Objects in Contact (when worlds collide …)

- Whenever two objects touch there will be an interaction and forces will occur.
- There are two aspects of contact: frictional force and normal force. To put this another way, whenever two objects are in contact the interaction can be modeled as two different types of forces. It can be argued that friction and normal force are just the parallel and perpendicular components of the *singular* electromagnetic force interaction of the atoms in the objects.

Normal Force

- The word “normal” in this context means *perpendicular to the surface* of an object.
- By definition “normal force” is the amount of force perpendicular to the surface at a point of contact between two objects.
- The magnitude of the normal force depends on how much the two objects are pressed together.

What is the *Source* of Normal Force?

- Normal force is ultimately an interaction of atoms and subatomic particles.
- It is an electromagnetic interaction of electrons and protons found in the atoms.
- Microscopically, the normal force increases as charged particles get closer together.
- Technically speaking, "*the*" "normal force" is actually the combined effect of millions of electromagnetic forces arising between the charged particles within matter.

Friction

Contact of Solids

Dynamics

I. Newton's 3 Laws of Motion
   - inertia, force, mass, weight
   - interaction & nature of force

II. Normal Force

III. Compression, Tension, Sections

IV. Pulleys and Systems

V. Friction (between solids)

VI. Air Resistance

VII. Inclines, ramps, etc.

	The student will be able to:	HW:
1	State Newton's 1st and 2nd Laws of Motion and apply these laws to physical situations in order to determine what forces act on an object and to explain the object's resulting behavior. Define and apply the concept of inertia and inertial frame of reference. ✓	1 – 7
2	Recognize and state the proper SI unit of force and give its equivalence in fundamental units and use the relation $\mathbf{F}_{net} = m\mathbf{a}$ to solve problems. ✓	8 – 10
3	Recognize the difference between weight and mass and convert from one to the other. ✓	11 – 14
4	State and utilize Newton's 3rd Law to solve related problems. ✓	15 – 18
5	Understand and utilize the concept of the normal force to solve related problems. ✓	19, 20
6	Define and apply the concepts of compression and tension and use the method of sections to solve for these. ✓	21 – 26
7	Solve force problems involving pulleys, including those involving multiple objects and systems of equations (such as Atwood's machine). ✓	27 – 31
8	Understand and utilize the relation between friction force, normal force, and coefficient of friction for both cases: static and kinetic.	32 – 37
9	Solve problems involving air resistance in which friction is assumed directly proportional to velocity; define and apply the concept of terminal velocity.	38 – 39
10	Apply force components to objects on an incline and solve related problems.	40 – 44

What is "friction"?

- Friction is a "contact force" that opposes relative sliding of one object across another.
- Friction is always directed parallel to the surfaces of the objects.
- Like all forces, friction occurs in equal and opposite pairs.
- Like the normal force, it results from an electromagnetic interaction of the atoms along the surfaces of the two objects.

What determines the amount of friction?

The type of surfaces influences the amount of friction. Generally rougher surfaces result in greater friction.

The greater the amount of normal force pressing objects together, the greater the amount of friction.

What does not affect the amount of friction? (surprisingly)

The amount of surface area in contact has little effect on the resulting amount of friction.

The relative speed of surfaces sliding across one another has little effect on the resulting amount of friction.

The simple model of friction:

$$F_f = \mu F_N$$

where: F_f = magnitude of friction
μ = coefficient of friction
F_N = magnitude of normal force

The coefficient of friction is a constant of proportionality depending on the surfaces.

Types of Friction

- If one object slides across another it is called *kinetic friction* or *sliding friction*.
- If an object is at rest against another object there may be *static friction*.
- The maximum amount of static friction is sometimes called the *starting friction*.

The model can be used for each type of friction:

kinetic friction: $F_f = \mu_k F_N$

static friction: $F_f \leq \mu_s F_N$

The coefficients are typically not the same for a given scenario. Generally speaking:

$$0 < \mu \leq 1$$

$$\mu_k \leq \mu_s$$

Coefficients of Friction		
Materials	μ_s	μ_k
steel/steel	0.74	0.57
glass/glass	0.94	0.40
wood/wood	0.5	0.3
tire/dry road	1.0	0.8
tire/wet road	0.7	0.5
teflon/teflon	0.04	0.04