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. 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 Fnet = 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

Create a three-trial data table for carts moving in one direction. Include mass, net force, and velocity at 0 s, 1 s, and 2 s, with one pair of trials that changes only force and one pair that changes only mass. Then write a two-sentence claim using numerical evidence to support Newton's second law.

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/s². 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/s² in the first trial to 1.20 m/s² 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/s². It is half the first-trial acceleration of 0.60 m/s².**
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 | Mass | Net force | Velocity at 0 s, 1 s, 2 s A | 2.0 kg | 1.0 N | 0.0, 0.50, 1.00 m/s B | 2.0 kg | 2.0 N | 0.0, 1.00, 2.00 m/s C | 4.0 kg | 2.0 N | 0.0, 0.50, 1.00 m/s With mass held at 2.0 kg, doubling net force from 1.0 N to 2.0 N doubles acceleration from 0.50 m/s² to 1.0 m/s². With net force held at 2.0 N, doubling mass from 2.0 kg to 4.0 kg halves acceleration from 1.0 m/s² to 0.50 m/s², so the data support a = Fnet/m.

Accept equivalent acceleration calculations and evidence statements that correctly use the velocity change per second. For the open task, accept any internally consistent data set that controls mass for one comparison, controls net force for another, and supports the stated relationship with numbers.