PHYS 1443 – Section 001
Lecture #8

Wednesday, February 23, 2011

Dr. Jaehoon Yu

- Application of Newton's Laws
  - Motion with friction
- Uniform Circular Motion
- Motion Under Resistive Forces
- Newton's Law of Universal Gravitation

Announcements

- Mid-term comprehensive exam
  - 1 – 2:20pm, Monday, Mar. 7, SH103
  - Covers: CH.1.1 through what we complete next Wednesday, Mar. 2 plus Appendix
- Reading assignment
  - Read CH5.1, 5.5 and 5.6 and follow through example problems in the chapters
- Colloquium this week: Our own Dr. C. Jackson on "Race to God Particle"

Physics Department
The University of Texas at Arlington

COLLOQUIUM

"The Race for the 'God Particle'"

Dr. Chris Jackson

UT Arlington, Dept of Physics

4:00 p.m Wednesday February 23, 2011
At SH Rm 101

Abstract:

Despite years of searching, the origin of mass has remained a mystery. Now, however, with the turn on of the Large Hadron Collider at CERN and the continuing efforts of the Tevatron at Fermilab, this mystery appears to be close to being solved. In the Standard Model of particle physics, mass generation occurs through a process called spontaneous symmetry breaking. The lone remnant of this process is a spinless particle called the Higgs boson. Detection of a Higgs boson (which has been called the 'holy grail' of particle physics) is one of the major goals of particle physics experiments, since this would provide direct evidence for the process of spontaneous symmetry breaking. In this talk, I will review the physics of the mechanism that produces mass in the Standard Model as well as discuss alternatives to the Standard Model. I will also give an update of where we stand (both theoretically and experimentally) in the search for the Higgs boson both in the Standard Model as well as in more exotic scenarios.

Refreshments will be served at 3:30pm in the Physics Lounge.

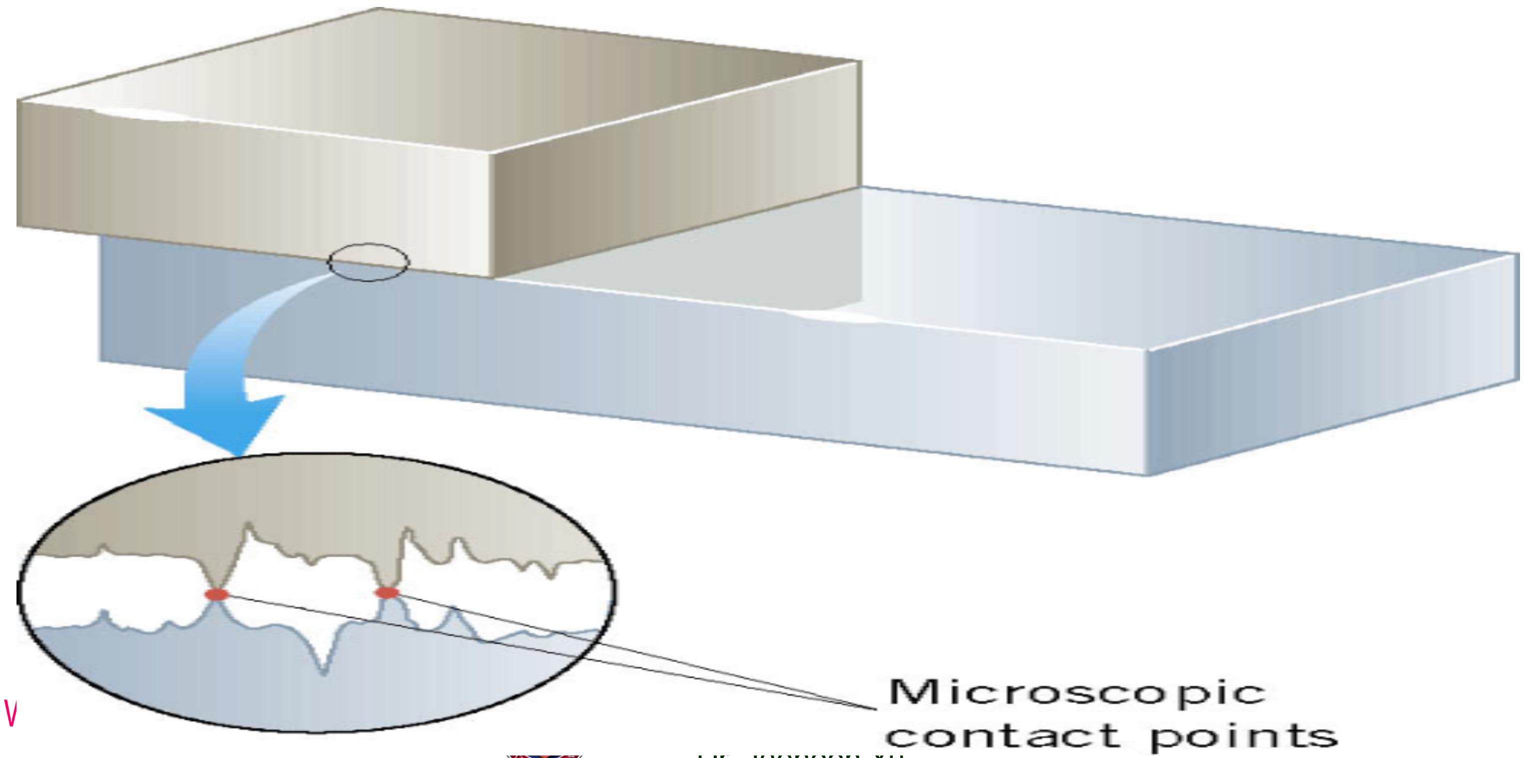
Reminder: Special Project for Extra Credit

