Force Data Detectives

Use motion data to test the force, mass, and acceleration relationship.

HS-PS2-1 "Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration..."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline every numerical measurement of force, mass, time, or velocity. Circle each sentence that explains how a controlled comparison can test the relationship among force, mass, and acceleration.

Three Cart Trials

1. The following idealized classroom data are simulated for analysis, not reported measurements from a named study. Newton's second law connects three measurable quantities in one-dimensional motion. Net force is the total force after forces in opposite directions are combined. When the net force stays constant, acceleration can be found from the change in velocity divided by the elapsed time. In a lab, a low-friction cart with a mass of 2.0 kg is pulled to the right by a constant net force of 1.2 N. Its velocities are 0.0 m/s at 0 s, 0.6 m/s at 1 s, 1.2 m/s at 2 s, and 1.8 m/s at 3 s. The equal velocity increases show a constant acceleration.

2. The relationship $F_{net} = ma$ can be tested by comparing trials in which only one variable changes. A second trial keeps the 2.0 kg cart but changes the constant net force to 2.4 N. The measured velocity changes by 1.20 m/s every second. The cart in the first trial receives half this net force and has the same mass. Because the velocity changes are constant in both trials, each change per second is an acceleration. Comparing these trials tests whether acceleration changes in the same proportion as net force when mass is controlled.

3. Mass also matters. In a third trial, the net force returns to 1.2 N, but two identical carts are connected, making the moving mass 4.0 kg. The velocity increases by 0.30 m/s each second. The first and third trials have the same net force, while their masses differ. This comparison tests how acceleration responds when force is controlled and mass changes. Data from all three trials can support the claim that acceleration equals net force divided by mass only if the calculated accelerations match the force-to-mass ratios. An analysis must use numerical evidence, not simply say that an object "moves faster."

2 ANSWER WITH EVIDENCE

Use the passage

1. Calculate the acceleration of the cart in the first trial. Show how the velocity data support your calculation.

2. Compare the first and second trials. When the net force doubles while mass stays the same, what happens to acceleration? Include both acceleration values.

3. Calculate the acceleration in the third trial. How does it compare with the first trial when the mass doubles and net force stays the same?

4. What variable is controlled when comparing the first and second trials? What variable is controlled when comparing the first and third trials?

3 YOUR TURN

Your own words

Organize the three trials described in the passage into the table. Use each trial's stated velocity changes to record velocities at 0, 1 and 2 seconds, starting at rest. Calculate acceleration from those velocities, then compare a with F_net/m. Identify the controlled pair for each comparison and explain why simulated data illustrate a law but do not independently verify it.

TRIAL	MASS	NET FORCE	VELOCITY AT 0 S, 1 S, 2 S

ANSWER KEY

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HIGH SCHOOL · HS-PS2-1

PART 1 · READ AND MARK

Underline every numerical measurement of force, mass, time, or velocity. Circle each sentence that explains how a controlled comparison can test the relationship among force, mass, and acceleration. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Calculate the acceleration of the cart in the first trial. Show how the velocity data support your calculation.	**0.60 m/s^2. The velocity increases by 0.60 m/s during each 1 s interval.**
2	Compare the first and second trials. When the net force doubles while mass stays the same, what happens to acceleration? Include both acceleration values.	**Acceleration doubles, from 0.60 m/s^2 in the first trial to 1.20 m/s^2 in the second trial.**
3	Calculate the acceleration in the third trial. How does it compare with the first trial when the mass doubles and net force stays the same?	**The third-trial acceleration is 0.30 m/s^2. It is half the first-trial acceleration of 0.60 m/s^2.**
4	What variable is controlled when comparing the first and second trials? What variable is controlled when comparing the first and third trials?	**Mass is controlled in the first and second trials. Net force is controlled in the first and third trials.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Trial 1: 2.0 kg, 1.2 N, velocities 0.0, 0.6, 1.2 m/s. Trial 2: 2.0 kg, 2.4 N, velocities 0.0, 1.2, 2.4 m/s. Trial 3: 4.0 kg, 1.2 N, velocities 0.0, 0.3, 0.6 m/s. Accelerations are 0.6, 1.2 and 0.3 m/s², matching F_net/m. Trials 1 and 2 hold mass constant; trials 1 and 3 hold force constant. These simulated values illustrate the relationship. Independent verification requires force, mass and velocity measurements obtained separately from the law being tested.

Require the given simulated trial values, correct velocity-based accelerations, controlled comparisons, and an explicit distinction between illustrating a model and testing it with independent measurements.