Friction

Friction $\left(\overrightarrow{F_f}\right)$ is a force that opposes the motion between two surfaces that are in contact.

Friction acts:

- parallel to the surfaces that are in contact
- opposite to the direction of motion of the object

There are two kinds of frictional forces:

1. **Static Friction**
   - force that opposes the start of motion
   - exists between any two objects that are in contact
   - has a **maximum value**
   - when the applied force exceeds the maximum value, the object begins to move
2. **Kinetic Friction**
   - force that opposes motion
   - acts between any two objects that are in relative motion
   - its magnitude is less than that of static friction for the same surfaces

The amount of friction that acts depends on two things:

1. The force pushing the surfaces together $\left(\overrightarrow{F_N}\right)$.
2. The nature of the surfaces in contact.

Mathematically, this can be expressed as:

$$F_f = \mu \cdot F_N$$

Where μ (mu) is the **coefficient of friction**. The coefficient of friction is a constant that depends upon the nature of the two surfaces that are in contact.

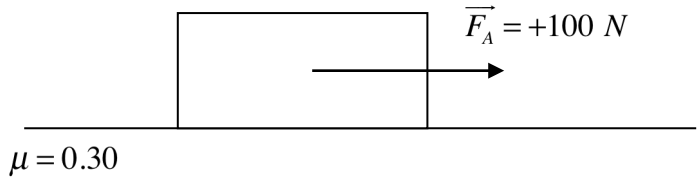
Note:

Static Friction $\quad F_f \leq \mu_s \cdot F_N$

Kinetic Friction $\quad F_f = \mu_k \cdot F_N$

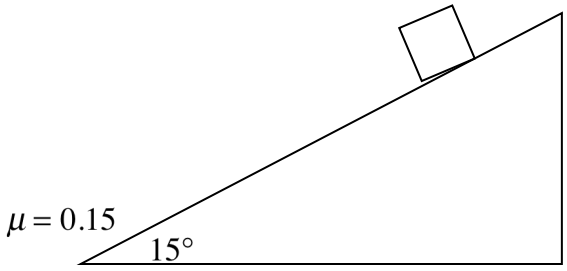
Example 1

Given the diagram of a $25\ kg$ mass, determine the velocity of the mass after $3\ s$ (assume it started from rest).



Example 2

Given the diagram of a 15 kg mass, determine the time required to move down the 10 m long ramp if the object started from rest.



Dynamics Worksheet #1

1. A horizontal force of $50\,N$ is required to pull an $8.0\,kg$ block of aluminum at a uniform velocity across a horizontal wooden desk. What is the coefficient of kinetic friction? (0.64)

2. A force of $40\,N$ accelerates a $5.0\,kg$ block at $6.0\,m/s^2$ along a horizontal surface.
   a. How large is the frictional force? $(-10\,N)$
   b. What is the coefficient of friction? (0.20)

3. Rachel pulls her $18\,kg$ suitcase at a constant speed by pulling on a handle that makes an angle θ with the horizontal. The frictional force on the suitcase is $27\,N$ and Rachel exerts a $43\,N$ force on the handle.
   a. What angle does the handle make with the horizontal? $(51°)$
   b. What is the normal force exerted on the suitcase? $(143\,N)$

4. A $20\,kg$ box is dragged across a level floor with a force of $100\,N$. The force is applied at an angle of $40°$ above the horizontal. If the coefficient of kinetic friction is 0.32, what is the acceleration of the box? $(1.72\,m/s^2)$

5. You place a box weighing $215\,N$ on an inclined plane that makes a $35°$ angle with the horizontal. Compute the component of the gravitational force acting down the inclined plane. $(123\,N)$

6. A $6\,kg$ mass slides down a frictionless inclined plane. The plane makes a $25°$ angle with the horizontal. Calculate the acceleration of the mass. $(4.14\,m/s^2)$

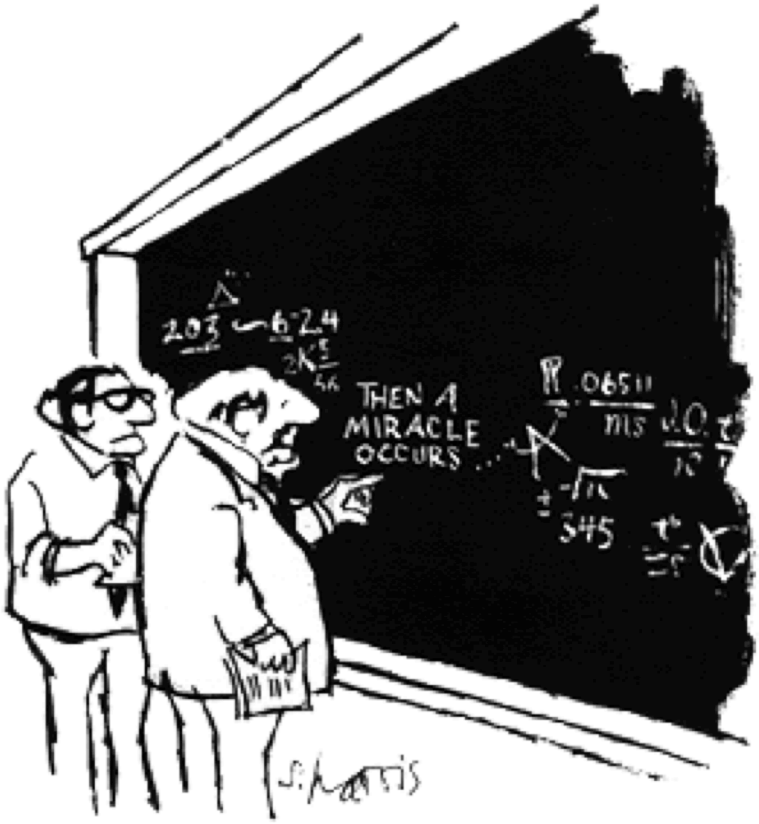
7. A $200\,kg$ crate rests on an inclined plane inclined $40°$ to the horizontal. What is the force of friction? $(-1260\,N)$

8. A boy on a toboggan is sliding down a snow-covered hillside. The boy and toboggan together have a mass of $50\,kg$, and the slope is at an angle of $30°$ to the horizontal. Find the boy's acceleration if the coefficient of kinetic friction is 0.15. $(3.6\,m/s^2)$

9. You slide a $325\,N$ trunk up a $20°$ inclined plane with a constant velocity by exerting a force of $211\,N$ parallel to the inclined plane.
   a. What is the component of the trunk's weight parallel to the plane? $(111\,N\,[DTS])$
   b. What is the sum of your applied force, friction, and the parallel component of the trunk's weight? Why? (0)
   c. What is the size and direction of the friction force? $(100\,N\,[DTS])$
   d. What is the coefficient of friction? (0.33)

10. What force would you have to exert on the trunk in Problem 9 so that it would slide down the plane with a constant velocity? What would be the direction of the force? $(11\,N\,[UTS])$

11. A 2.5 kg block slides down a 25° inclined plane with constant acceleration. The block starts from rest at the top. At the bottom, its velocity reaches 0.65 m/s. The length of the incline is 1.6 m.
    a. What is the acceleration of the block? (0.13 m/s^2)
    b. What is the coefficient of friction between the plane and the block? (0.45)
    c. Does the result of either a or b depend on the mass of the block?



"I think you should be more explicit here in step two."