A large man and a small boy stand facing each other on **frictionless ice**. They put their hands together and push against each other so that they move apart. a) Who moves away with the higher speed, by how much and why? b) Who moves farther in the same elapsed time, by how much and why?

- Derive the formulae for the two problems above in much more detail and explain your logic in a greater detail than what is in this lecture note.
- Be sure to clearly define each variables used in your derivation.
- Each problem is 10 points.
- Due is Wednesday, Mar. 2.

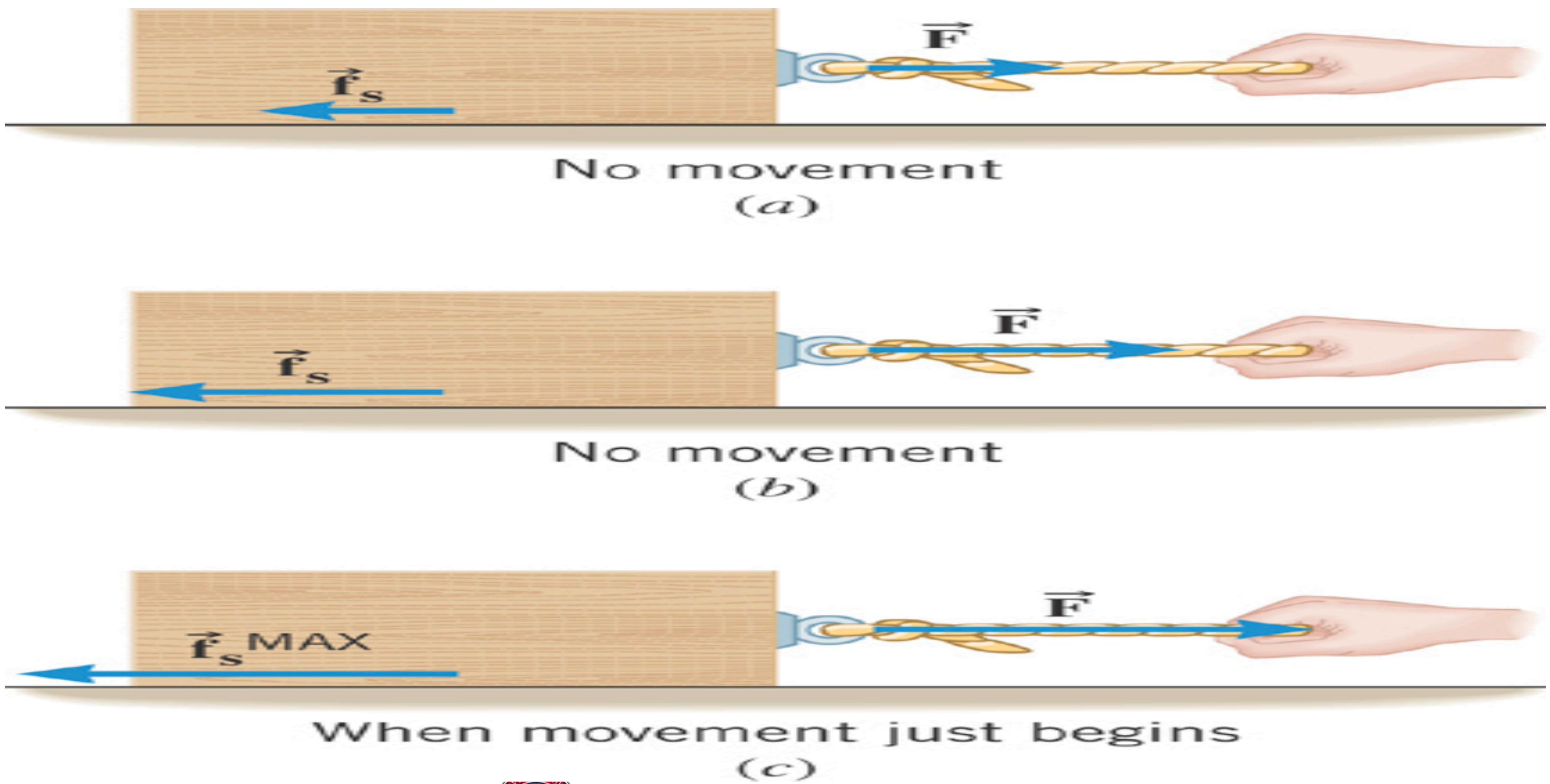
Friction Force

When an object is in contact with a surface there is a force acting on that object. The component of this force that is parallel to the surface is called the ***friction force***. *This resistive force is exerted on a moving object due to viscosity or other types of frictional property of the medium in or surface on which the object moves.* *Always opposite to the movement!!*



Static Friction

When the two surfaces are not sliding across one another the friction is called ***static friction***. *The resistive force exerted on the object up to the time just before the object starts moving.*



Magnitude of the Static Friction

The magnitude of the static friction force can have any value from zero up to the maximum value.

$$f_s \leq f_s^{MAX}$$

$$f_s^{MAX} = \mu_s F_N$$

$0 < \mu_s < 1$ is called the **coefficient of static friction**.

