Physics 207, Lecture 6, Sept 23 ‘09

- Chapter 6: Dynamics Along a Line

Assignments:
- Lab M4 Acceleration of Gravity this week
- Discussions this week - problem solving
- Monday - Read Chapter 7 (Newton’s Third Law)
- Mastering Physics: HW4 due Friday 6pm
  - practice problems for next week (no HW)
- Exam Thurs Oct 1 5:45 - 7:00   125 Agriculture Hall
  - Chapters 1, 2, 3, 4.1 - 4.2, 5, 6
  - Lectures, discussion, labs, HW
Rules for finding acceleration

Newton's Laws

1) There exists a coordinate system in which a point-like object will move at constant velocity iff the net force acting on the object is zero. This coordinate system is called an inertial frame.

2) A point-like object of mass $m$ subjected to forces $\vec{F}_1, \vec{F}_2, \vec{F}_3, \ldots$ will undergo an acceleration given by

$$\vec{F}_{\text{net}} = \sum_{f} \vec{F}_i = m \vec{a}$$

3) If object A exerts a force $\vec{F}_{A,B}$ on B, an equal but opposite force $\vec{F}_{B,A}$ is exerted by object B on object A: $\vec{F}_{A,B} = -\vec{F}_{B,A}$

} deferred until later chapter
Example

Hockey puck glides at constant \( \vec{v} \) if the friction against ice/water is negligible until the player strikes the puck w/ the hockey stick.
Second Law: \[ \sum \vec{F} = m \vec{a} \]

units: \( N = \text{Newton} = \text{kg} \frac{\text{m}}{\text{s}^2} \)

Law 2 also defines a property of the body called mass: "m"
Same forces (or pushes) can lead to different acceleration, and this difference is a property of the body and not the external force!
A mass of 10. kg is acted on by two forces: 
$F_1$ is 10. N due East and 
$F_2$ is 10. N due North. 
The acceleration of the mass is:

A. 1.4 m/s$^2$, 45$^0$ North of East
B. 1.4 m/s$^2$, 30$^0$ South of East
C. 1.4 m/s$^2$ due East
D. 2.0 m/s$^2$, 30$^0$ North of East
E. 2.0 m/s$^2$, 45$^0$ North of East
Dynamics Problem-solving Strategy

- Model
  - Make simplifying assumptions
- Visualize
  - Translate words into symbols
  - Draw a sketch
  - Identify forces
  - Draw a free-body diagram
- Solve
  - Use Newton’s 2nd law
  - Use kinematics to find velocities and positions
- Assess
  - Does the result make sense?

\[ \vec{F}_{\text{net}} = \sum_{i} \vec{F}_i = m\vec{a} \]
**Drawing and Labeling**

This is the hardest step, as it requires recognition of forces (and invention of labels).

**Drawing the force on an**

**Example**

A ball of mass \( M \) is sitting on a table. What is the force exerted by the table on the ball?

Assume a constant gravitational field \( \vec{g} = -g \hat{i} \)

(see previous lecture) \( g \equiv 9.8 \, \text{m/s}^2 \)

**Free body diagram**

\[ \vec{N} \] = normal force acted by the table on the ball

\[ M \vec{g} \]

\[ |\vec{g}| = 9.8 \, \text{m/s}^2 \]

Note, idealized as a point.
\[
\vec{F}_{\text{net}} = \vec{N} + M\vec{g} = M\vec{a} = 0
\]

\[\therefore \quad \vec{N} = -M\vec{g}\]

Example

Which of the following free-body diagrams represents the block sliding down a frictionless inclined plane?

(1) \hspace{1cm} (2) \hspace{1cm} (3) \hspace{1cm} (4) \hspace{1cm} (5)
Friction is a complicated process.

Friction arises from the attraction of molecules between two surfaces that are in close contact. (Sometimes bonds form and break.)

When normal force is applied, the effective contact is greater!

Hence, one would expect friction to be greater.

polished steel
Static friction:

If surfaces in contact do not slide

\[ f_s \leq \mu_s N \]

Normal force magnitude

static friction coefficient of force magnitude static friction

a) direction as necessary to prevent motion

b) magnitude is unknown until the opposing force is known

This impasse is supposed to be caused by chemical bonds (if true, quantum mechanics)
Kinetic Friction

\[ f_k = \mu_k N \]

When surfaces in contact are skidding.

Suppose a block of mass \( m \) is pulled at a constant velocity across a horizontal surface by a string of tension \( T \) making an angle as shown. What is the frictional force?