Section 1: Newton's First and Second Laws

Preview

Key Ideas

- What makes an object speed up, slow down, or change directions?
- What determines how much an object speeds up or slows down?

Bellringer

The concept of force explains many occurrences in our everyday lives. From your own experience, state what will happen in the following situations.

1. A marble is placed at the top of a smooth ramp. What will happen to the marble? What force causes this?

2. A marble is rolling around in the back of a small toy wagon as the wagon is pulled along the sidewalk. When the wagon is stopped suddenly by a rock under one of the wheels, the marble rolls toward the front of the wagon. Why does the marble keep going when the wagon stops? (Hint: Consider what it takes to change the velocity of the wagon and the marble.)

Bellringer, *continued*

3. If you dropped a flat uncrumpled sheet of notebook paper and a similar piece of notebook paper that was crushed into a ball from the same height, which will reach the floor first? Why are the forces on these two pieces of paper different?

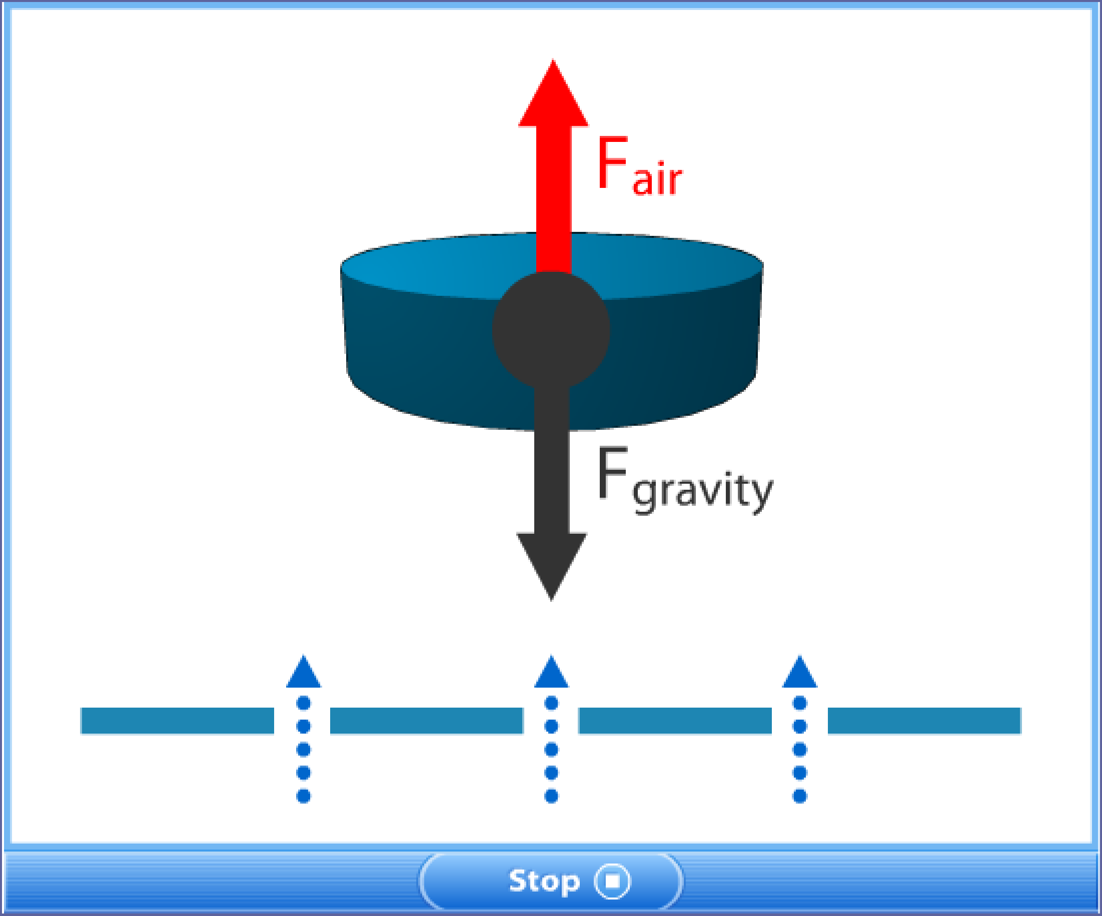
Newton’s First Law

- What makes an object speed up, slow down, or change directions?

- Objects change their state of motion only when a net force is applied.