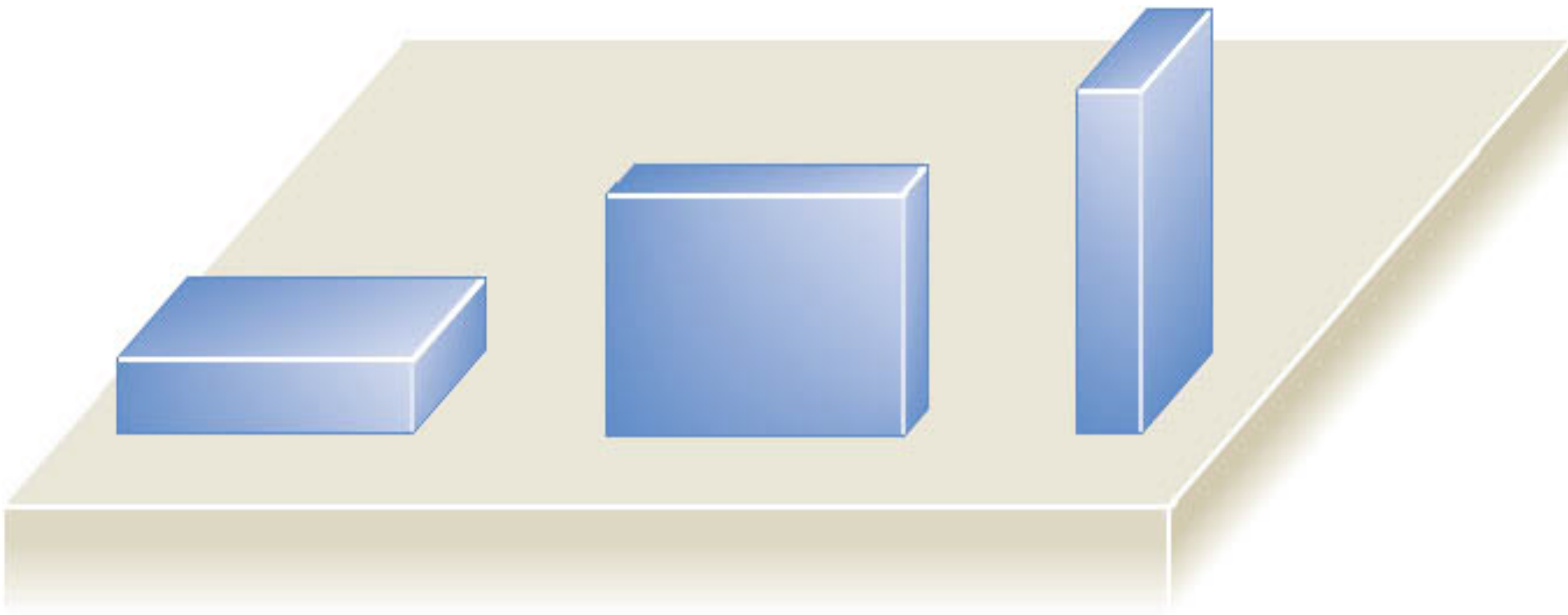
What is the unit? None

Once the object starts moving, there is **NO MORE** static friction!!

Kinetic friction applies during the move!!

Note that the magnitude of the frictional force **does not depend on the contact area of the surfaces**.

$$f_s^{MAX} = \mu_s F_N$$



Kinetic Friction

Static friction opposes the *impending* relative motion between two objects.

Kinetic friction opposes the relative sliding motions that is happening. ***The resistive force exerted on the object during its movement.*** ***Normally much smaller than static friction!!***

