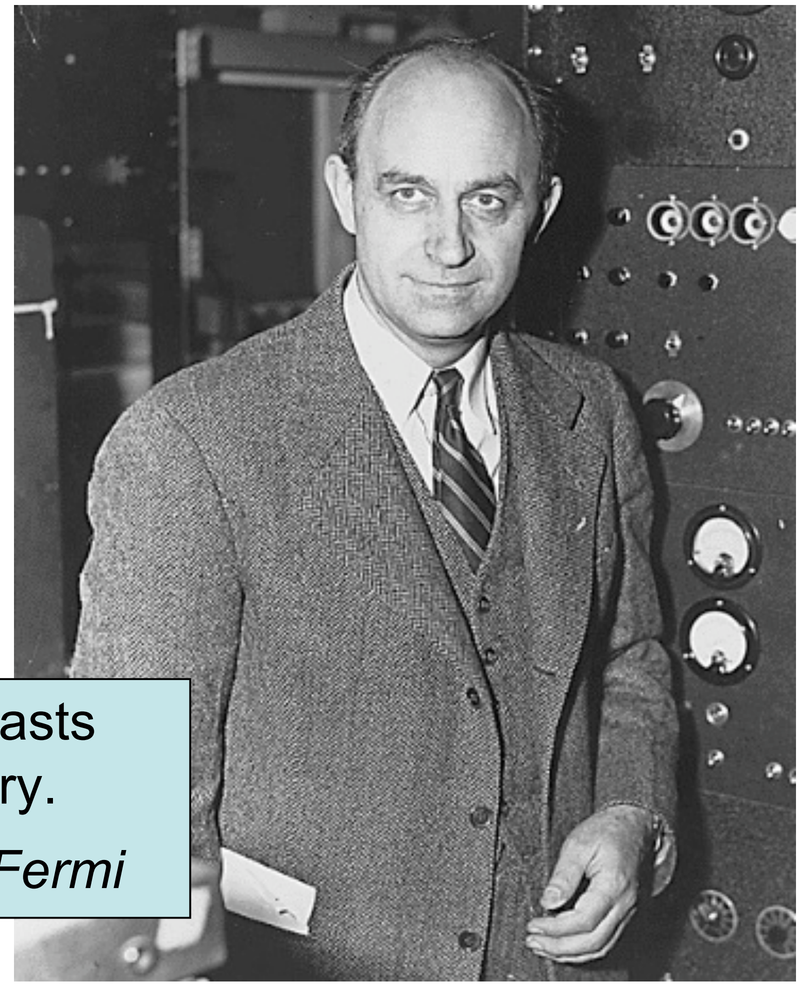
Physics 140 – Fall 2007
lecture #13 : 18 Oct