- This principle is *Newton’s first law.*

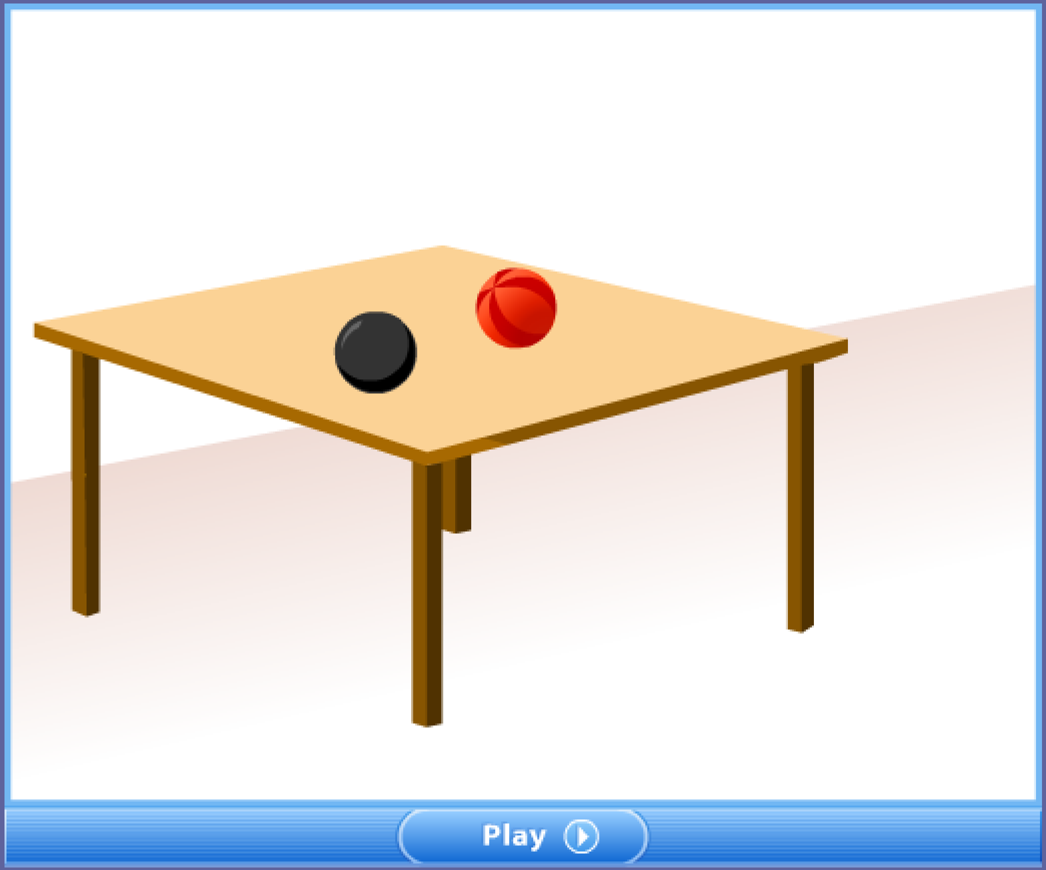
Visual Concept: Newton's First Law



Newton's First Law, *continued*

- Objects tend to maintain their state of motion.
- Inertia is related to an object's mass.
  - **inertia:** the tendency of an object to resist a change in motion unless an outside force acts on the object
- Seat belts and car seats provide protection.
  - When a car comes to a stop, your seat belt and the friction between you and the seat provide the unbalanced backward force that is needed to bring you to a stop as the car stops.

