands-On Lab Small groups 45 minutes

Design a Racecar, Part 1

SEP Asking Questions and Defining Problems

In a series of three lessons, small groups of students design and build a model racecar that will travel as far as possible after being rolled down a ramp. Students will not build their cars in this first lab. Instead, they will define the engineering problem by identifying the criteria and constraints of the problem.

Setup

- It will be helpful to have materials available for students to inspect as they research and analyze the racecar problem.
- Set up the ramp for students to observe as part of the research portion of the Part 1 lab. Make sure the ramp is built the same during each part of the lab. When building the ramp, try a ramp angle from 10° to 30°. Ramps with higher angles will typically make the cars travel a greater distance, and activity space may become a limiting factor.
- Corrugated cardboard may be difficult for students to cut. Other materials to consider for the car body include cereal boxes, poster board, note cards, and foam board. Flimsier materials may need to be stacked together to make a sturdy body for the car. Students can experiment with different materials as part of their engineering design process. Be sure students have the tools and skills to safely cut and shape whatever materials you select.

Strategies

- The lab instructions include one criterion (a car that travels as far as possible after being released from a ramp) and several constraints (limits on dimensions, time, and available materials). Students should brainstorm other criteria and constraints and come to an agreement as a class on what should be included in the problem definition.
- The class needs to agree on how to measure distance traveled. For example, if a car curves off instead of going in a straight line, will that count as distance traveled?

Teardown

Students will use the problem definition they developed in Part 1 to inform the Part 2 lab, which will focus on designing and testing a model car. Students should be confident they have enough information before moving on to Part 2.

PDF Student Lab Worksheet available online

Name

Date

HANDS-ON LAB

Design a Racecar, Part 1

You will design a solution for a gravity racecar in class over several lessons. Your challenge is to design and build a car that will travel as far as possible when released from a ramp that your teacher will set up. In developing a solution, you need to think about how limits such as the materials available to you, the time you have to complete the solution, and scientific principles will affect the available solutions.

MATERIALS
- cardboard or similar material
- digital scale
- measuring tape
- metal washers (weights)
- smoothie straws
- scissors
- tape
- wooden axles (2)
- wooden wheels (4)

Procedure

STEP 1 You are building a small gravity racecar. What questions do you have before you begin?

Sample questions:
What are the allowed dimensions of the car?
What materials are available to build the car?
How is the shape of the car likely to affect its speed?
How much is the car's maximum mass?
What can the car look like?
How long do we have to build the car?

You will only have one class period to build and test your racecar and you can only use materials provided by your teacher. Here are some dimensional limits for the car:
- The mass of the car is less than or equal to 100 g.
- The length of the car is less than or equal to 15 cm.

STEP 2 Clearly state the design problem. What need(s) will the design address?

Possible answer: The problem is to develop a gravity racecar that will travel as far as possible when released at the top of a ramp. A well-developed and optimized car could win a competition if the car travels the greatest distance.

STEP 3 Criteria are desirable features of the solution. Constraints are the limitations the designers need to work within. What criteria would you use to define this problem? List the criteria given in the problem details and add at least two more of your own.

Given criterion: a car that travels down a ramp and rolls as far as possible
Sample criteria: car is reusable (able to make multiple runs); looks good; is easy to assemble; has a place for a driver

STEP 4 What constraints would you use to define this problem? List the constraints given in the problem details and at least two more that you come up with.

Given constraints: mass of the car is less than or equal to 100 g; length of the car is less than or equal to 15 cm

Sample constraints: car has four wheels; uses only materials provided by the teacher; travels in a straight line/stays on the course

STEP 5 Work as a class to agree on a set of criteria and constraints.

STEP 6 In a competition, why is it important for all teams to be working with the same list of criteria and constraints?

Sample answer: In order to be a fair competition, everyone needs to follow the same limitations and rules.

Analysis

STEP 7 Now that you have an official list of criteria and constraints, score the criteria in order of importance to your design problem so you can design the best racecar. Use a scale from 1 to however many criteria you have. One will be assigned to the least important criterion and your highest number will be assigned to the most important criterion.

STEP 8 Why did you rank your criteria in this order?

Sample answer: Traveling the farthest is how a racecar wins, so that criterion gets top priority. Durability is second because we plan to test the racecar a lot. Appearance is least important because it doesn't affect the racecar's performance.

STEP 9 Why is it important to define the design problem more precisely than "design a small racecar that travels as far as possible"? Explain your answer in terms of an engineering design process.

Sample answer: It is important to define the design problem more precisely because the racecar must meet the constraints of the race rules to compete and will be evaluated based on the criteria. "Design a small racecar that travels as far as possible" does not include enough information to determine if a racecar design is suitable.

STEP 10 Do you have enough information to continue to the next stage of the engineering design process?

Sample answer: Yes, the list of criteria and constraints we have is enough to precisely define the problem and continue to the next step.

Self-Management Have students keep a journal to document their goals and progress as they work through the series of three labs to define, design, test, and optimize a model racecar. At the end of each lab, have students reflect on how the lab builds on the previous one(s), what questions they still have, and what steps or challenges remain before they reach their goals.

Hands-On Lab Scoring Rubric

Points	Criteria
	Follows lab procedures carefully and fully
	Identifies relationships
	Works well with others: shares responsibility, participates in group decision-making, listens carefully and respectfully to others, communicates ideas clearly, and supports own point of view with reasons or evidence