ANSWER KEY.

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Newton's Third Law

Physics | Answer Key

Part A: Force Pairs

1. For each force, name its reaction force. Give the object exerting it, the object it acts on, and its direction.

a. A foot kicks a soccer ball forward.

b. Earth pulls down on a falling apple.

c. A swimmer's hands push backward on the water.

d. A car's tires push backward on the road.

a. The **ball pushes backward on the foot**.

b. The **apple pulls up on Earth** (gravity).

c. The **water pushes forward on the swimmer's hands**, which moves the swimmer ahead.

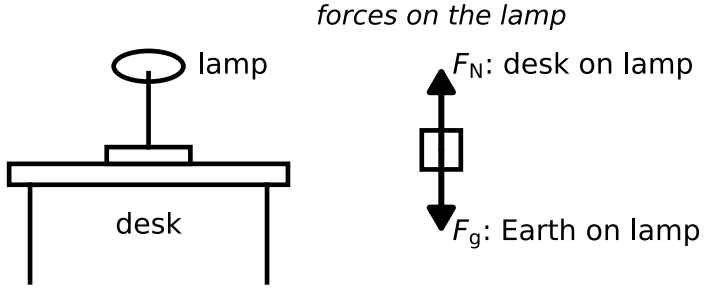
d. The **road pushes forward on the tires** (friction), which moves the car forward.

Each reaction has the same size as the action and is the same type of force.

2. A horse pulls forward on a cart. Dani says, "The cart pulls back on the horse just as hard, so the forces cancel and they can never start moving." Explain what is wrong with Dani's reasoning.

The two forces act on **different objects**: one on the cart and one on the horse. Forces only cancel when they act on the same object. The cart moves forward because the horse's pull on it is bigger than the friction on the cart. The horse moves forward because the ground pushes it forward harder than the cart pulls it back.

3. A lamp sits at rest on a desk. The two forces on the lamp are shown.



a. F_N and F_g are equal and opposite. Are they a third-law force pair? Give two reasons.

b. Name the real third-law partner of each force.

a. No. Both forces act on the same object (the lamp), and they are different types of force (a normal force and gravity). Third-law pairs act on two different objects and are the same type.

b. Partner of F_N (desk on lamp): **the lamp pushes down on the desk**. Partner of F_g (Earth on lamp): **the lamp pulls up on Earth**.

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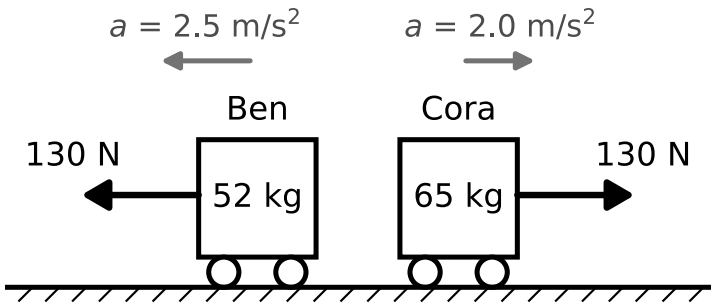
Part B: Same Force, Different Acceleration

Show Knowns, Equation, Substitute, and Answer with units. Use $a = F/m$ for each object.

4. Ben and Cora stand on scooters and push off each other's hands. Each one feels a 130 N push. Find each person's acceleration and describe the directions.



Knowns: F = 130 N on each person, Ben: m = 52 kg, Cora: m = 65 kg

Equation: $a = F/m$ for each person

Ben: a = 130 N / 52 kg = **2.5 m/s^2 left**

Cora: a = 130 N / 65 kg = **2.0 m/s^2 right**. They accelerate in opposite directions, and the lighter person accelerates more.

5. A golf club hits a 0.045 kg golf ball with a force of 3,600 N toward the hole. The head of the club has a mass of 0.20 kg.

a. What force does the ball exert on the club? Give its size and direction.

b. Find the acceleration of the ball and of the club head during the hit.

a. By the third law, the ball pushes on the club with **3,600 N, away from the hole** (opposite the club's push).

b. Ball: $a = F/m$ = 3,600 N / 0.045 kg = **8.0 × 10^4 m/s^2** toward the hole.

Club head: a = 3,600 N / 0.20 kg = **1.8 × 10^4 m/s^2** away from the hole (the club slows down). The forces are equal, but the ball has less mass, so it accelerates more.

6. During a space walk, a 95 kg astronaut (including her suit) pushes on a 380 kg satellite. The satellite accelerates away from her at 0.25 m/s^2. Find the force on the satellite, the force on the astronaut, and the astronaut's acceleration.

Force on the satellite: $F = ma$ = (380 kg)(0.25 m/s^2) = **95 N**, away from the astronaut

Force on the astronaut: third law: **95 N**, in the opposite direction (away from the satellite)

Astronaut's acceleration: $a = F/m$ = 95 N / 95 kg = **1.0 m/s^2**, away from the satellite

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