Visual Concept: Mass and Inertia



Newton's Second Law

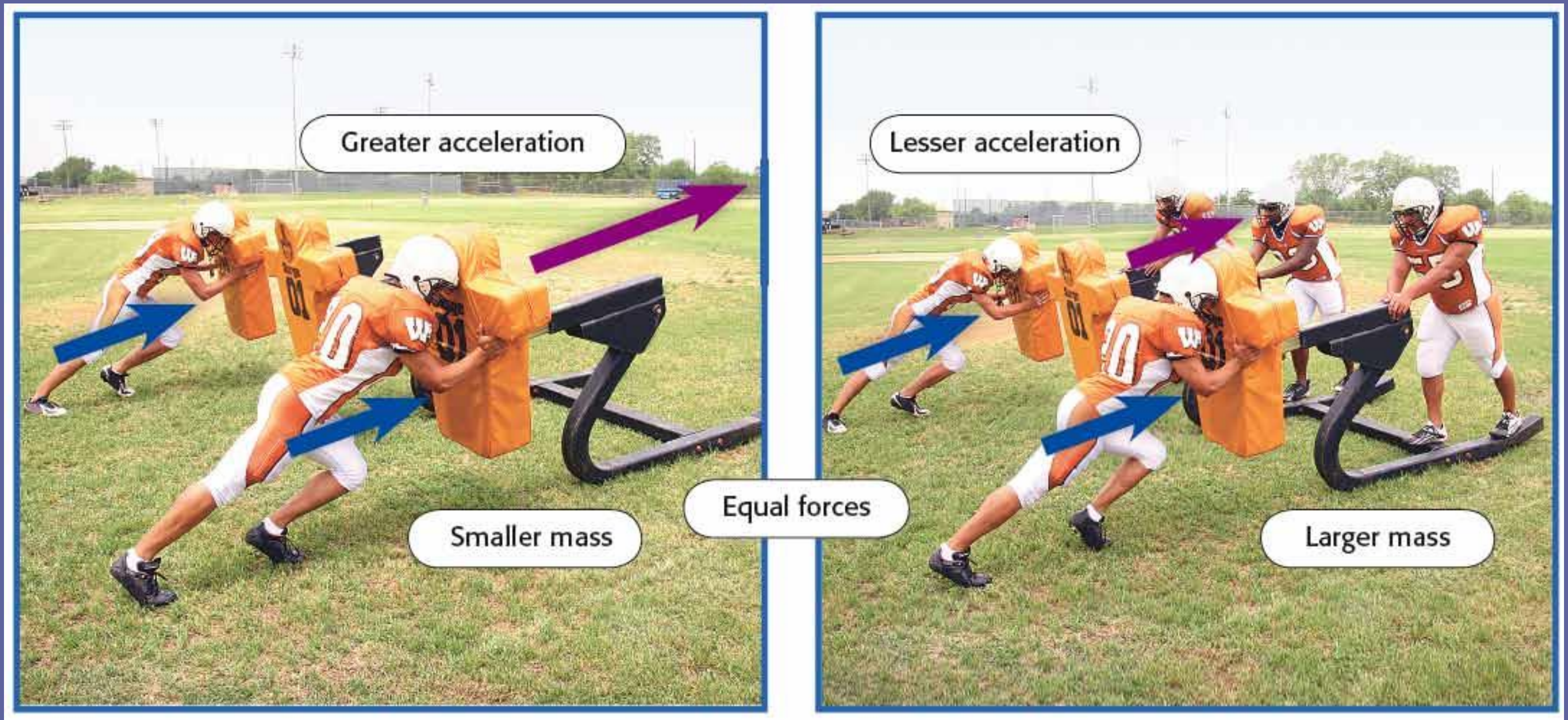
〉 What determines how much an object speeds up or slows down?

〉 Net force is equal to mass times acceleration. The unbalanced force on an object determines how much an object speeds up or slows down.

- This principle is *Newton's second law.*
- *net force = mass × acceleration,* or *F = ma*
- Force is measured in newtons (N): 1 N = 1 kg × 1 m/s^2

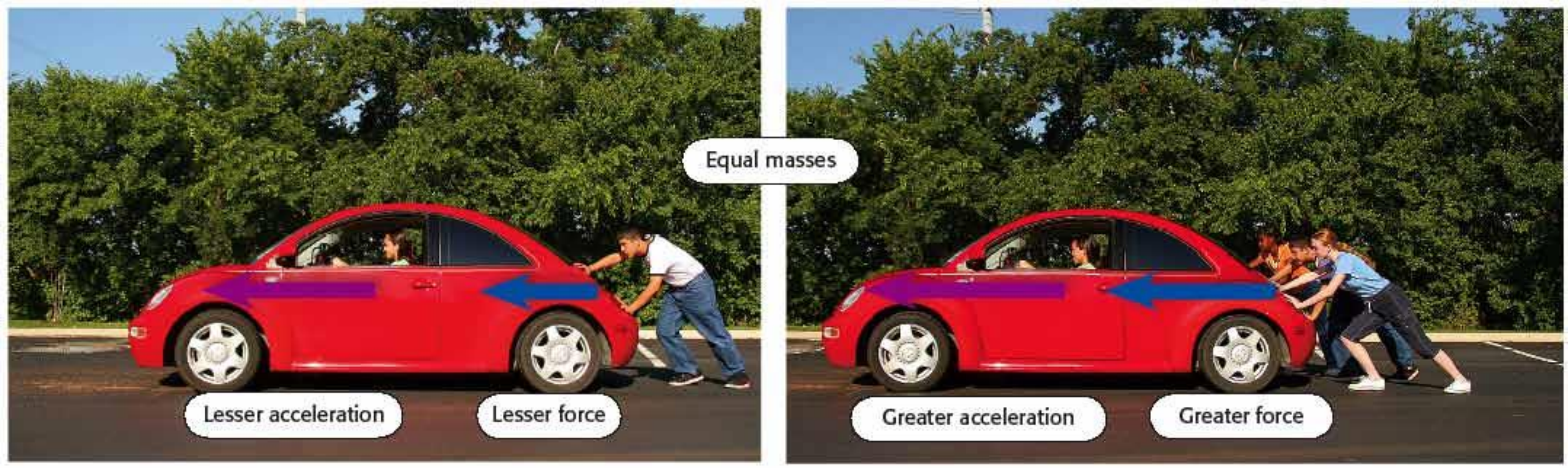
Newton's Second Law, *continued*

- For equal forces, a larger mass accelerates less.

