Physics 121.
Thursday, February 7, 2008.

Carry-on Luggage.

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Physics 121.
Thursday, February 7, 2008.

- Topics:
  - Course announcements
  - Quiz
  - Newton's Law of Motion:
    - Review of Newton's First, Second, and Third Law of Motion
    - Problem Solving Strategies
  - Friction:
    - Static and Kinetic Friction
    - Rounding a Curve
    - Terminal Velocity

Physics 121.
Course announcements.

- Homework set # 2 due on Saturday morning, February 9, at 8.30 am.

- Homework set # 3 will be available on the WEB on Saturday morning, February 9, at 8.30 am and will be due next week on Saturday morning, February 16, at 8.30 am.

- As part of homework set # 3 you will be asked to download and install loggerPro from the Physics 121 website and install it on your computer. The software runs on both Windows and Mac OSX. We will be using this tool to start carrying out video analysis on homework set # 4.

Physics 121.
Course announcements.

- In order to access the restricted areas of the Physics 121 website (containing solutions to homework assignments and exams) you will need the use the username and password combinations distributed via email on Wednesday.

- This same combination will give you access to the installers of the loggerPro software.

WeBWork set # 3.
All about friction.

Similar to problem 4 on set # 2, but now with friction.

The normal force in this problem is directed horizontally.

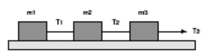
Determine the net acceleration of the blocks in order to determine their contact force.

Frank Wolfs — **Physics 121, Spring 2008**

Homework Set 03 — **Due date: 02/16/2008 at 08:30am EST**

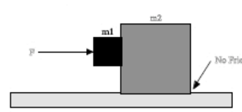
This assignment will be counted toward your final grade. You can attempt each problem 15 times; once you exceed this number of attempts, your solutions will not be recorded anymore. You may need to give 4 or 5 significant digits for some (floating point) numerical answers in order to have them accepted by the computer. Note: to use scientific notion, use a notion like xxE+yy. It is important that you use a capital E; answers with a lower case e will be evaluated differently

1. (15 pts) library/type10/prob12.pg
Three blocks are located on a horizontal table. The coefficient of kinetic friction between the blocks and the table is 0.151. They are connected by a massless cord, as shown in the figure below, and pulled to the right. The masses of the three blocks are $m_1 = 8.0\ kg$, $m_2 = 7.5\ kg$, and $m_3 = 8.5\ kg$. The pulling force is equal to $T_3 = 80.0\ N$. What is the tension T_2? ________

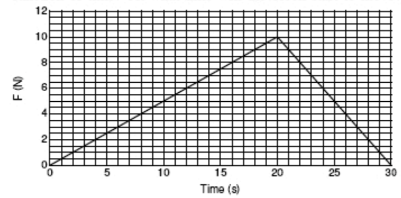


2. (15 pts) library/type10/prob26.pg
The Wall of Death in an amusement park is comprised of a vertical cylinder that can spin around the vertical axis. Riders stand against the wall of the spinning cylinder and the floor falls away leaving the riders held up by friction. The radius of the cylinder is 4.3 m and the coefficent of static friction between the rider and the wall is 0.46. Find the minimum number of revolutions per minute necessary so that the riders do not slip down the wall (note: to specify revolutions per minute as the units in your answer, enter rev/min). ________

3. (15 pts) library/type10/prob19.pg
Two blocks with masses $m_1 = 5.8\ kg$ and $m_2 = 56.2\ kg$, shown in the figure, are free to move. The coefficient of static friction between the blocks is 0.16 but the surface beneath m_2 is frictionless. What is the minimum force F required to hold m_1 against m_2? ________

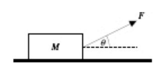


4. (20 pts) library/type10/prob07.pg
A 1.5-kg block is initially at rest on a one-dimensional horizontal track. The static and the kinetic friction coefficients between the block and the track are 0.089 and 0.048, respectively. The force exerted on this block is shown in the Figure as a function of time. At what time will the block start to move?



____
What is its velocity at $t = 20\ s$?
____
What is its velocity at $t = 30\ s$?
____

5. (15 pts) library/type10/prob21.pg
A 5.40 kg block located on a horizontal floor is pulled by a cord that exerts a force $F = 10.5\ N$ at an angle $\theta = 33.0°$ above the horizontal, as shown in the Figure. The coefficient of kinetic friction between the block and the floor is 0.10. What is the speed of the block 4.9 s after it starts moving?



