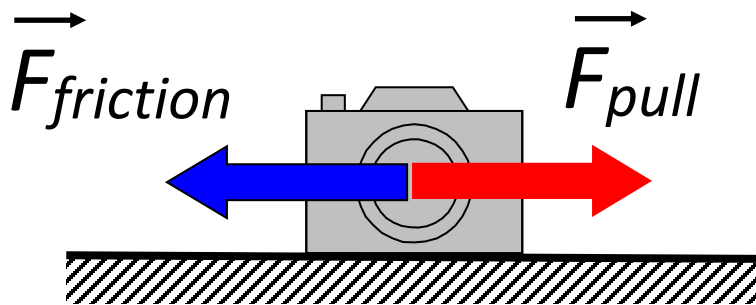


Homework 8.

Friction force

When we try to push or pull a heavy box standing on the floor it may not move in spite of a considerable pushing or pulling force applied. Some force (or forces) applied to the box by the surface compensates the pushing force and the acceleration in the “pushing” direction is zero. If the magnitude of pushing (or pulling) force is less than certain magnitude which we will call *static friction force*, the box will not move and friction force magnitude is equal to this of the pushing force. If we increase the pushing force, the friction force increases as well until the static friction force is reached. After that, the friction force does not increase anymore and, if we increase the pushing force just a little bit, the box will start moving.



$$ma = F_{friction} - F_{pull} = 0$$

$$F_{friction} = F_{pull}$$

Here our positive direction is chosen from left to right.

How to calculate the static friction force F_{fs} ? The magnitude of the static friction force is proportional to the magnitude of the normal force. Speaking “common sense language” the heavier the box the stronger we have to push to move it.

$$F_{fs} = \mu \cdot N$$

Here μ is the coefficient of friction. This is a number which depends of the object (box) and surface materials and the roughness of the surfaces. If the surfaces are rough, this number is large, so more force is required to move the object.

After the box started moving the friction force is equal to μN . Strictly speaking this is not always correct and, in some cases, the friction force applied to a moving object (dynamic friction force) is not equal to the static friction force. This time we will not discuss this effect in details and, for simplicity, assume that the static friction force is equal to the dynamic one.

Problems:

1. A 400,000 kg train moving at a speed of 40 km/h starts braking and stops. What is the friction force applied to the train if after braking it slides for 200 meters?
2. A bicyclist hits the brakes moving at a speed of 11m/s. The friction coefficient between the tires and the road is 0.7. Find:
 - a) Acceleration of the bicyclist after he pressed the brakes
 - b) Time to complete stop.
 - c) Distance, passed by the bicyclist to complete stop.
3. The car from the problem 3 accelerated to 100km/h and moves at a constant velocity. Find total net force applied to the car. :)
4. The driver of a car moving at a velocity of 100km/h presses the brake so a friction force of 500N is applied to the car. How long will it take for the car to stop?