Checklist for Today

- Things that were due **Monday**:  
  - Chapter 8 Quizzes on WebCT

- Things due **Tuesday**:  
  - Read Chapters 10 & 11

- Things that are due yesterday for Recitation:  
  - Chapter 9 problems

- Things due **Monday**:  
  - Chapter 9 in WebCT
The Schedule

This Week: (3/17)
- Chapter 8 quizzes due in WebCT
- Reading for Chapters 10 & 11
- Lecture on Chapter 10 (11 in recitation next week)
- Chapter 9 and Exam 2 Review in recitation

Next Week: (3/24)
- Chapter 9 due in WebCT (mini-practice exam 2 available)
- Exam 2 on Tuesday
- Recitation on Chapters 10 & 11
- Reading for Chapters 12 & 13 for Thursday
- Lecture 12 & 13 on Thursday

Following week
- Chapter 10 & 11 material in WebCT
- Reading: Chapters 14-16
- Lectures on 14-16 (Lectures 1 and 2 of Four)
- Recitation on Chapters 12 & 13
Today’s Lecture: Rest of Chap 10

- Center of Mass
- Center of Mass and Translational Motion
- Collision & Explosion Problems using:
  - Conservation of Momentum
  - Center of Mass
Center of Mass (CM)

What is the “Center of Mass?”

• More importantly “Why do we care?”

• This is a special point in space where “it’s as if the object could be replaced by all the mass at that one little point”
Examples where this is useful:

- We have a spherical cow that weighs two tons. We can model defenestrating her as if she were a single point.

- We can model the earth moving around the sun as a single point at "the center of the earth."

At some level we've been assuming these things for doing problems all semester.
Yet another example: there are only a couple of points on a ruler that you can put your finger under and hold it up.

-Your finger provides the normal force.
Visual Examples

The center of mass has the same trajectory as a point since both have the same acceleration and initial velocity.
How do you calculate CM?

1. Pick an origin

2. Look at each “piece of mass” and figure out how much mass it has and how far it is (vector displacement) from the origin. Take mass times position

3. Add them all up and divide out by the sum of the masses

The center of mass is a displacement vector “relative to some origin”
Spelling out the math:

\[ \vec{X}_{\text{cm for 2 particles}} = \frac{m_1 \vec{x}_1 + m_2 \vec{x}_2}{m_1 + m_2} \]

\[ \vec{X}_{\text{cm for 3 particles}} = \frac{m_1 \vec{x}_1 + m_2 \vec{x}_2 + m_3 \vec{x}_3}{m_1 + m_2 + m_3} \]

etc...

Note that \( \vec{x} \) is the 3-D vector displacement.
2-D Example

Three balls with masses $m_1$, $m_2$ and $m_3$ are located at the points given to the right.

Where is the center of mass?
So what?

2 ways to solve collision/explosion problems:

1. Conservation of Momentum in all directions
2. Watching the Center of Mass

Need to be able to do both
- Pick easier method
- Physics is the same
Two balls are moving in outer space. They have known masses $2M$ and $3M$ and speeds $4V$ and $2V$, respectively, and they collide at the origin. The directions are as shown in the figure. After the collision, the two balls stick together and form a blob.

**What is the final velocity of the blob?**
Toy Rocket Problem

Your friend fires a toy rocket into the air with an unknown velocity. You observe that at the peak of its trajectory it has traveled a distance $d$ in the $x$-direction. It then breaks into two equal mass pieces. Part I falls straight down with no initial velocity.

*Where does the 2nd half of the toy end up?*
Two Balls in Two Dimensions

Before a collision, ball 1 moves with speed $v_1$ in the $x$ direction, while ball 2 is at rest. Both have the same mass. After the collision, the balls go off at angles $\Theta$ and $-\Theta$.

*What are the velocities, $v'_1$ and $v'_2$, after the collision?*
Coming up next week...

- Homework 9 due Monday in WebCT
- Make sure you do ALL the quizzes in the learning module (folder)
- Mini-practice exam 2 and bonus points

Exam 2:
- Tuesday March 25th

- Start Chapters 12-16 in Lecture on Thursday