Racing Day with \( a = F/m \)

In each situation below, Cart A has a mass of 1 kg. **Circle the correct answers (A, B, or Same for both).**

1. Cart A is pulled with a force of 1 N. Cart B also has a mass of 1 kg and is pulled with a force of 2 N. Which undergoes the greater acceleration?
   - (A) (B) (Same for both)

2. Cart A is pulled with a force of 1 N. Cart B has a mass of 2 kg and is also pulled with a force of 1 N. Which undergoes the greater acceleration?
   - (A) (B) (Same for both)

3. Cart A is pulled with a force of 1 N. Cart B has a mass of 2 kg and is pulled with a force of 2 N. Which undergoes the greater acceleration?
   - (A) (B) (Same for both)

4. Cart A is pulled with a force of 1 N. Cart B has a mass of 3 kg and is pulled with a force of 3 N. Which undergoes the greater acceleration?
   - (A) (B) (Same for both)

5. This time Cart A is pulled with a force of 4 N. Cart B has a mass of 4 kg and is pulled with a force of 4 N. Which undergoes the greater acceleration?
   - (A) (B) (Same for both)

6. Cart A is pulled with a force of 2 N. Cart B has a mass of 4 kg and is pulled with a force of 3 N. Which undergoes the greater acceleration?
   - (A) (B) (Same for both)

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**CONCEPTUAL PHYSICS**

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Drop and Pull

1. Consider a 1-kg cart being pulled by a 10-N applied force. According to Newton’s second law, acceleration of the cart is

\[ a = \frac{F}{m} = \frac{10 \text{ N}}{1 \text{ kg}} = 10 \text{ m/s}^2. \]

This is the same as the acceleration of free fall, \( g \)—because a force equal to the cart’s weight accelerates it.

2. Consider the acceleration of the cart when the applied force is due to a 10-N iron weight attached to a string draped over a pulley. Will the cart accelerate as before, at 10 m/s²? The answer is no, because the mass being accelerated is the mass of the cart plus the mass of the piece of iron that pulls it. Both masses accelerate. The mass of the 10-N iron weight is 1 kg—so the total mass being accelerated (cart + iron) is 2 kg. Then,

\[ a = \frac{F}{m} = \frac{10 \text{ N}}{2 \text{ kg}} = 5 \text{ m/s}^2. \]

Don’t forget: the total mass of a system includes the mass of the hanging iron.

a. Find the acceleration of the 1-kg cart when two identical 10-N weights are attached to the string.

\[ a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \frac{20 \text{ N}}{3 \text{ kg}} = 6.7 \text{ m/s}^2. \]

Here we simplify and say \( g = 10 \text{ m/s}^2 \).
**Drop and Pull—continued**

b. Find the acceleration of the 1-kg cart when three identical 10-N weights are attached to the string.

\[ a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \frac{30 \text{ N}}{4 \text{ kg}} = 7.5 \text{ m/s}^2 \]

\[ \begin{align*} 
\text{Cart with 3 weights} 
\end{align*} \]

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\[ \begin{align*} 
\text{Cart with 4 weights} 
\end{align*} \]

c. Find the acceleration of the 1-kg cart when four identical 10-N weights (not shown) are attached to the string.

\[ a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \frac{40 \text{ N}}{5 \text{ kg}} = 8 \text{ m/s}^2 \]

d. This time 1 kg of iron is added to the cart, and only one iron piece dangles from the pulley. Find the acceleration of the cart.

\[ a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \frac{10 \text{ N}}{3 \text{ kg}} = 3.3 \text{ m/s}^2 \]

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\[ \begin{align*} 
\text{Cart with 1 iron piece} 
\end{align*} \]

e. Find the acceleration of the cart when it carries two pieces of iron and only one iron piece dangles from the pulley.

\[ a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \frac{10 \text{ N}}{4 \text{ kg}} = 2.5 \text{ m/s}^2 \]

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**CONCEPTUAL PHYSICS**

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f. Find the acceleration of the cart when it carries 3 pieces of iron and only one iron piece dangles from the pulley.

\[ a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \frac{10 \text{ N}}{5 \text{ kg}} = 2 \text{ m/s}^2 \]

Mass of cart is 1 kg. Mass of 10-N iron is also 1 kg.

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g. Find the acceleration of the cart when it carries 3 pieces of iron and 4 pieces of iron dangle from the pulley.

\[ a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \frac{40 \text{ N}}{8 \text{ kg}} = 5 \text{ m/s}^2 \]

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h. Draw your own combination of masses and find the acceleration.

\[ a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \text{ } \text{ } = \text{ } \text{ m/s}^2 \]