Friction

Review: Define each concept.

a) Gravitational Force

b) Normal Force

Friction

Up until now, we have largely ignored the force of friction on objects. Today, we will start to examine this force.

Lab: Friction on a Loonie* (pg. 170)

Make sure you:

- Make a data table to collect data.
- Answer the questions.

***Not for Hand-in.**

There are two main categories of friction: fluid and dry. In this class, we will look only at dry friction.

Dry friction is 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.

We will examine two types of dry friction:

Static Friction: the friction which keeps an object from moving.

ex) The friction that keeps the loonie on the incline.

Kinetic Friction: the friction resisting the movement of a moving object.

ex) The friction that slows a car down on the highway.

Question: What factors might affect friction?

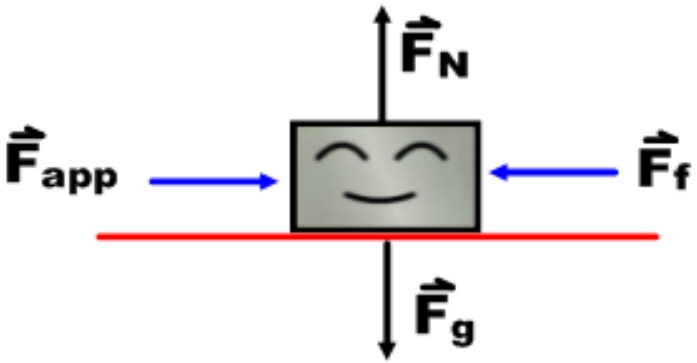
For our purposes, only two variables affect the amount of friction:

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

The amount of surface area DOES NOT effect the amount of friction on an object (this is merely an empirical observation...)

Let's put a box in a situation with a little FRICTION!!!

Consider: a box on a line...



- the force of friction resists the applied force

From this diagram (and Newton's ____ Law) we know that the force of friction will balance any force applied to the object.

The force keeping the object in place until it starts to move is <u>static friction</u>. Once this is overcome, the friction acting against the moving object is <u>kinetic friction.</u>

Calculating Friction

We can calculate the force of friction using:

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

where:

μ = the coefficient due to friction (unit less constant)

μ = Greek letter "mu".

The coefficient due to friction is found experimentally. The larger the coefficient, the larger the force of friction.

A list of many coefficients is given in your text on page 183.

Approximate Coefficients of Friction for Some Materials

Table 3.4

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

Question: Why is the $\mu_s > \mu_k$?

ex) Mr. P is pulling a sack of potatoes across the floor. The sack has a mass of 7.6 kg. The coefficient of kinetic friction between the floor and sack is 0.20. What is the force of friction?

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

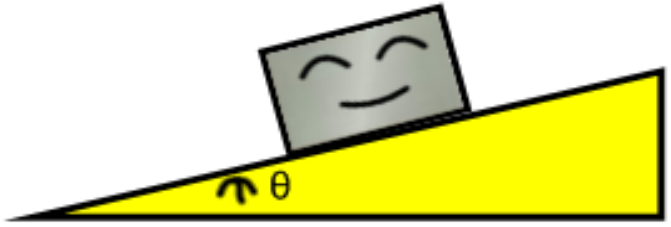
a) How far does the car take to stop?

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

Inclined Planes

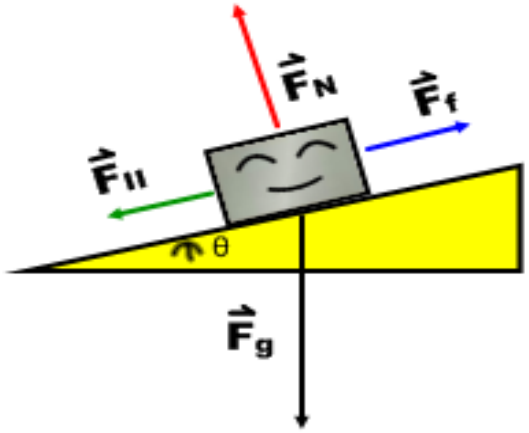
A good place to examine the effects of static and kinetic friction is on inclined planes.

Imagine a box living on such a plane:



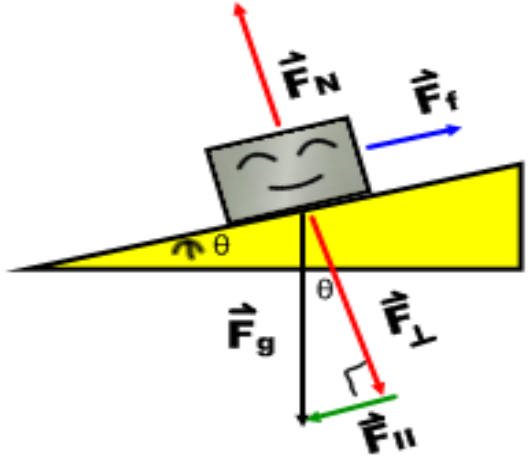
θ = angle of incline

What forces are acting on this box?



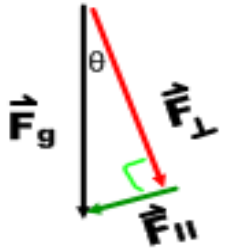
$\vec{F}_{II}$ = force parallel (to the inclined plane). This is a component of the force of gravity.

But things don't quite balance out here. Let's redraw our vectors....



$\vec{F}_\perp$ = force perpendicular (to the plane).

This too is a component of the force of gravity.



All we have done is broken the force of gravity into components. The angle in the triangle is the same as the angle of incline.

From this diagram:

$$\vec{F}_{\parallel} = -\vec{F}_f$$

$$\vec{F}_{\perp} = -\vec{F}_N$$

We can now start to work some problems with friction when objects are on inclines.

ex) A box weighing 562 N is on an incline of 30°. Find each force acting on the box.

Hint - The direction of the box can just be "down the ramp".

Step 1: Draw a free-body diagram.

Step 2: Calculate the parallel and perpendicular forces using trig.

ex) _____, mass 70 kg, is skiing down an incline of 38°. The snow is dry and the skis are hickory. What is _____'s acceleration?

b) If the snow melts some and becomes wet, what is the new acceleration?