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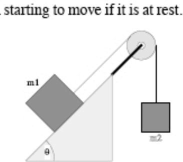
6. (20 pts) library/type10/prob02.pg
Two blocks with mass $m_1 = 5.0\ kg$ and $m_2 = 27.5\ kg$ are connected by a massless string over a frictionless and massless pulley. The angle of the incline is equal to 42.5°. The kinetic coefficient of friction between m_1 and the incline is 0.22. What is the minimum value of the static friction coefficient that will prevent m_1 from starting to move if it is at rest. ________



Find the magnitude of the acceleration of the system if m_1 is moving up the incline. ________
Find the magnitude of the acceleration of the system if m_1 is moving down the incline. ________

1

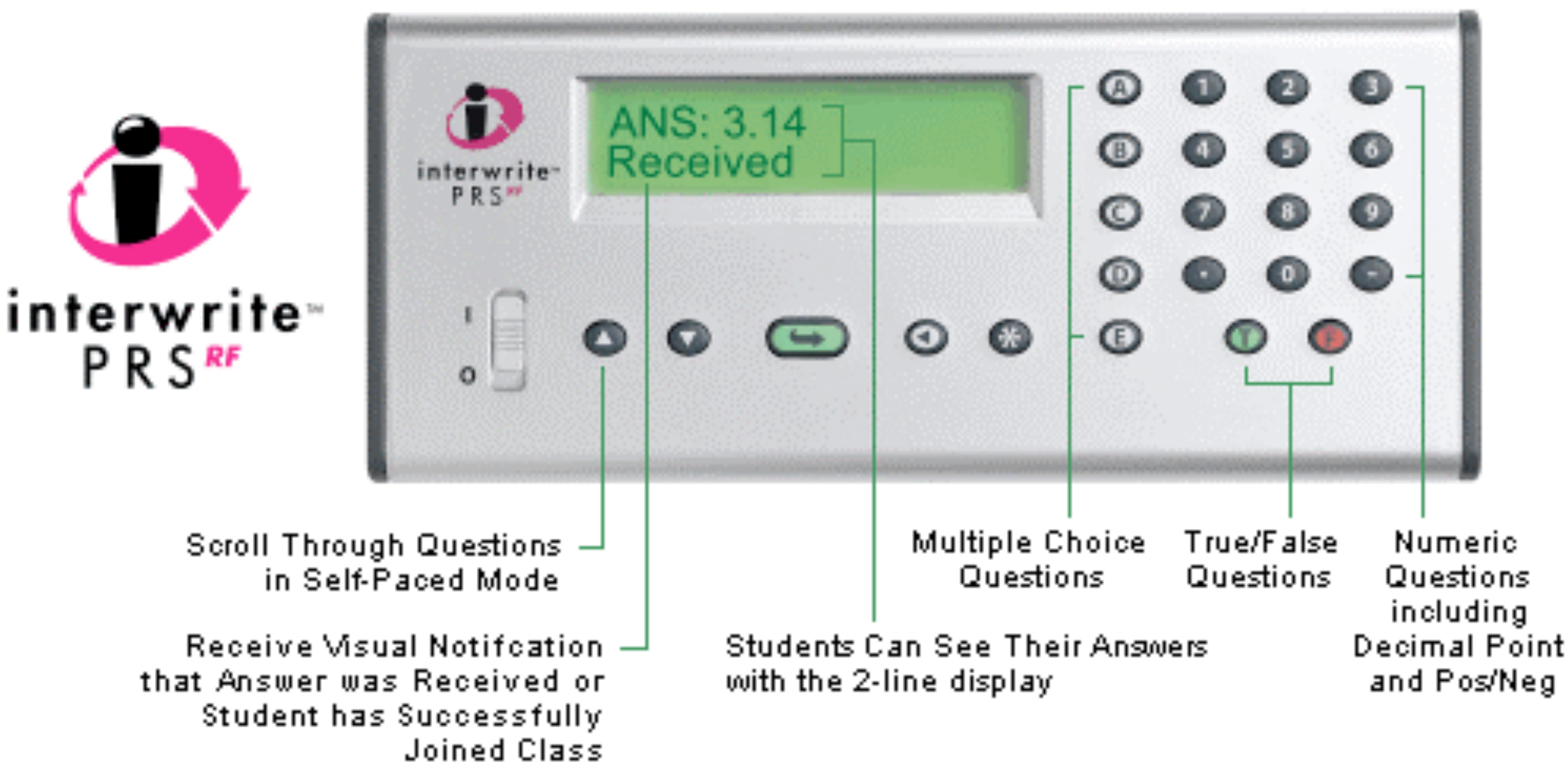
Motion with variable acceleration!

Make sure you determine the normal force correctly!

Make sure you deter-Mine the correct Directions of the friction and normal forces.

Physics 121.
Quiz Lecture 5.

