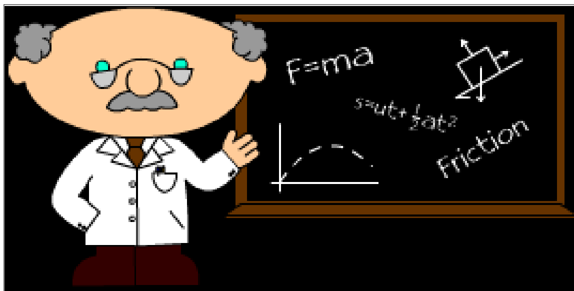
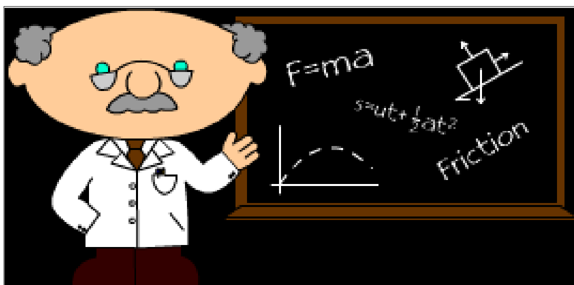


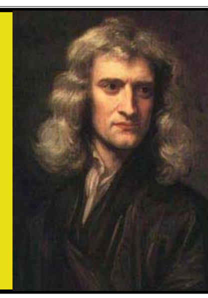
Unit 2: Dynamics

2.7 Friction

In order to study other concepts, we have ignored the force of friction on objects or assumed systems were "frictionless." This isn't realistic however so we must examine the role that friction plays in systems.

There are two main categories of friction: fluid and dry. Today we will look at dry friction.





Some Definitions:

Dry Friction: the resistive force arising when two surfaces come into contact with one another. This force stems from weak chemical bonds being created between the two surfaces.

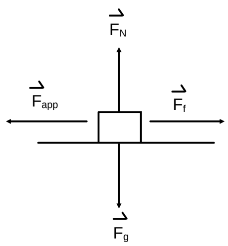
Two Types of Dry Friction:

- **Static Friction**: the friction between two surfaces that are not moving relative to each other (eg. this keeps us from sliding on the ground when we stand)
- **Kinetic Friction**: the friction between two surfaces that are moving relative to each other (eg. this slows a car down on the highway)

In Physics 20, we consider only two variables that affect the amount of friction:

1. The surfaces in contact.
2. The amount of normal force between the surfaces.

Surface area does not affect the amount of friction on an object.



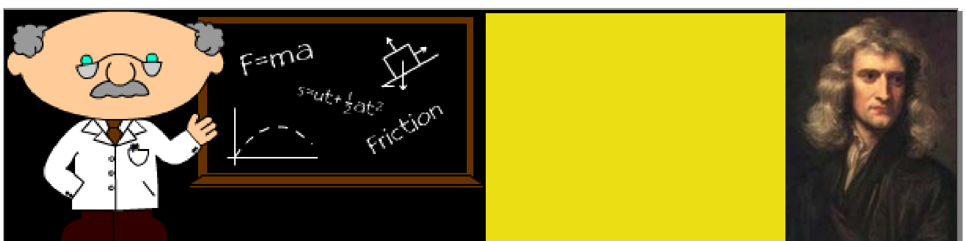
This diagram shows that the force of friction will balance the force applied until it is overcome and the box begins to move.

Static friction keep the box in place until it starts to move.

Kinetic friction acts against the moving object once it begins moving.

$$|\vec{F}_f| = \mu|\vec{F}_N|$$

μ - greek letter mu, coefficient of friction (unit-less constant)



Experiments have given us approximate coefficients of friction for common materials. They can be found on page 183 of your textbook.

The larger the frictional force, the larger the coefficient of friction.

Table 3.4 Approximate Coefficients of Friction for Some Materials

Material	Coefficient of Static Friction μ_s	Coefficient of Kinetic Friction μ_k
Copper on copper	1.6	1.0
Steel on dry steel	0.41	0.38
Steel on greased steel	0.15	0.09
Dry oak on dry oak	0.5	0.3
Rubber tire on dry asphalt	1.2	0.8
Rubber tire on wet asphalt	0.6	0.5
Rubber tire on dry concrete	1.0	0.7
Rubber tire on wet concrete	0.7	0.5
Rubber tire on ice	0.006	0.005
Curling stone on ice	0.003	0.002
Teflon™ on Teflon™	0.04	0.04
Waxed hickory skis on dry snow	0.06	0.04
Waxed hickory skis on wet snow	0.20	0.14
Synovial fluid	0.01	0.01

Ex.) Katie is pulling a wheel'less suitcase across the floor. The suitcase has a mass of 7.6 kg. The coefficient of kinetic friction between the floor and the suitcase is 0.20. What is the force of friction?

$\vec{F}_f = \mu \vec{F}_N$

$\vec{F}_f = \mu(-\vec{F}_g)$

$= \mu \cdot -m \cdot \vec{g}$

$= (0.20)(-7.6)(-9.81)$

$= \boxed{15\ N}$

>15 N would move the suitcase

Ex.) A 750 kg car is travelling 30 m/s on dry asphalt when it skids to a stop.

a) How far did it take for the car to stop?

Kinetic $\mu = 0.8$

$m = 750\ kg$

$\vec{V}_i = 30\ m/s$

$\vec{V}_f = 0\ m/s$

$\vec{d} = ?$

$\vec{F}_f = \mu \vec{F}_N$

$= \mu \cdot -m\vec{g}$

$= (0.8)(-750)(-9.81) = 5886\ N$

$\vec{F} = m\vec{a}$

$-5886 = 750\vec{a}$

$\vec{a} = -7.848\ m/s^2$

$\vec{V}_f^2 = \vec{V}_i^2 + 2\vec{a}\vec{d}$

$0^2 = 30^2 + 2(-7.848)\vec{d}$

$\boxed{\vec{d} = 57m}$

b) If the asphalt is wet, how much further will it take the car to stop?

$\mu = 0.5$

$\vec{F_f} = \mu \cdot -mg$
$= (0.5)(-750)(-9.81) = 3678.75N$

$\vec{F} = m\vec{a}$
$-3678.75 = 750\vec{a}$
$\vec{a} = -4.905 \, m/s^2$

$v_f^2 = v_i^2 + 2ad$
$0^2 = 30^2 + 2(-4.905)\vec{d}$
$\vec{d} = 92m$

It takes 35m more to stop.

Read Chapter 3.5