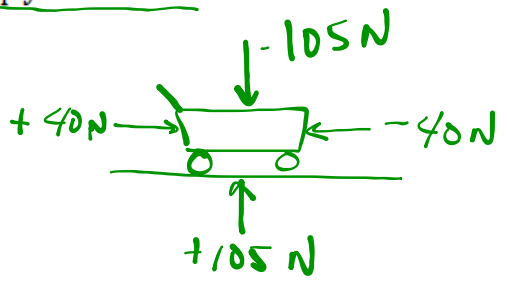
Newton's first law tells us that when the net force is zero, objects at rest stay at rest and objects in motion keep moving with the same speed and direction. Changes in motion come from unbalanced forces.

Concept practice:

- An empty shopping cart is pushed along a grocery store aisle at constant velocity. The shopper produces a force of +40 newtons between the wheels and the floor. The normal force on the cart is +105 newtons.
  - Hint: drawing free-body diagrams may help you with some of the following questions.

1. What is the friction force on the cart?

   $-40\ N$



2. What is the weight of the cart?

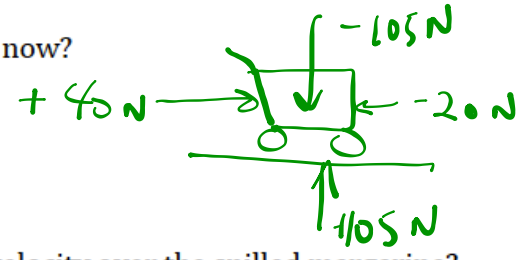
   $-105\ N$

3. If the cart is at rest, what is the force of friction and the weight of the cart?

   $F_s = 0N$ $\quad -105N$

4. While the cart is moving along an aisle, it comes in contact with a smear of margarine that had recently been dropped on the floor. Suddenly the friction force is reduced to -20 newtons.
   a. What is the net force on the cart now?

   $+20N$



   b. Does the cart move at constant velocity over the spilled margarine? Why or why not?

   NO - b/c net force $\neq 0$

5. Identify the normal force on the shopping cart after 75 newtons of groceries are added to the cart.

weight of cart = −105 N
+ −75 N
−180 N → +180 N

6. The shopper pays for his groceries and pushes the shopping cart out of the store, where he encounters a ramp the helps him to move the cart from the sidewalk down to the parking lot.
   a. What force accelerates the cart down the ramp?

gravity

   b. Compare the friction force on the cart when it is rolling along the blacktop parking lot to the friction force on the cart when it is inside the grocery store on the vinyl tile floor.

parking lot friction greater b/c rougher surface

7. Why it is easy to get one empty cart moving but difficult to get a line of 20 empty carts moving?

20X more mass ∴ 20X more inertia ∴ 20X more resistance to changes in motion