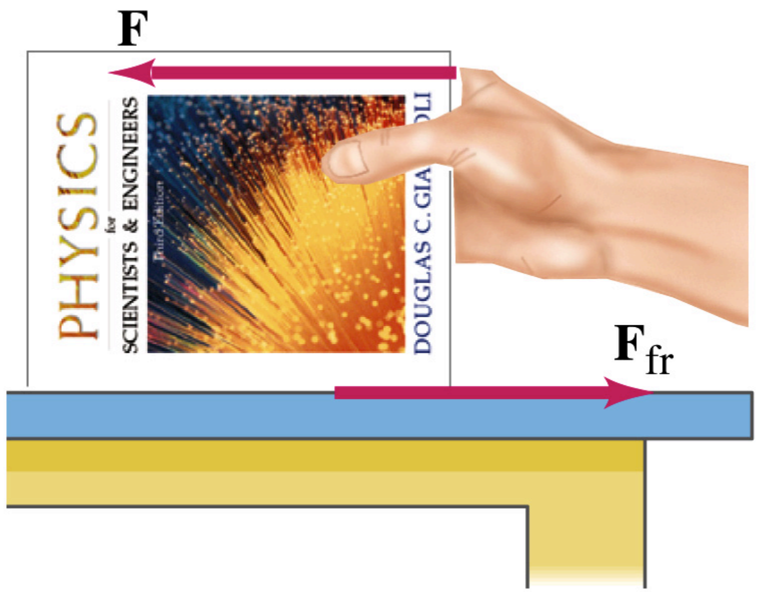
- The quiz today will have 3 questions.



A quick review:
Newton's first law of motion.

First Law:

Consider a body on which no net force acts. If the body is at rest, it will remain at rest. If the body is moving with constant velocity, it will continue to do so.



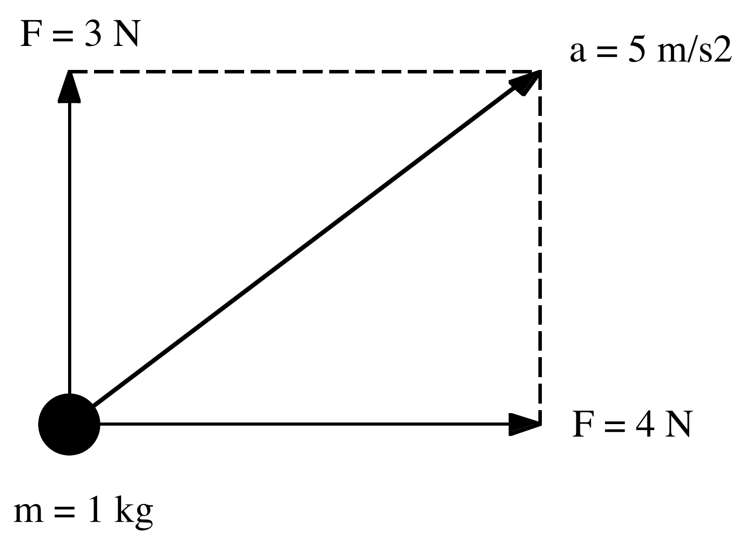
- Notes:
  - **Net force:** sum of ALL forces acting on the body.
  - An object at rest and an object moving with constant velocity both have **no acceleration**.

A quick review:
Newton's second law of motion.

Second Law:

The acceleration of an object is directly proportional to the net force acting on it and it inversely proportional to its mass. The direction of the acceleration is in the direction of the net force acting on the object:

$$\sum \vec{\mathbf{F}} = m\,\vec{\mathbf{a}}$$



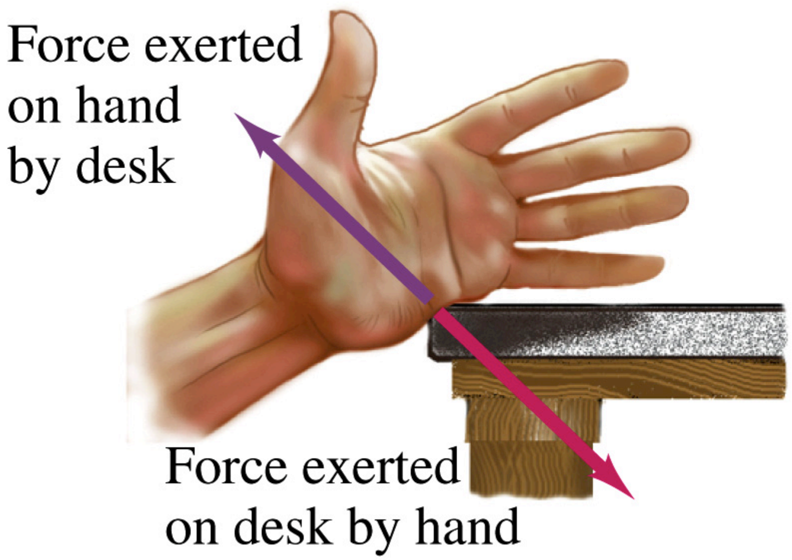
A quick review:
Newton's third law of motion.

Third law:

Suppose a body A exerts a force (F_{BA}) on body B. Experiments show that in that case body B exerts a force (F_{AB}) on body A. These two forces are equal in magnitude and oppositely directed:

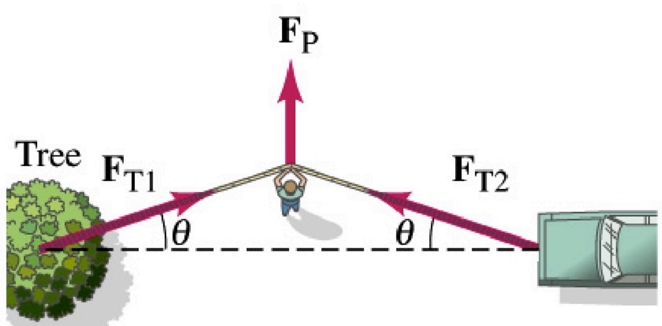
$$\vec{\mathbf{F}}_{BA} = -\vec{\mathbf{F}}_{AB}$$

Note: these forces act on different objects and they do not cancel each other.

