Cart Track Trials

Predict motion changes from force, time, and distance

HS-PSII-1.1 "For a system consisting of a single object with a net external force applied, qualitatively and quantitatively predict changes in its linear momentum using the impulse-momentum theorem and in its translational kinetic energy using the..."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline each trial's starting speed and net force direction, circle its time or distance, and number the impulse and work equations in the passage.

Four Tests on a Straight Track

1. At a testing track, a motor pulls a single cart along a straight rail. The cart is the system, and the net external force combines all forces on it. Momentum is $p = mv$, where velocity v includes direction. For a constant net force, impulse changes momentum: $\Delta p = F_{net}t$. Net work changes kinetic energy: $\Delta K = F_{net}d$ when force and displacement align; opposite directions give negative work. Kinetic energy is $K = \frac{1}{2}mv^2$. To find distance for an object starting from rest, first find acceleration $a = F_{net}/m$, then use $d = \frac{1}{2}at^2$.

2. In two separate trials, technicians use a 2 kg cart and measure motion to the right as positive. In trial A, the cart begins at 3 m/s to the right. A constant net force of 4 N to the right acts for 2 s. In trial B, the cart begins at 5 m/s to the right. A constant net force of 6 N to the left acts for 1 s. A leftward impulse subtracts from rightward momentum; whether the cart reverses depends on how that impulse compares with its starting momentum. Treat each trial as a fresh start.

3. For two more separate trials, the cart's mass remains 2 kg, but the technicians record distance rather than time. In trial C, the cart starts at 2 m/s to the right. A constant net force of 3 N to the right acts while it travels 4 m to the right. In trial D, the cart starts at 6 m/s to the right. A constant net force of 4 N to the left acts while it travels 3 m to the right. In each case, calculate initial kinetic energy before adding signed net work. A decrease in kinetic energy means a lower speed for the same cart.

2 ANSWER WITH EVIDENCE

Use the passage

1. In trial A, what impulse acts on the cart? Calculate its final momentum.

2. In trial B, calculate the cart's final momentum. Does it reverse direction?

3. In trial C, calculate the change in kinetic energy and the final kinetic energy. Does the cart speed up?

4. In trial D, calculate the change in kinetic energy and the final kinetic energy. Does the cart speed up or slow down?

3 YOUR TURN

Your own words

Invent a new trial with one cart starting from rest: choose its mass, a constant net force to the right, and how long the force acts. Calculate its final momentum from impulse, use $a = F_{net}/m$ and $d = \frac{1}{2}at^2$ to find its distance, then use net work to find its final kinetic energy and describe its speed change.

Cart Track Trials

PART 1 · READ AND MARK

Underline each trial's starting speed and net force direction, circle its time or distance, and number the impulse and work equations in the passage. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	In trial A, what impulse acts on the cart? Calculate its final momentum.	**Impulse = (4 N)(2 s) = 8 N·s right. Initial momentum = (2 kg)(3 m/s) = 6 kg·m/s right, so final momentum = 14 kg·m/s right.**
2	In trial B, calculate the cart's final momentum. Does it reverse direction?	**Initial momentum is 10 kg·m/s right, and impulse is 6 N·s left. Final momentum is 4 kg·m/s right, so the cart does not reverse.**
3	In trial C, calculate the change in kinetic energy and the final kinetic energy. Does the cart speed up?	**Net work is (3 N)(4 m) = 12 J, so kinetic energy increases by 12 J. Initial kinetic energy is 4 J, giving a final kinetic energy of 16 J. The cart speeds up.**
4	In trial D, calculate the change in kinetic energy and the final kinetic energy. Does the cart speed up or slow down?	**The opposing force does -12 J of work, so kinetic energy decreases by 12 J. Initial kinetic energy is 36 J, giving a final kinetic energy of 24 J. The cart slows down.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

My 2 kg cart starts from rest. A 4 N net force acts to the right for 3 s. Its impulse is (4 N)(3 s) = 12 N·s right, so its final momentum is 12 kg·m/s right. Its acceleration is 4 N ÷ 2 kg = 2 m/s^2, and it travels ½(2 m/s^2)(3 s)^2 = 9 m. Net work is (4 N)(9 m) = 36 J, so its final kinetic energy is 36 J. Its speed increases from rest.

For Part 3, accept any positive mass, rightward constant net force, and positive time with consistent impulse, distance, and work calculations. Equivalent units for impulse and momentum are acceptable.