Practice Problem #1
Newton's Laws of Motion

Question: *A large box containing your new computer sits on the bed of your pickup truck. You are stopped at a red light. The light turns green and you stomp on the gas, and the truck accelerates. To your horror, the box starts to slide toward the back of the truck. Draw clearly labeled free-body diagrams for the truck and the box. Indicate pairs of forces, if any, that are third-law action-reaction pairs. (The bed of the truck is <u>not</u> frictionless.)*

Solution: Start by drawing free-body diagrams of both objects.

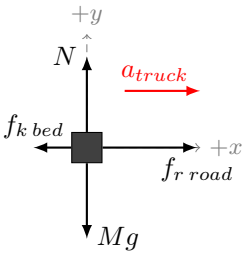

Figure 1: FBD of the truck.

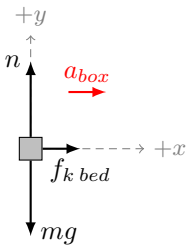

Figure 2: FBD of the box.

For the truck, N and Mg are equal and opposite in magnitude where M represents the total mass of the truck and the box together. While the box is sliding, there is kinetic friction acting on the truck bed. This frictional vector points to the *left*, as it is opposes the motion of the truck in the $+x$ direction. As the tires of the truck rotate along the road, they experience rolling friction that points to the *right*.

Similarly for the box, n and mg are equal and opposite with m representing the mass of the box. During the sliding motion, kinetic friction also acts on the box pointing to the *right* - opposite to the direction that the box is sliding in.

Both objects accelerate in the $+x$ direction, but the friction force acting on the box is much smaller than the net friction acting on the truck. This is because the frictional terms depend on mass (and the mass of the truck is presumably much larger than the mass of the box).
Hence, the truck experiences a much larger acceleration.

To find the action-reaction pairs, recall that:

- Action-reaction pairs are equal & opposite in length.
- Action-reaction pairs act on different objects.

The only force that fits the above points is the **kinetic friction force** between the truck bed and the box.