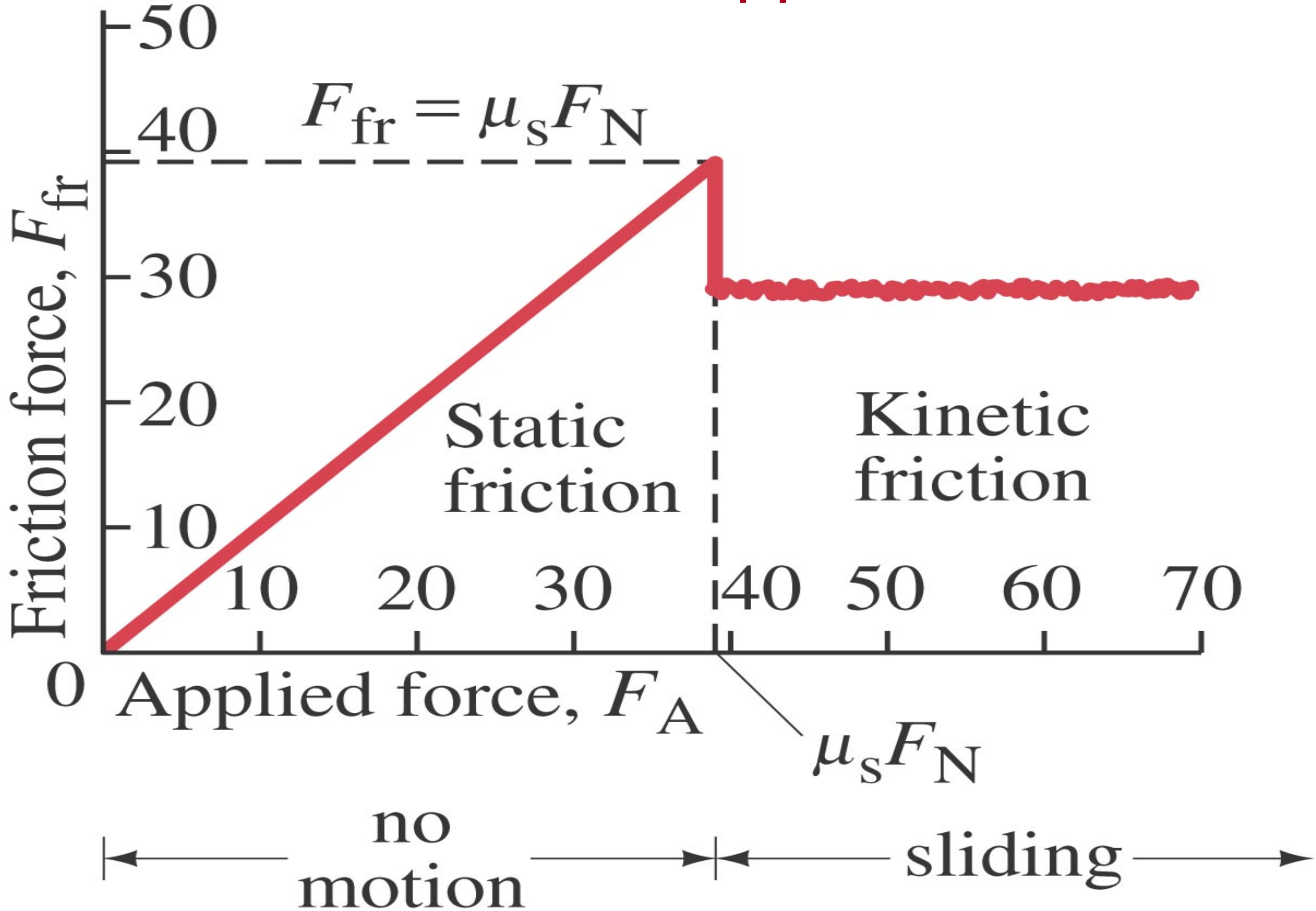
$$f_k = \mu_k F_N$$

$0 < \mu_k < 1$ is called the **coefficient of kinetic friction**.

What is the direction of friction forces? **opposite to the movement**

Figure 5.3

Friction Force vs Applied Force



Coefficients of Friction

TABLE 5–1 Coefficients of Friction†

Surfaces	Coefficient of Static Friction, μ_s	Coefficient of Kinetic Friction, μ_k
Wood on wood	0.4	0.2
Ice on ice	0.1	0.03
Metal on metal (lubricated)	0.15	0.07
Steel on steel (unlubricated)	0.7	0.6
Rubber on dry concrete	1.0	0.8
Rubber on wet concrete	0.7	0.5
Rubber on other solid surfaces	1–4	1
Teflon® on Teflon in air	0.04	0.04
Teflon on steel in air	0.04	0.04
Lubricated ball bearings	<0.01	<0.01
Synovial joints (in human limbs)	0.01	0.01

†Values are approximate and intended only as a guide.

What are these?

Forces of Friction Summary

Resistive force exerted on a moving object due to viscosity or other types frictional property of the medium in or surface on which the object moves.

These forces are either proportional to the velocity or the normal force.

Force of static friction, f_s: *The resistive force exerted on the object until just before the beginning of its movement*

Empirical Formula

$$\left|\vec{f}_s\right| \le \mu_s \left|\vec{F}_N\right|$$

What does this formula tell you?

Frictional force increases till it reaches the limit!!

Beyond the limit, the object moves, and there is **NO MORE** static friction but the kinetic friction takes it over.

Force of kinetic friction, f_k

$$\left|\vec{f}_k\right| = \mu_k \left|\vec{F}_N\right|$$

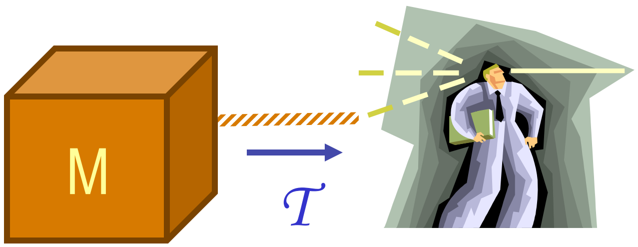
The resistive force exerted on the object during its movement

Which direction does kinetic friction apply?