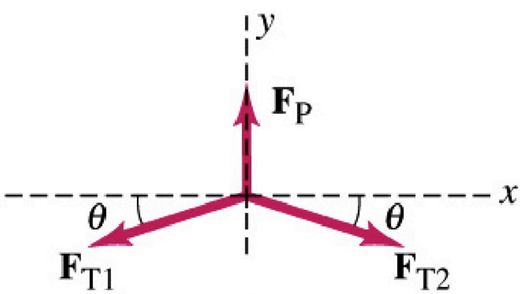


Newton's laws of motion. Problem solving strategies.

- The first step in solving problems involving forces is to determine all the forces that act on the object(s) involved.
- The forces acting on the object(s) of interest are drawn into a free-body diagram.
- Apply Newton's second law to the sum of to forces acting on each object of interest.

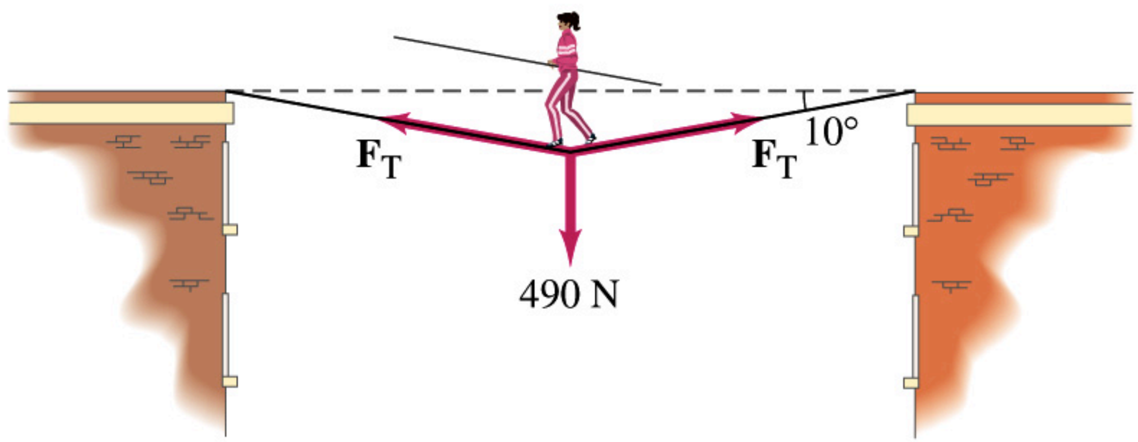


(a)



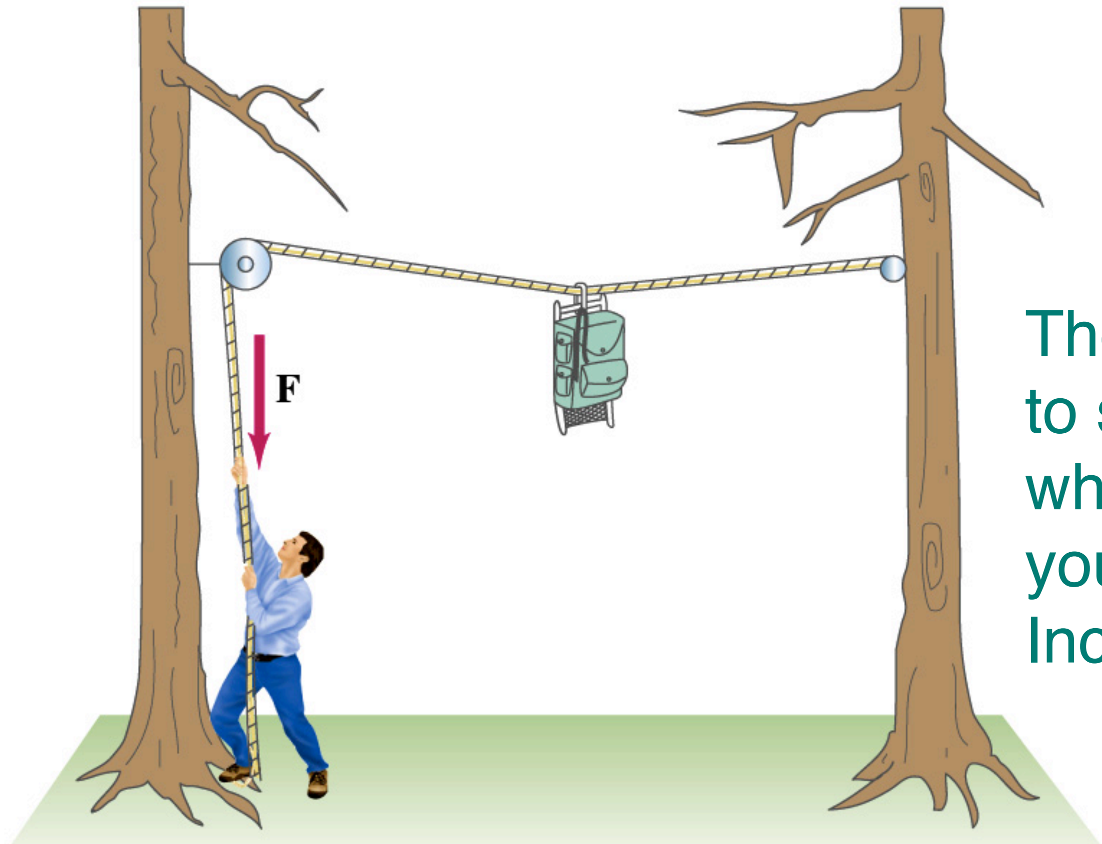
(b)

