Rescue Cart Test

Plan fair comparisons of force, mass, and acceleration

PHS.5.5 "Design and construct an investigation using probe systems and/or online simulations to observe relationships between force, mass, and acceleration (F=ma)."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline each description of a comparison that holds one quantity fixed, circle the three quantities the simulator reports, and box how the team summarizes repeated runs.

Testing a Rescue Cart

1. A robotics team tests a rescue cart in an online motion simulator. Their question is how the cart's acceleration changes when either its net force or its total mass changes. The simulator reports net force, total mass, and acceleration. The team turns off friction so the applied horizontal push equals the net force. They start each run from rest.

2. To test force, the team holds mass at 1 kg and compares pushes of 2 N and 4 N. To test mass, they hold net force at 2 N and compare carts of 1 kg and 2 kg. They repeat every force-mass setting three times; the table reports the mean acceleration for each setting.

MEAN ACCELERATION FROM THREE RUNS PER SETTING

Net force (N)	Total mass (kg)	Mean acceleration (m/s^2)
2	1	2
4	1	4
2	2	1
4	2	2

3. The table also includes the 4 N, 2 kg setting, allowing another mass comparison at constant force. A fair comparison changes one input and keeps the other fixed. Because each table value averages three runs, a single unusual run has less influence. The team can check whether each setting agrees with F = ma by multiplying its mass and mean acceleration.

2 ANSWER WITH EVIDENCE

Use the passage

1. Which two settings isolate the effect of force when mass is 1 kg? How does mean acceleration change?

2. Which two settings isolate the effect of mass when net force is 4 N? How does mean acceleration change?

3. A student compares 2 N, 1 kg with 4 N, 2 kg to test the effect of force. Why is this not a fair comparison? Which setting could replace 4 N, 2 kg?

4. Use the mean acceleration to check F = ma for the 2 N, 2 kg setting. Show the calculation and state whether it agrees.

3 YOUR TURN

Your own words

Design a two-setting investigation of how total mass affects acceleration using a force probe and a motion probe on a low-friction cart. Choose a fixed net force not used in the table, give two masses, explain what each probe measures and how many runs you would make, and predict both accelerations using F = ma.

ANSWER KEY

Rescue Cart Test

PART 1 · READ AND MARK

Underline each description of a comparison that holds one quantity fixed, circle the three quantities the simulator reports, and box how the team summarizes repeated runs. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Which two settings isolate the effect of force when mass is 1 kg? How does mean acceleration change?	**Compare 2 N and 4 N at 1 kg. Mean acceleration doubles from 2 to 4 m/s^2.**
2	Which two settings isolate the effect of mass when net force is 4 N? How does mean acceleration change?	**Compare 1 kg and 2 kg at 4 N. Mean acceleration falls from 4 to 2 m/s^2.**
3	A student compares 2 N, 1 kg with 4 N, 2 kg to test the effect of force. Why is this not a fair comparison? Which setting could replace 4 N, 2 kg?	**Both force and mass change. Replace 4 N, 2 kg with 4 N, 1 kg so only force changes.**
4	Use the mean acceleration to check F = ma for the 2 N, 2 kg setting. Show the calculation and state whether it agrees.	**F = (2 kg)(1 m/s^2) = 2 N, which agrees with the reported net force.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would test total masses of 1.5 kg and 3 kg at a fixed net force of 3 N. A force probe would measure the horizontal pull, which is close to net force when friction is small. A motion probe would measure the cart's motion so I could find acceleration. I would run each setting three times and average the accelerations. Since a = F/m, I predict 2 m/s^2 and 1 m/s^2, respectively.

Accept any two distinct positive masses and a fixed net force other than 2 N or 4 N, with correctly calculated accelerations. The plan must change only mass between settings and use both probes to gather evidence.