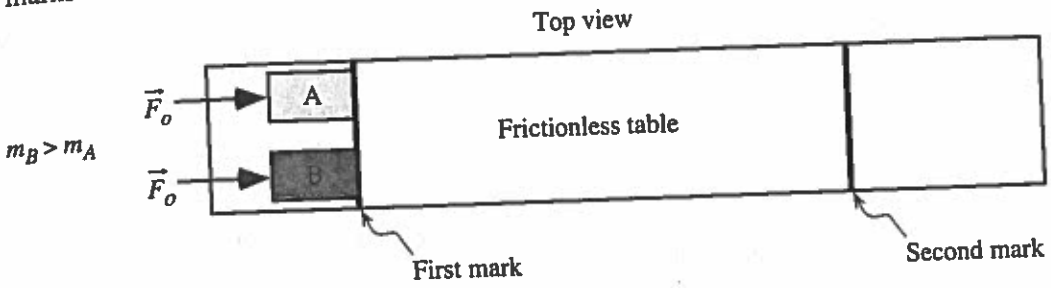
I. Relating forces to changes in kinetic energy and momentum

Two carts, A and B, are initially at rest on a horizontal frictionless table as shown in the top-view diagram below. A constant force of magnitude F_o is exerted on each cart as it travels between two marks on the table. Cart B has a greater mass than cart A.



A. Three students discuss the final momentum and kinetic energy of each cart.

Student 1: *"Since the same force is exerted on both carts, the cart with the smaller mass will move quickly, while the cart with the larger mass will move slowly. The momentum of each cart is equal to its mass times its velocity."*

Student 2: *"This must mean that the speed compensates for the mass and the two carts have equal final momenta."*

Student 3: *"I was thinking about the kinetic energies. Since the velocity is squared to get the kinetic energy but mass isn't, the cart with the bigger speed must have more kinetic energy."*

In the space below, write down whether you agree or disagree with the statements made by each student.

B. Which cart takes longer to travel between the two marks? Explain your reasoning.

C. Use Newton's second law and the definition of acceleration to derive an equation for each cart relating the net force on the cart to the change in velocity of the cart ($\Delta\vec{v}_A$ or $\Delta\vec{v}_B$) and the time interval (Δt_A or Δt_B) that the cart spends between the two marks.

1. Is the quantity $m_A|\Delta\vec{v}_A|$ *greater than, less than,* or *equal to* $m_B|\Delta\vec{v}_B|$? Explain how you can tell.

For a constant net force, the quantity $\vec{F}_{net}\,\Delta t$ is called the *impulse* imparted to the object.

2. Is the magnitude of the impulse imparted to cart A *greater than, less than,* or *equal to* the magnitude of the impulse imparted to cart B? Explain your reasoning.

3. Write an equation showing how the impulse imparted to cart A is related to the *change in momentum vector* of cart A ($\Delta\vec{p}_A$), where momentum, denoted by $\vec{p}$, is the product of the mass and velocity of the object.

This relationship is known as the *impulse-momentum theorem.*

4. Is the magnitude of the final momentum of cart A (p_{A_f}) *greater than, less than,* or *equal to* the magnitude of the final momentum of cart B (p_{B_f})? Explain.

D. How does the net work done on cart A ($W_{net,A}$) compare to the net work done on cart B ($W_{net,B}$)? Explain.

Is the kinetic energy of cart A *greater than, less than,* or *equal to* the kinetic energy of cart B after they have passed the second mark?

E. Refer again to the discussion among the three students in part A. Do you agree with your original answer?

If you disagree with any of the students, identify what is incorrect with their statements.

⇨ Discuss your answers to parts C and D with a tutorial instructor before continuing.