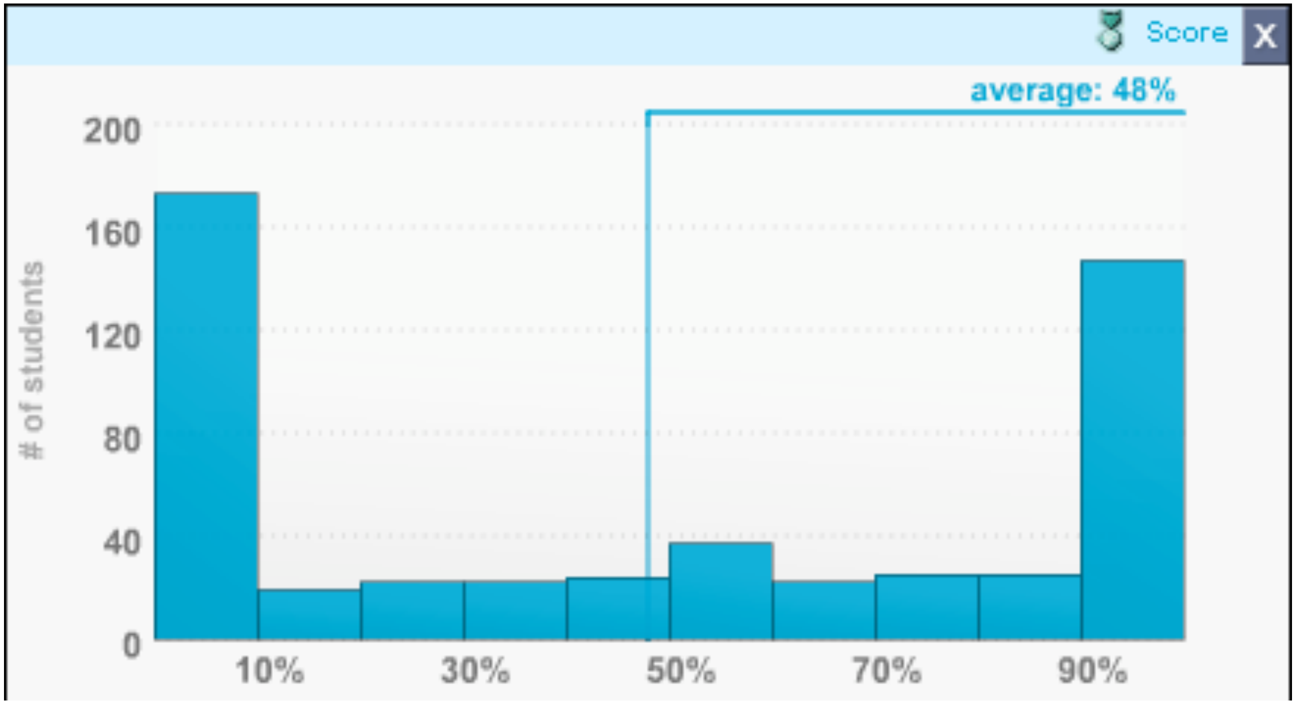
Ch 8 topics:
- elastic and inelastic encounters
- collisions in two dimensions

Announcements:
- check scores on SAMS
  send score corrections within
  two weeks of occurrence


Source: National Archives

> A 50 minute class period lasts roughly one micro-century.
>
> – *Enrico Fermi*

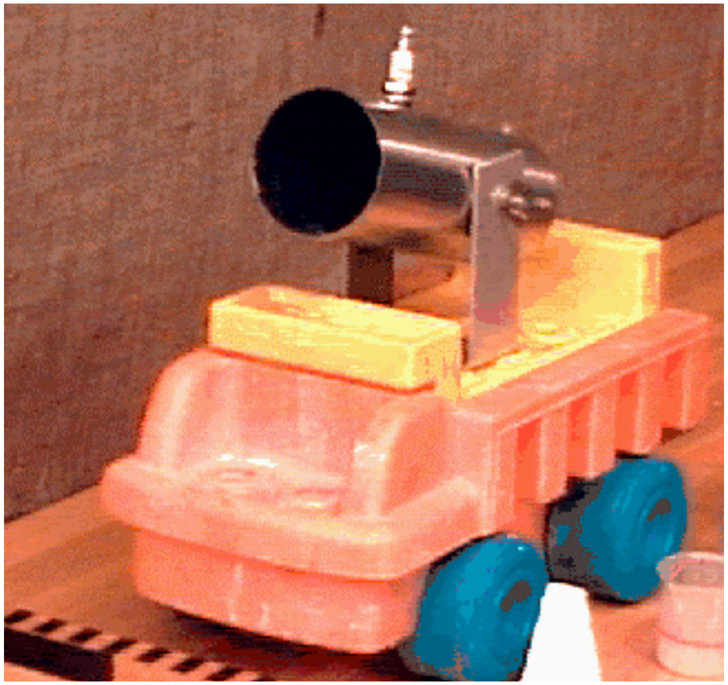
Homework set #6 closes in <15 hours. Half of you need to get going…



Set #7 opens today, closes next TUESDAY.

The baby cannon on the lecture bench is aimed to shoot at some angle θ above the horizontal. Since it is on wheels, it will recoil freely when it fires the tennis ball. Viewed from your seat, what angle above the horizontal does the tennis ball's trajectory make as it emerges from the cannon's muzzle?

