Cushion the Collision

Design and test a bumper using Newton's Third Law

MS-PS2-1 "Design a solution to a problem involving the motion of two colliding objects that illustrates Newton's Third Law. (SEP: 6; DCI: PS2.A, ETS1.B; CCC: Systems) Alignment may include MS-ETS1-1"

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the problem and two bumper rules, circle the two opposite pushes, and number the test steps in the passage to track how the team judges its design.

A Safer Cart Collision

1. In a school lab, a camera rides on a small cart rolling right. A supply cart rolls left toward it. The carts will collide at the end of a narrow track. A hard bump could damage the camera, so a design team needs a bumper that reduces the hardest push during impact. The bumper must fit on the front of a cart and cannot hook the carts together. After the collision, both carts must be able to roll to separate collection areas. The team can change the bumper, but not the carts' masses.

2. When the carts touch, the camera cart pushes the supply cart right, and the supply cart pushes the camera cart left. These pushes happen together. At each moment, the forces on the two carts are equal in size and opposite in direction. A bumper cannot make the force on only one cart smaller. The team considers a thick foam pad fixed to the camera cart. Foam can compress, allowing the carts to change their motion over more time. For similar changes in motion, this can reduce the largest force on both carts.

3. To test the idea, the team plans two collisions: one with bare fronts and one with the foam pad. They release the same carts from the same starting points so the approach speeds are alike. Force sensors on both carts record the largest push during each collision. The team also checks whether the carts separate and whether the pad stays on. A useful bumper would show a lower peak force than bare fronts, while still meeting the fit and separation rules. If the carts stick, the team must redesign the pad.

2 ANSWER WITH EVIDENCE

Use the passage

1. Besides reducing the hardest push, what two rules must the team's bumper meet?

2. During contact, which cart pushes right and which pushes left? How do the sizes of those forces compare?

3. How could the foam pad reduce the largest force on the camera cart without breaking Newton’s Third Law?

4. What should the team keep alike in both tests, and what results would show that the foam pad is useful?

3 YOUR TURN

Your own words

Two toy carts, one carrying an egg, roll toward each other; design a bumper using only folded cardboard and rubber bands so the egg is less likely to break and the carts can separate. Describe how you would attach it, explain the force pair and how your bumper could change the collision, then plan a fair test against bare carts and state what results would show success.

ANSWER KEY

Cushion the Collision

GRADES 6-8 · MS-PS2-1

PART 1 · READ AND MARK

Underline the problem and two bumper rules, circle the two opposite pushes, and number the test steps in the passage to track how the team judges its design. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Besides reducing the hardest push, what two rules must the team's bumper meet?	**It must fit on the front of a cart, and it must not hook the carts together so they can separate.**
2	During contact, which cart pushes right and which pushes left? How do the sizes of those forces compare?	**The camera cart pushes the supply cart right. The supply cart pushes the camera cart left. The forces are equal in size at each moment.**
3	How could the foam pad reduce the largest force on the camera cart without breaking Newton's Third Law?	**The foam can extend the time over which the carts change motion, reducing the peak force on both carts. Their forces remain equal in size and opposite in direction at each moment.**
4	What should the team keep alike in both tests, and what results would show that the foam pad is useful?	**They should use the same carts and starting points so the approach speeds are alike. The padded collision should have a lower peak force, and the pad should stay on while the carts separate.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would fasten folded cardboard to the front of the egg cart with rubber bands that stay on that cart. The folded layers could bend during impact, increasing contact time and reducing the peak force if the change in motion is similar. Each cart pushes the other with an equal-sized force in the opposite direction. I would send the same carts toward each other at the same speeds with and without the bumper. I would compare the highest forces, check the egg for cracks, and make sure the carts separate.

Accept other workable cardboard-and-rubber-band bumpers that do not join the carts. Responses should identify equal and opposite forces on the two carts, keep approach speeds alike for a fair comparison, and give evidence related to egg protection and separation.