Friction

Draw a free-body diagram for each situation. Use Newton's second law and kinematics when needed.

Mild

1. A 0.50 kg book rests on a horizontal table. The greatest horizontal force that can be applied before it starts sliding is 3.25 N.
   a. Determine the coefficient of static friction between the book and the table.
   b. If a student pushes horizontally with only 2.0 N, determine the actual static frictional force acting on the book.

2. A 150 kg refrigerator slides across a horizontal floor. The coefficient of kinetic friction is 0.55.
   a. Determine the horizontal applied force needed to keep it moving at constant velocity.
   b. While it is sliding, the applied force increases to 1000 N. Determine its acceleration.

3. A 5.0 kg cardboard box rests on a tiled floor. The coefficients of static and kinetic friction are 0.30 and 0.23, respectively.
   a. Determine the maximum static friction. What does this tell you about the force required to start the box moving?
   b. Once it is sliding, determine the horizontal applied force needed to maintain constant velocity.
   c. Explain why the force required to start the box moving differs from the force needed to keep it moving.

Medium

4. An 80.0 kg table is already sliding to the right across a horizontal floor. A student pushes horizontally to the right with 500 N. If the coefficient of kinetic friction is 0.40, determine the acceleration of the table.

5. Matthew pushes a 12.0 kg chair that is already sliding to the right across a level floor. The coefficient of kinetic friction is 0.45. If Matthew applies a horizontal force of 120 N to the right, determine the acceleration.

6. While the chair in question 5 is still sliding to the right, Luke adds a horizontal force of 45 N to the left. Matthew continues pushing with 120 N to the right. Determine the chair's new acceleration.

Spicy

7. A 20.0 kg box initially rests on a horizontal floor. The coefficients of static and kinetic friction are 0.50 and 0.30, respectively.
   a. A student pushes horizontally to the right with 80 N. Determine the frictional force and the acceleration of the box.
   b. The student increases the push to 120 N. Determine whether the box starts moving and, once it is sliding, its acceleration.

Extra-Spicy

8. Matthew again pushes his 12.0 kg chair horizontally to the right with 120 N. The chair is sliding right across a level floor, and the coefficient of kinetic friction is 0.45. This time, Luke pushes straight downward on the chair with 45 N.
   a. Determine the new normal force, kinetic friction, and acceleration of the chair.
   b. Explain why the acceleration differs from question 6, even though Luke applies 45 N in both situations.

9. A 0.16 kg hockey puck slides 60 m across level ice. Its initial speed is 15 m/s, and it takes 4.5 s to cover the distance. Assume that constant kinetic friction is the only horizontal force acting on the puck.
   a. Determine the coefficient of kinetic friction.
   b. Would a heavier puck with the same initial speed and coefficient of kinetic friction slow down more quickly? Explain using the force relationships.