Sled Force Investigation

Use motion data to explain what forces do

P.2 "Construct explanations of dynamics from evidence, using Newton's laws of motion. a. Evaluate the effects of balanced and unbalanced forces on an object's motion. b. Use mathematical, graphical..."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline each force acting on the sled, and circle the force that the sled exerts on another object. Number the three pull strengths in the table from least to greatest so you can compare their effects on acceleration.

A Sled on the Track

1. A 20 kg training sled slides to the right along a level gym track. It is already moving when each measurement begins. A student pulls its rope horizontally to the right. The track pushes on the sled vertically and rubs against it horizontally. A force sensor records the rope's pull during three short trials.

2. The sled's weight is 196 N downward, and the track's normal force is 196 N upward in every trial. The sled has no vertical acceleration. Motion sensors measure acceleration to the right, while a second sensor measures friction to the left. Each trial uses the same sled and track, so its mass and measured friction remain constant.

HORIZONTAL FORCES AND MOTION

Rope pull right (N)	Friction left (N)	Acceleration right (m/s²)
20	20	0
40	20	1
60	20	2

3. During the middle trial, the rope pulls the sled rightward with 40 N. At the same instant, the sled pulls the rope leftward with 40 N. A force diagram for the sled includes forces from the rope, Earth, and track. The table records horizontal measurements for all three trials, taken while the sled is moving.

2 ANSWER WITH EVIDENCE

Use the passage

1. In the 20 N pull trial, are the forces on the sled balanced? What happens to its velocity?

2. For the 40 N pull trial, list all four forces you would put on a free-body diagram of the sled. Give each force's direction and magnitude.

3. Compare the 40 N and 60 N pull trials. Calculate each net horizontal force, then explain the change in acceleration using the sled's mass.

4. The rope pulls the sled with 40 N in the middle trial. Identify its equal and opposite force, and explain why the two forces do not balance the sled.

3 YOUR TURN

Your own words

A 10 kg cart already rolls right on a level floor; friction is 10 N left, weight is 98 N down, and the normal force is 98 N up. In two panels, draw and label every force on the cart for rope pulls of 10 N right and 30 N right, then state each acceleration and explain why the cart's pull on the rope does not cancel the rope's pull on the cart.

Sled Force Investigation

PART 1 · READ AND MARK

Underline each force acting on the sled, and circle the force that the sled exerts on another object. Number the three pull strengths in the table from least to greatest so you can compare their effects on acceleration. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	In the 20 N pull trial, are the forces on the sled balanced? What happens to its velocity?	**Yes. The horizontal forces cancel, as do the vertical forces. The sled continues moving right at a constant velocity.**
2	For the 40 N pull trial, list all four forces you would put on a free-body diagram of the sled. Give each force's direction and magnitude.	**Rope pull: 40 N right; friction: 20 N left; normal force: 196 N up; weight: 196 N down.**
3	Compare the 40 N and 60 N pull trials. Calculate each net horizontal force, then explain the change in acceleration using the sled's mass.	**The net forces are 20 N right and 40 N right. With the same 20 kg mass, doubling the net force doubles the acceleration from 1 to 2 m/s² right.**
4	The rope pulls the sled with 40 N in the middle trial. Identify its equal and opposite force, and explain why the two forces do not balance the sled.	**The sled pulls the rope with 40 N left. That force acts on the rope, not the sled, so it cannot balance a force on the sled.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Panel 1: ↑ normal 98 N, ↓ weight 98 N, → rope 10 N, ← friction 10 N. Panel 2: ↑ normal 98 N, ↓ weight 98 N, → rope 30 N, ← friction 10 N. The cart's accelerations are 0 and 2 m/s² right, respectively. The cart pulls the rope left, but that force acts on the rope, not the cart.

Accept any clear force labels and arrow directions in the panels. The first cart has zero net force and constant velocity; the second has 20 N net force to the right.