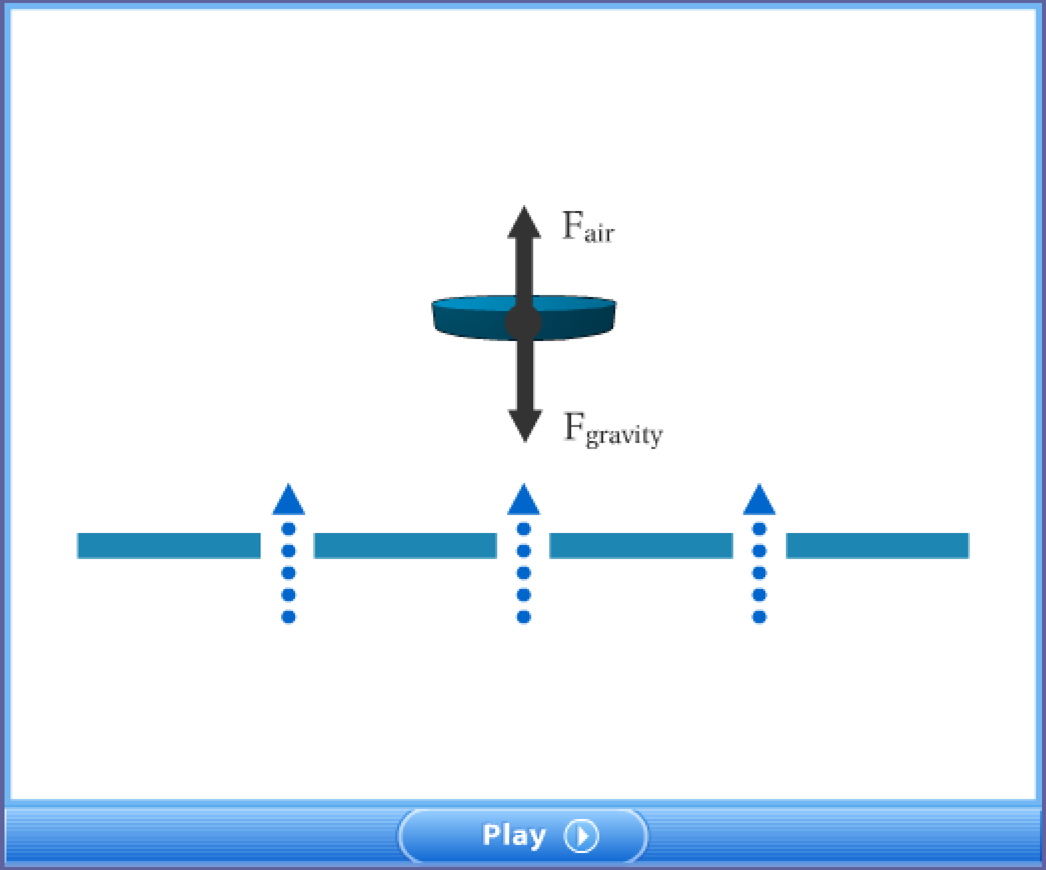


Newton's Second Law, *continued*

- For equal masses, a greater force produces a greater acceleration.



Visual Concept: Newton's Second Law



Math Skills

Newton's Second Law

Zookeepers lift a stretcher that holds a sedated lion. The total mass of the lion and stretcher is 175 kg, and the upward acceleration of the lion and stretcher is 0.657 m/s^2. What force is needed to produce this acceleration of the lion and the stretcher?

1. List the given and unknown values.

Given: *mass, m* = 175 kg

acceleration, a = 0.657 m/s^2

Unknown: *force, F* = ? N

Math Skills, *continued*

2. Write the equation for Newton's second law.

force = *mass* × *acceleration*

$F = ma$

3. Insert the known values into the equation, and solve.

$F = 175 \text{ kg} \times 0.657 \text{ m/s}^2$

$F = 115 \text{ kg} \times \text{m/s}^2$

$\boxed{F = 115 \text{ N}}$

Newton's Second Law, *continued*

- Newton's second law can also be stated as follows:
  - The acceleration of an object is proportional to the net force on the object and inversely proportional to the object's mass.

$$acceleration = \frac{force}{mass}$$

$$a = \frac{F}{m}$$