Opposite to the motion!

Look at this problem again…

Suppose you are pulling a box on a rough surfice, using a rope.



What are the forces being exerted on the box?

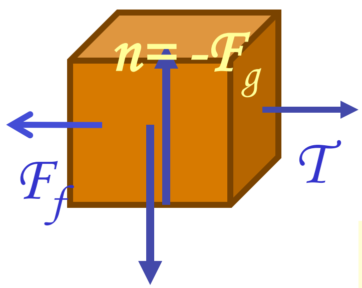
Gravitational force: $\boldsymbol{F_g}$

Normal force: $\boldsymbol{n}$

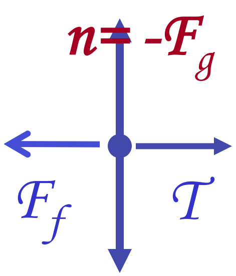
Tension force: $\boldsymbol{T}$

Friction force: $\boldsymbol{F_f}$

Free-body diagram



$F_g=Mg$



$F_g=Mg$

Total force:

$\boldsymbol{F=F_g+n+T+F_f}$

$$\sum F_x = T - F_f = Ma_x \qquad \boxed{a_x = \frac{T - F_f}{M}}$$

$$\sum F_y = -F_g + n = Ma_y = 0 \qquad \boxed{a_y = 0} \qquad \boxed{n = F_g}$$

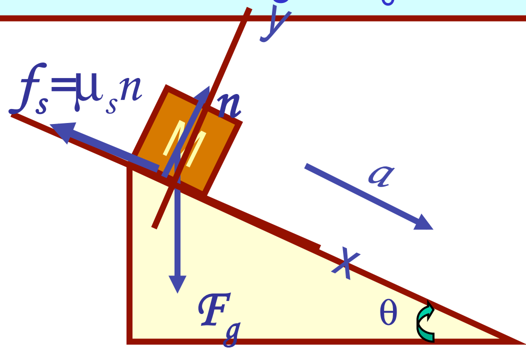
If T is a constant force, a_x, is constant

$$v_{xf} = v_{xi} + a_x t = v_{xi} + \left(\frac{T - F_f}{M}\right)t$$

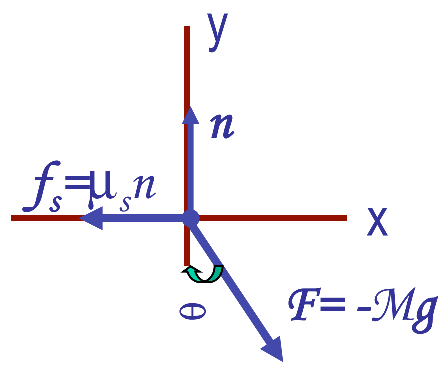
$$\Delta x = x_f - x_i = v_{xi}t + \frac{1}{2}\left(\frac{T - F_f}{M}\right)t^2$$

Example 4.16 w/ Friction

Suppose a block is placed on a rough surface inclined relative to the horizontal. The inclination angle is increased till the block starts to move. Show that by measuring this critical angle, θ_c, one can determine coefficient of static friction, μ_s.



Free-body Diagram



Net force $$\vec{F} = M\vec{a} = \vec{F}_g + \vec{n} + \vec{f}_s$$

x comp. $$F_x = F_{gx} - f_s = Mg\sin\theta - f_s = 0 \quad f_s = \mu_s n = Mg\sin\theta_c$$

y comp. $$F_y = Ma_y = n - F_{gy} = n - Mg\cos\theta_c = 0 \quad n = F_{gy} = Mg\cos\theta_c$$

$$\mu_s = \frac{Mg\sin\theta_c}{n} = \frac{Mg\sin\theta_c}{Mg\cos\theta_c} = \tan\theta_c$$