Field forces also exist in pairs

Newton's third law also applies to field forces. For example, consider the gravitational force exerted by Earth on an object. During calibration at the crash-test site, engineers calibrate the sensors in the heads of crash-test dummies by removing the heads and dropping them from a known height.

The force that Earth exerts on a dummy's head is $\mathbf{F_g}$. Let's call this force the action. What is the reaction? Because $\mathbf{F_g}$ is the force exerted on the falling head by Earth, the reaction to $\mathbf{F_g}$ is the force exerted on Earth by the falling head.

According to Newton's third law, the force of the dummy on Earth is equal to the force of Earth on the dummy. Thus, as a falling object accelerates toward Earth, Earth also accelerates toward the object.

The thought that Earth accelerates toward the dummy's head may seem to contradict our experience. One way to make sense of this idea is to refer to Newton's second law. The mass of Earth is much greater than that of the dummy's head. Therefore, while the dummy's head undergoes a large acceleration due to the force of Earth, the acceleration of Earth due to this reaction force is negligibly small because of Earth's enormous mass.

extension

Integrating Technology

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SECTION REVIEW

1. A 6.0 kg object undergoes an acceleration of 2.0 m/s^2.

a. What is the magnitude of the net force acting on the object?

b. If this same force is applied to a 4.0 kg object, what acceleration is produced?

2. A child causes a wagon to accelerate by pulling it with a horizontal force. Newton's third law says that the wagon exerts an equal and opposite force on the child. How can the wagon accelerate? (Hint: Draw a free-body diagram for each object.)

3. Identify the action-reaction pairs in the following situations:

a. A person takes a step.

b. A snowball hits someone in the back.

c. A baseball player catches a ball.

d. A gust of wind strikes a window.

4. The forces acting on a sailboat are 390 N north and 180 N east. If the boat (including crew) has a mass of 270 kg, what are the magnitude and direction of the boat's acceleration?

5. Critical Thinking If a small sports car collides head-on with a massive truck, which vehicle experiences the greater impact force? Which vehicle experiences the greater acceleration? Explain your answers.