Newton's laws of motion.
Interesting effects.



The rope must **always** sag!
Why?

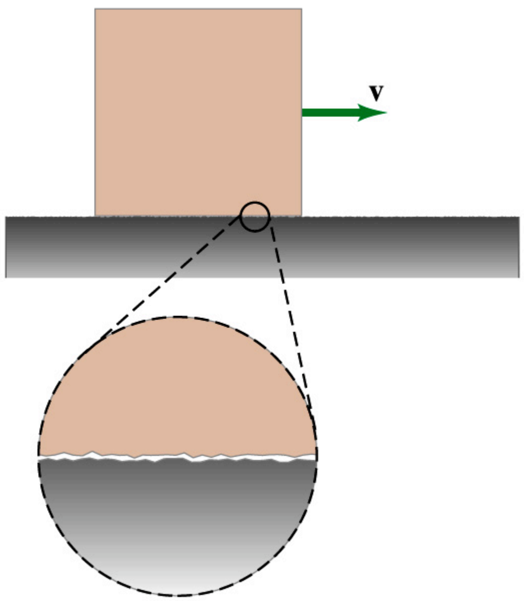
Newton's laws of motion.
Interesting effects.



The force you need to supply increases when the height of your backpack Increases. Why?

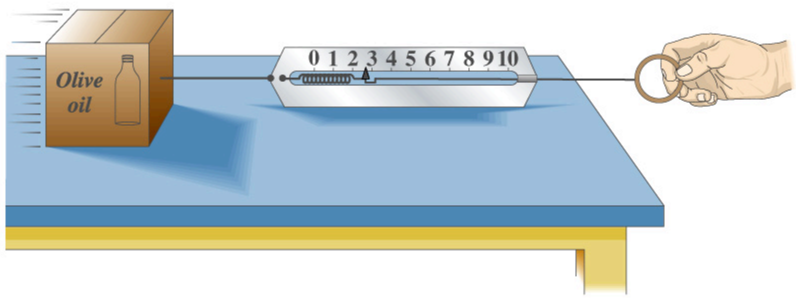
Friction.

- A block on a table may not start to move when we apply a small force on it.
- This means that there is no net force in the horizontal direction, and that the applied force is balanced by another force.
- This other force must change its magnitude and direction based on the direction and magnitude applied force.
- If the applied force is large enough, the block will start to move and accelerate.



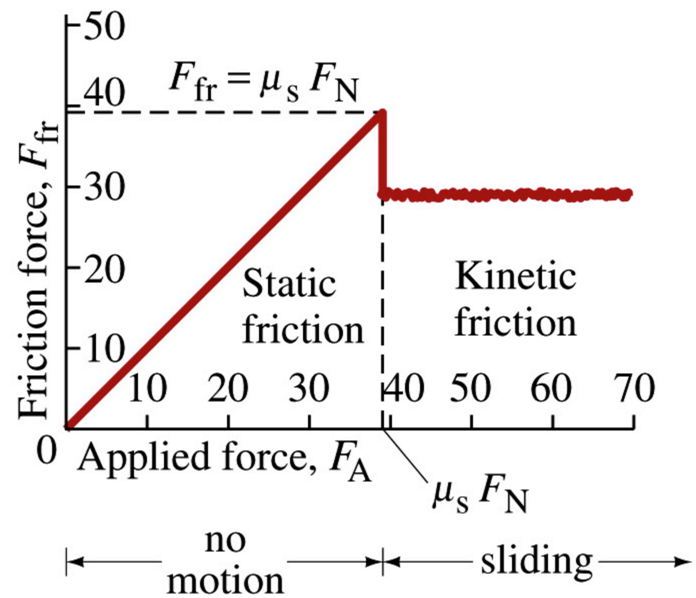
Friction.

