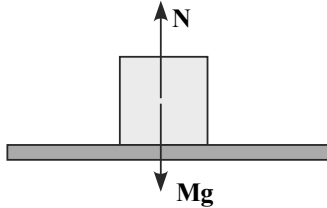


# FRICTION

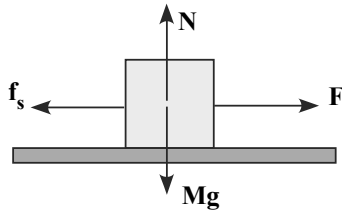
One type of force that we have not yet considered is that due to friction. The following situations demonstrate the two types of frictional forces we will be considering – static and kinetic frictional forces.

no applied force;  
object remains at rest  
friction force = 0



no tendency of motion;  
no relative motion

weak applied force;  
object remains at rest  
friction force =  $f_s$

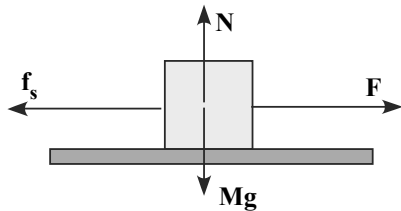


tendency of motion to the right

$$f_s = F$$

stronger applied force;  
object on the verge of moving

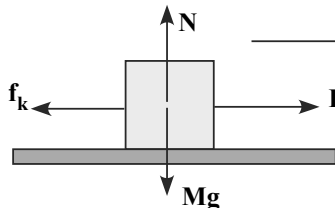
force of friction =  $f_s$   
 $f_s(\text{max}) = \mu_s N$



tendency of motion to the right

$$f_s = F$$

force of friction =  $f_k$   
object sliding to the right at constant velocity;



$v = \text{constant}$

relative motion to the right

$$f_k = F$$

The previous examples demonstrated the two types of frictional forces:

1. Kinetic frictional force ( $f_k$ ) - Relative motion between objects
2. Static frictional force ( $f_s$ ) - **NO** relative motion between objects

Experimentally it is found that  $f_k$  and  $f_s$  are both proportional to the normal force acting on an object:

$$\boxed{f_k = \mu_k N} \text{ Kinetic Frictional Force}$$

$$\boxed{f_s \leq \mu_s N} \text{ Static Frictional Force}$$

$\mu_k$  = coefficient of kinetic friction

$\mu_s$  = coefficient of static friction

The equality in  $f_s \leq \mu_s N$  holds **only** when the object is on the verge of moving. This corresponds to the maximum static frictional force:

$$\boxed{f_s(\text{max}) = \mu_s N} \text{ When object is on verge of moving}$$

The inequality in  $f_s \leq \mu_s N$  holds when the applied force on object is less than  $f_s(\text{max}) = \mu_s N$ .

1.  $\mu_s$  is generally greater than  $\mu_k$
2.  $f_k$  is in the opposite direction of the relative motion of an object.
3.  $f_s$  is in the opposite direction of the tendency of motion of an object.