CHAPTER 4: Dynamics: Newton's Laws of Motion

Answers to Questions

1. The child tends to remain at rest (Newton's 1st Law), unless a force acts on her. The force is applied to the wagon, not the child, and so the wagon accelerates out from under the child, making it look like the child falls backwards relative to the wagon. If the child is standing in the wagon, the force of friction between the child and the bottom of the wagon will produce an acceleration of the feet, pulling the feet out from under the child, also making the child fall backwards.

2. (*a*) Mary sees the box stay stationary with respect to the ground. There is no horizontal force on the box since the truck bed is smooth, and so the box cannot accelerate. Thus Mary would describe the motion of the box in terms of Newton's 1st law – there is no force on the box, so it does not accelerate.
   (*b*) Chris, from his non-inertial reference frame, would say something about the box being "thrown" backwards in the truck, and perhaps use Newton's 2nd law to describe the effects of that force. But the source of that force would be impossible to specify.

3. If the acceleration of an object is zero, then by Newton's second law, the *net* force must be zero. There can be forces acting on the object as long as the vector sum of the forces is zero.

4. If only once force acts on the object, then the net force cannot be zero. Thus the object cannot have zero acceleration, by Newton's second law. The object can have zero velocity for an instant. For example, an object thrown straight up under the influence of gravity has a velocity of zero at the top of its path, but has a non-zero net force and non-zero acceleration throughout the entire flight.

5. (*a*) A force is needed to bounce the ball back up, because the ball changes direction, and so accelerates. If the ball accelerates, there must be a force.
   (*b*) The pavement exerts the force on the golf ball.

6. When you try to walk east, you push on the ground (or on the log in this case) with a westward force. When you push westward on the massive Earth, the Earth moves imperceptibly, but by Newton's 3rd law there is an eastward force on you, which propels you forward. When walking on the log, the relatively light and unrestricted log is free to move, and so when you push it westward, it moves westward as you move eastward.

7. By Newton's 3rd law, the desk or wall exerts a force on your foot equal in magnitude to the force with which you hit the desk or wall. If you hit the desk or wall with a large force, then there will be a large force on your foot, causing pain. Only a force on your foot causes pain.

8. (*a*) When you are running, the stopping force is a force of friction between your feet and the ground. You push forward with your feet on the ground, and thus the ground pushes backwards on you, slowing your speed.
   (*b*) A fast person can run about 10 meters per second, perhaps takes a distance of 5 meters over which to stop. Those 5 meters would be about 5 strides, of 1 meter each. The acceleration can be found from Eq. 2-11c.

$$v^2 - v_0^2 = 2a(x - x_0) \rightarrow a = \frac{v^2 - v_0^2}{2(x - x_0)} = \frac{0 - (10\,\text{m/s})^2}{10\ \text{m}} = -10\,\text{m/s}^2$$