Forces in Motion

Read, mark, and calculate forces on two carts

PHY.2.1 "Identify forces acting on a system by applying Newton's laws mathematically and graphically (e.g., vector and scalar quantities)."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline each force acting on a cart, circle each force value in newtons, and write R or L above each horizontal force to show its direction.

Two Trials on the Track

1. At a school science fair, two teams test wheeled carts on a level floor. A force is a vector: it has both size and direction. Mass is a scalar: it has size but no direction. To make a free-body sketch, choose one object, then draw one arrow for each external force acting on it. Label each arrow with the force and its size. Opposite arrows on the same axis compete. Add forces with signs, such as positive for right and negative for left, to find net force. Newton's second law states that net force equals mass times acceleration.

2. For the first trial, the system is a 4 kg cart rolling to the right across the level floor. A student pushes the cart with a horizontal force of 18 N to the right. Friction from the floor acts on the cart with a force of 6 N to the left. Earth's gravitational force on the cart is 40 N downward, and the floor's normal force on the cart is 40 N upward. A camera records the cart's position every second as it rolls along a straight taped track. To interpret those positions, the team needs to predict the cart's acceleration from the forces.

3. In the second trial, the system is a different cart with a mass of 6 kg. A rope pulls it with a horizontal force of 20 N to the right, while friction from the floor acts with a force of 20 N to the left. Earth's gravitational force on this cart is 60 N downward, and the floor's normal force is 60 N upward. At the moment these measurements are taken, the cart is moving right. A force arrow's length represents force size, not speed. Compare the opposing arrows before predicting changes in motion.

2 ANSWER WITH EVIDENCE

Use the passage

1. For the first cart, list the four force arrows you would draw. Give each force's size and direction.

2. Take right and up as positive. Calculate the first cart's net force on each axis, including direction.

3. Use Newton's second law to calculate the first cart's acceleration. Include its direction.

4. For the second cart, compare the opposing forces on both axes. What are its net force and acceleration?

3 YOUR TURN

Your own words

Invent a level-floor cart trial with a mass and four force values different from those in both trials. In the box, draw and label four force arrows, then write the horizontal net-force calculation and the cart's acceleration with direction.

ANSWER KEY

Forces in Motion

PART 1 · READ AND MARK

Underline each force acting on a cart, circle each force value in newtons, and write R or L above each horizontal force to show its direction. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	For the first cart, list the four force arrows you would draw. Give each force's size and direction.	**Push: 18 N right; friction: 6 N left; gravity: 40 N down; normal force: 40 N up.**
2	Take right and up as positive. Calculate the first cart's net force on each axis, including direction.	**Horizontal: 18 N − 6 N = 12 N right. Vertical: 40 N − 40 N = 0 N.**
3	Use Newton's second law to calculate the first cart's acceleration. Include its direction.	**$a = 12\ N \div 4\ kg = 3\ m/s^2$ right.**
4	For the second cart, compare the opposing forces on both axes. What are its net force and acceleration?	**The 20 N horizontal forces cancel, and the 60 N vertical forces cancel. Net force is 0 N, so acceleration is 0 m/s^2.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

3 kg cart with arrows labeled: push, 15 N right; friction, 3 N left; normal force, 30 N up; gravity, 30 N down. Horizontal net force = 15 N − 3 N = 12 N right. Acceleration = 12 N ÷ 3 kg = 4 m/s^2 right.

Accept equivalent force sketches and calculations with consistent directions. In the open task, check that the vertical forces balance for a cart on a level floor and that the calculated acceleration matches the student's chosen mass and horizontal forces.