The Longer Push

Use collision data to connect contact time, force, and momentum.

PS.1.d "Investigate collisions and other real-world situations to evaluate the effects of impulse on changes in momentum."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the sentence that connects impulse to force, time, and momentum. Circle the negative final velocities in the table, then draw a line between each pair of trials with the same final velocity.

When a Ball Hits a Wall

1. A lab launches the same 0.20 kg rubber ball toward a test wall at 10 m/s in every trial. Call motion toward the wall positive, so the starting velocity is +10 m/s. When the ball touches a surface, the surface pushes on it. That push acts for a short time and can change both the ball's speed and its direction.

2. Each row records a separate trial. The ball either stops at the wall or rebounds away from it. Negative final velocity means it moves away from the wall. The measured force is the average force exerted by the wall on the ball during contact. All four trials start with the same ball and the same approach velocity.

BALL COLLISION TRIALS

Trial	Final velocity (m/s)	Contact time (s)	Average force on ball (N)
Rigid wall, stop	0	0.010	−200
Foam wall, stop	0	0.040	−50
Rigid wall, rebound	−5	0.010	−300
Foam wall, rebound	−5	0.060	−50

3. Momentum equals mass times velocity, and its change is final momentum minus initial momentum. Impulse equals average force times contact time and also equals the change in momentum. A negative impulse points away from the wall. When comparing two trials, check both how long contact lasts and how much the ball's momentum changes before explaining a difference in force.

2 ANSWER WITH EVIDENCE

Use the passage

1. What is the ball's change in momentum in the rigid-wall stop trial? Show your calculation and include the direction.

2. Use force and contact time to find the impulse in the foam-wall rebound trial. What does its sign tell you?

3. Compare the two stop trials. How can their average forces differ even though the ball has the same change in momentum?

4. Compare the two rigid-wall trials. Why is the average force greater when the ball rebounds, even though contact time is the same?

3 YOUR TURN

Your own words

Invent a collision involving an object other than a ball. Give its mass, starting and ending velocities, and two possible contact times; calculate the momentum change and average force for each time, then explain which setup reduces force and why.

The Longer Push

PART 1 · READ AND MARK

Underline the sentence that connects impulse to force, time, and momentum. Circle the negative final velocities in the table, then draw a line between each pair of trials with the same final velocity. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	What is the ball's change in momentum in the rigid-wall stop trial? Show your calculation and include the direction.	**(0.20 kg)(0 − 10 m/s) = −2 kg·m/s. The change points away from the wall.**
2	Use force and contact time to find the impulse in the foam-wall rebound trial. What does its sign tell you?	**(−50 N)(0.060 s) = −3 N·s. The impulse points away from the wall.**
3	Compare the two stop trials. How can their average forces differ even though the ball has the same change in momentum?	**Both trials have an impulse of −2 N·s. Contact lasts four times as long with foam, so its average force magnitude is one-fourth as large: 50 N instead of 200 N.**
4	Compare the two rigid-wall trials. Why is the average force greater when the ball rebounds, even though contact time is the same?	**Rebounding changes the ball's momentum by −3 kg·m/s instead of −2 kg·m/s. With the same 0.010 s contact time, the larger impulse requires a greater average force magnitude: 300 N instead of 200 N.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

A 5 kg rolling suitcase moves at +2 m/s and stops when it hits a barrier. Its momentum change is (5 kg)(0 − 2 m/s) = −10 kg·m/s in either setup. A rigid barrier stops it in 0.10 s, so the average force is −100 N. A padded barrier stops it in 0.50 s, so the average force is −20 N. Padding reduces the force magnitude because the same momentum change takes longer.

Accept a consistent sign convention and equivalent units for impulse and momentum change. In Part 3, the two calculated forces must match the stated momentum change and contact times.