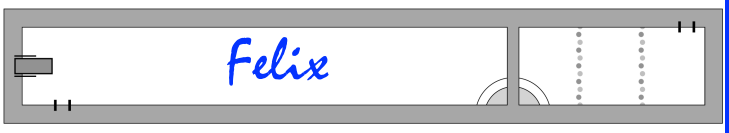
PhyzSpringboard: Newton's Second Law



LIMITATIONS OF THE FIRST LAW

1. a. Newton's first law of motion describes motion that can occur under what specific conditions?

When no unbalanced, external forces are acting.

b. It therefore fails to describe motion that occurs when…

Unbalanced, external forces are acting.

THE SECOND LAW

2. a. The following is a statement of Newton's second law of motion (although it's not the one he stated in the *Principia*).

When a body is acted on by unbalanced, external forces, it will accelerate. The acceleration of the body will be directly proportional to the net force acting on the body and inversely proportional to the mass of the body.

b. What is meant by "net force"?

The vector sum of the forces: $\sum F$.

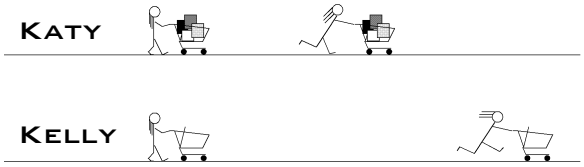
3. How can Newton's second law be abbreviated using symbols?

$a = \sum F/m$

INTERPRETING MOTION THROUGH THE SECOND LAW

4. Use the second law of motion to explain the following observations.

a. Twin dudettes Katy and Kelly have a grocery cart race. Katy pushes a loaded grocery cart; Kelly pushes an empty grocery cart. Kelly wins the race. Why?



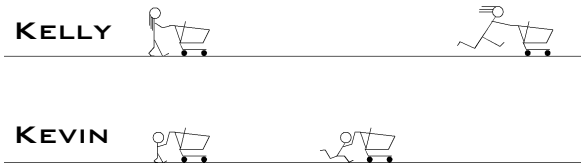
Both push with equal force;

Kelly pushes less mass.

Katy: $a = \sum F/m$

Kelly: $a = \sum F/m$

b. Kelly and her little brother Kevin have a grocery cart race. Both carts are empty. Kelly wins the race. Why?



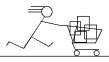
Both push equal mass;

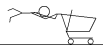
Kelly pushes with more force.

Kelly: $a = \sum F/m$

Kevin: $a = \sum F/m$

c. Katy and her little brother Kevin have a grocery cart race. Katy's cart is loaded; Kevin's cart is empty. They tie. Why?

KATY  

KEVIN  

Kelly pushes more mass with more force; Kevin pushes less mass with less force.

Katy: $a = \sum F/m$

Kevin: $a = \sum F/m$

NEWTON'S EXPLANATION OF GALILEO'S DESCRIPTION

5. One of Galileo's surprising findings was that heavy bodies and light bodies fall with the same acceleration. How does Newton's second law explain that observation?

Heavy bodies are pulled with greater force but have more mass; lighter bodies are pulled with less force but have less mass. The ratio of force to mass is the acceleration.

UNITS

6. a. To avoid division bars, Newton's second law of motion is often written in the form…

$$\sum F = ma$$

N $\quad$ $kg \cdot m/s^2$

newton

b. Identify the SI (metric) units for each quantity in the expression above.

PRACTICE WITH THE EQUATION AND UNITS

7. a. What net force is needed to cause a 3 kg body to accelerate at 4 m/s^2?

$\sum F = ma$

$\sum F = 3\ kg \cdot 4\ m/s^2$

$\sum F = 12\ kg \cdot m/s^2 = 12\ N$

b. What is the acceleration of an 8 kg mass acted on by a 24 N net force?

$\sum F = ma$

$a = \sum F/m$

$a = 24\ N / 8\ kg = 3\ N/kg = 3\ kg \cdot m/s^2/kg = 3\ m/s^2$

c. What is the mass of a body that undergoes an acceleration of 5 m/s^2 when acted upon by a 35 N force?

$\sum F = ma$

$m = \sum F/a$

$m = 35\ N / 5\ m/s^2 = 7\ N/m/s^2 = 7\ kg \cdot m/s^2/m/s^2 = 7\ kg$