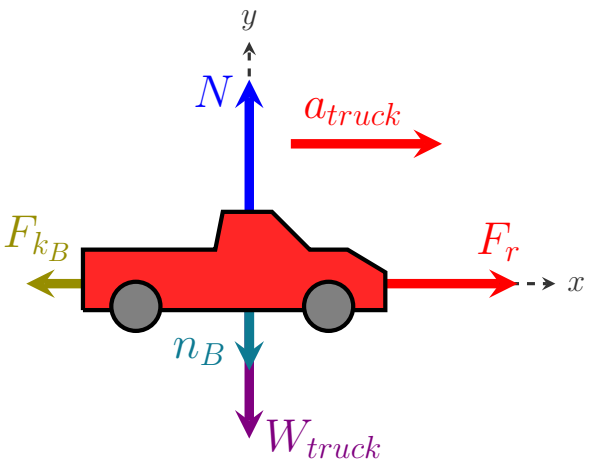
Free-Body Diagram Problem #1

Newton's Laws of Motion

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

Begin by drawing free-body diagrams of the truck and the box, considering the forces acting on each object individually:

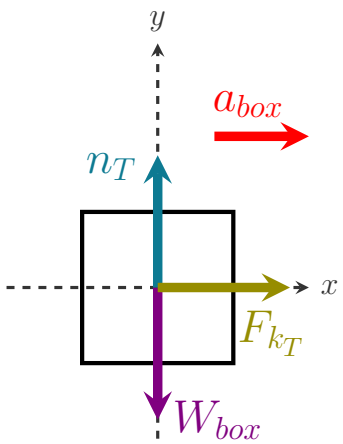


The vertical forces acting on the truck are:

- The upwards normal force from the ground (N)
- The downwards normal force of the box (n_B)
- The weight of the truck (W_{truck})

The horizontal forces acting on the truck are:

- Rolling friction between the tires and the road (F_r)
- Kinetic friction due to the box (F_{k_B})



The vertical forces acting on the box are:

- The upwards normal force of the truck (n_T)
- The weight of the box (W_{box})

The horizontal forces acting on the box are:

- Kinetic friction due to the truck (F_{k_T})

Note that both objects accelerate in the $+x$ direction, but the friction force f_k acting on the box is much smaller than the net friction acting on the truck. Thus, $a_{truck} > a_{box}$.

The action-reaction pairs in the problem exhibit the following two properties:

1. The forces in the pair are equal & opposite in length.
2. The forces act on different objects.

The forces W_{truck}, W_{box}, N, and F_r only act on one object, and therefore are not part of an action-reaction pair.

Of the remaining forces, n_B & n_T form an action-reaction pair, as well as F_{K_B} & F_{K_T}.