- When the applied force exceeds a certain maximum value, the object will start to move.
- Once the object starts to move, the magnitude of the force required to keep the object moving with constant velocity is smaller than the magnitude of the force required to start the motion.
- The forces that try to oppose our motion are the friction forces between the object and surface on which it is resting.



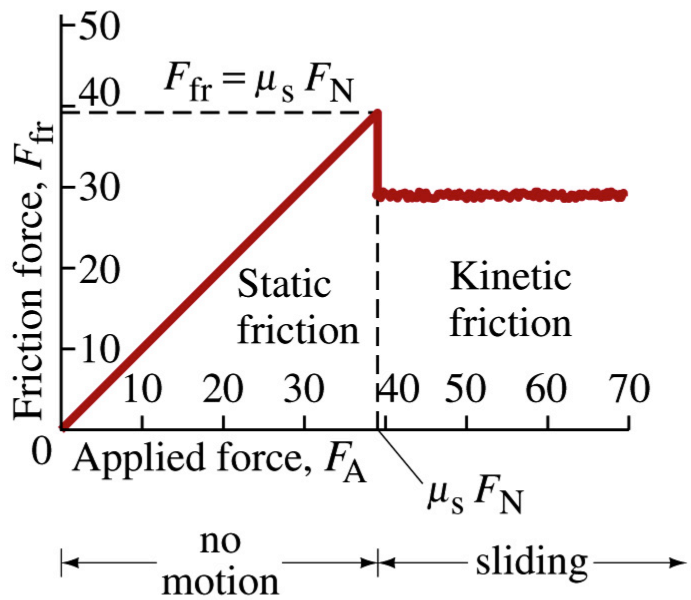
Friction.

- Based on these observations we can conclude :
  - There are two different friction forces: the **static friction** force (no motion) and the **kinetic friction** force (motion).
  - The static friction force increases with the applied force but has a maximum value.
  - The kinetic friction force is independent of the applied force, and has a magnitude that is less than the maximum static friction force.



Friction and braking.

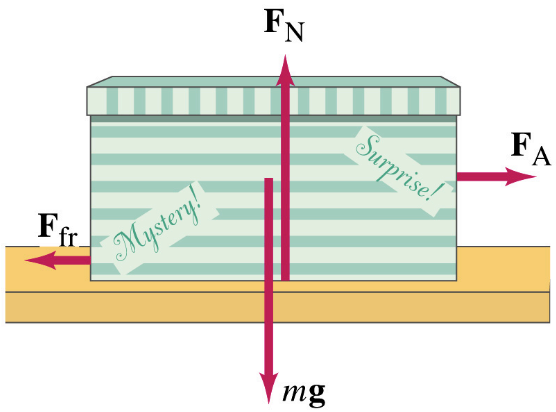
- Consider how you stop in your car:
  - The contact force between the tires and the road is the static friction force (for most normal drivers). It is this force that provides the acceleration required to reduce the speed of your car.
  - The maximum static friction force is larger than the kinetic friction force. As a result, your are **much** more effective stopping your car when you can use static friction instead of kinetic friction (e.g. when your wheels lock up).

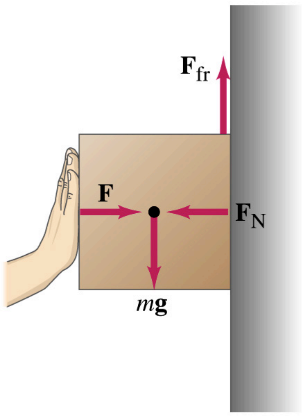


Friction and normal forces.

- The maximum static friction force and the kinetic friction force are proportional to the normal force.
- Changes in the normal force will thus result in changes in the friction forces.

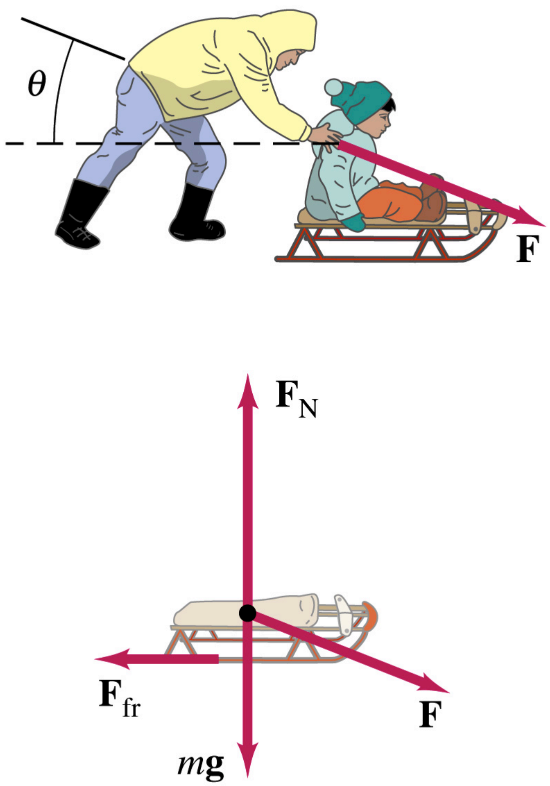
- **NOTE:**
  - The normal force will be always perpendicular to the surface.
  - The friction force will be always opposite to the direction of (potential) motion.



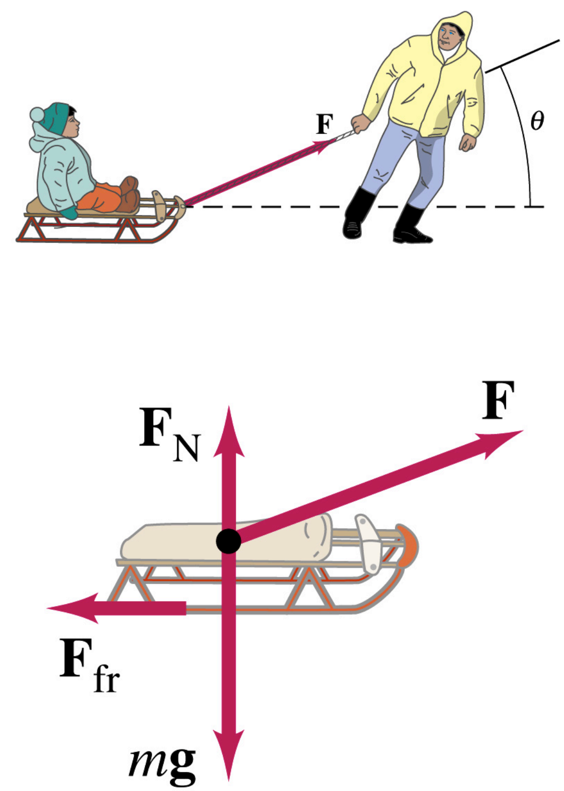


Pushing or pulling: a big difference.

More Friction

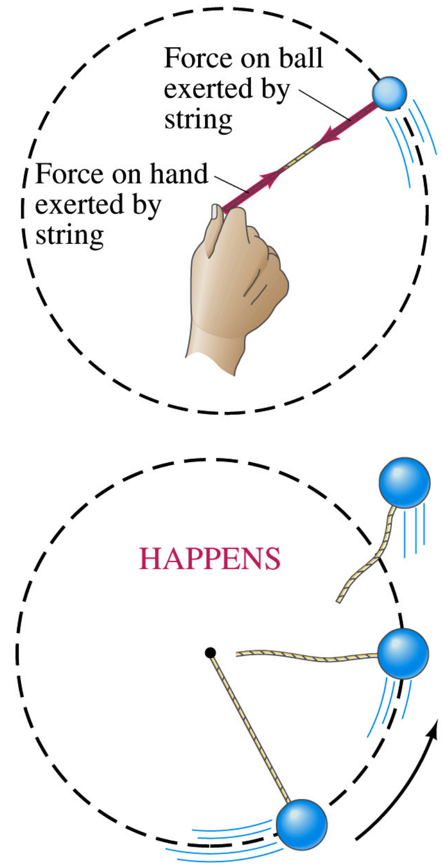


Less Friction



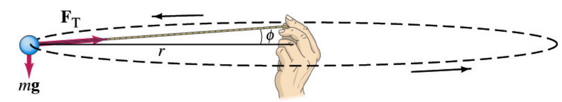
Circular motion.
A quick review.

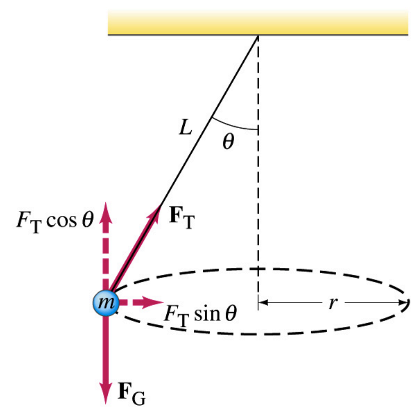
- When we see an object carrying out circular motion, we know that there must be force acting on the object, directed towards the center of the circle.
- When you look at the circular motion of a ball attached to a string, the force is provided by the tension in the string.
- When the force responsible for the circular motion disappears, e.g. by cutting the string, the motion will become linear.



Circular motion.
A quick review.

- In most cases, the string force not only has to provide the force required for circular motion, but also the force required to balance the gravitational force.
- Important consequences:
  - You can never swing an object with the string aligned with the horizontal plane.
  - When the speed increases, the acceleration increases up to the point that the force required for circular motion exceeds the maximum force that can be provided by the string.

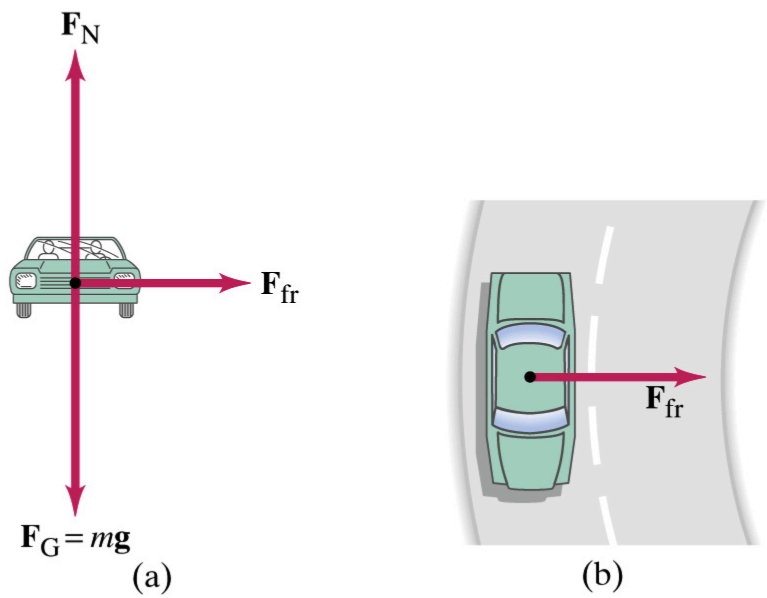




Circular motion and its connection to friction.

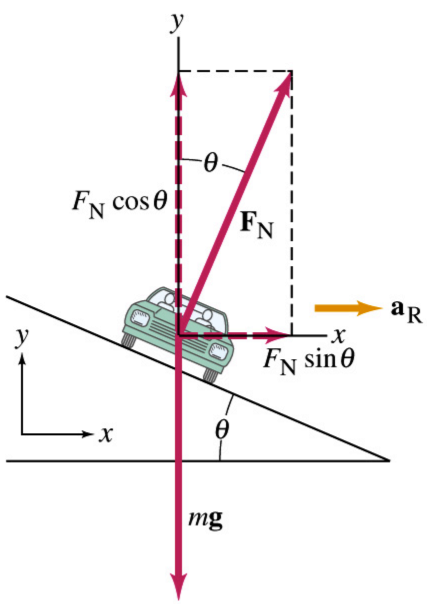
- When you drive your car around a corner you carry out circular motion.
- In order to be able to carry out this type of motion, there must be a force present that provides the required acceleration towards the center of the circle.
- This required force is provided by the friction force between the tires and the road.
- But remember ….. The friction force has a maximum value, and there is a maximum speed with which you can make the turn.

Required force = Mv^2/r.
If v increases, the friction force must increase and/or the radius must increase.



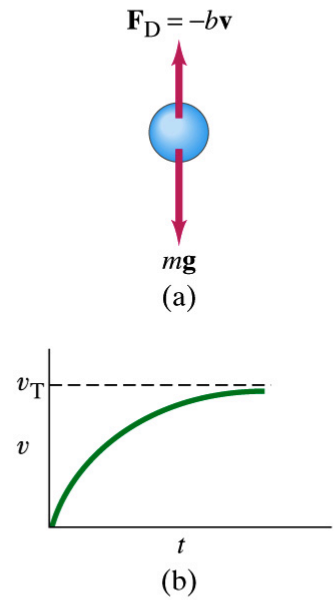
Circular motion and its connection to friction.

- Unless a friction force is present you can not turn a corner …… unless the curve is banked.
- A curve that is banked changes the direction of the normal force.
- The normal force, which is perpendicular to the surface of the road, can provide the force required for circular motion.
- In this way, you can round the curve even when there is no friction ……. but only if you drive with exactly the right speed (the posted speed).



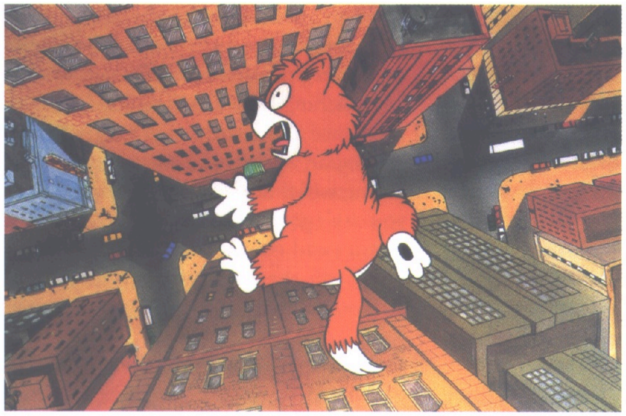
Air "friction" or drag.

- Objects that move through the air also experience a "friction" type force.
- The drag force has the following properties:
  - It is proportional to the cross sectional area of the object.
  - It is proportional to the velocity of the object.
  - It is directed in a direction opposite to the direction of motion.
- The drag force is responsible for the object reaching a terminal velocity (when the drag force balances the gravitational force).



Terminal air "friction" or drag.

- The science of falling cats is called feline pesematology.
- This area of science uses the data from falling cats in Manhattan to study the correlation between injuries and height.
- The data show that the survival rate is doubling as the height increases (effects of terminal velocity). E.g. only 5% of the cats who fell seven to thirty-two stories died, while 10% of the cats died who fell from two to six stories.



That's all!
Next week: gravity keeps us together!