1. **An angle larger than θ**
2. **An angle smaller than θ**
3. **The same angle θ**



Kinetic energy and momentum

The kinetic energy of an object of mass m and velocity v,

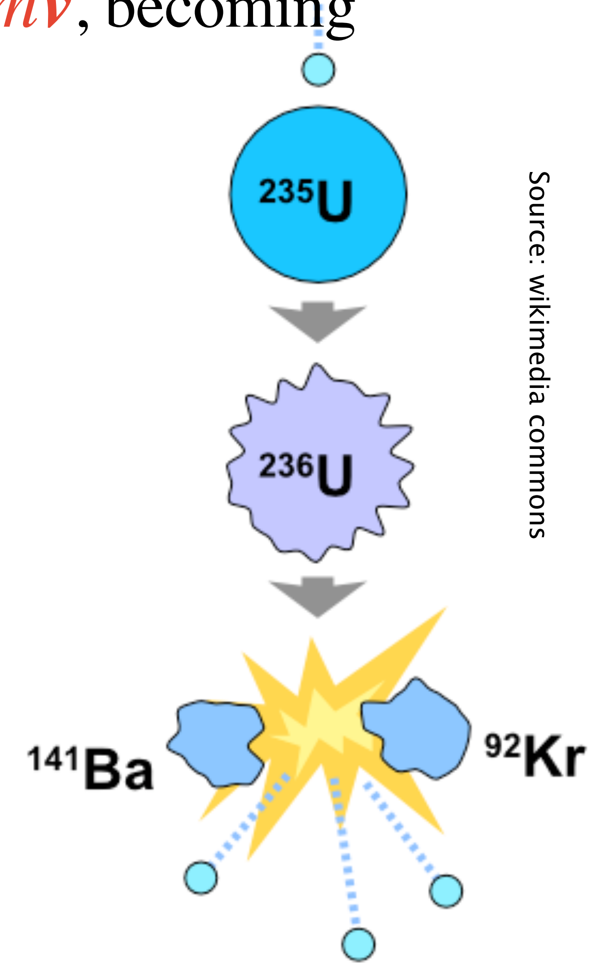
$$K = mv^2 / 2,$$

can be rewritten in terms of momentum, $p = mv$, becoming

$$K = p^2 / 2m.$$

At fixed momentum, lighter objects have more kinetic energy than massive ones.

During nuclear fission of Uranium, neutrons (blue dots) carry away more kinetic energy than the `daughter' products (Barium and Krypton).



Source: wikimedia commons

Kinetic energy in collisions

Unlike the total momentum, the **total kinetic energy** of a colliding pair of bodies (1 and 2) ***may change*** during the encounter. The total kinetic energy, $K=K_1+K_2$, cannot increase (unless some other force, such as a spring or an explosion, assists the encounter), but ***K can either decrease or remain constant***.

These outcomes lead to different categories of collisions -

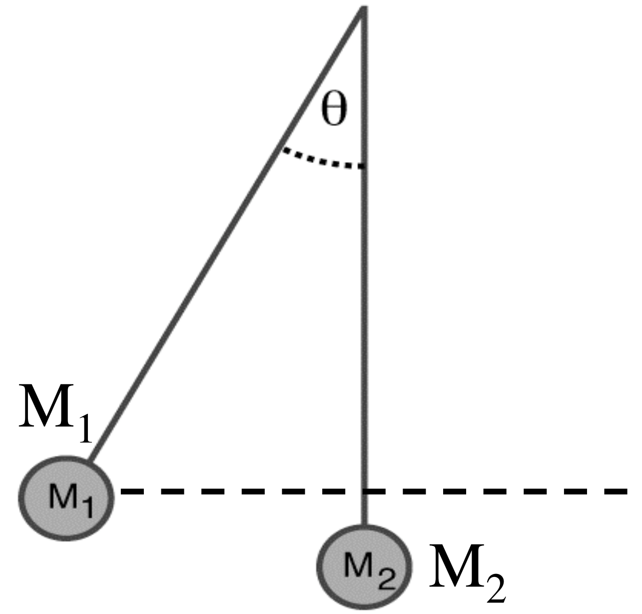
elastic (hard bounce): K_1+K_2 remains constant

inelastic (soft bounce): K_1+K_2 decreases

completely inelastic: K_1+K_2 decreases **and** $v_{1f} = v_{2f}$
(1+2 are stuck together)

For inelastic encounters, the "lost" kinetic energy is converted into internal energy (heat/stress/spin) of the bodies involved.

A ball of mass M_1 is released at rest from an initial angle θ from the vertical and collides a suspended ball of mass M_2 hanging at rest. Under what circumstances will the maximum height that M_2 rises lie ***below*** the initial height of M_1?



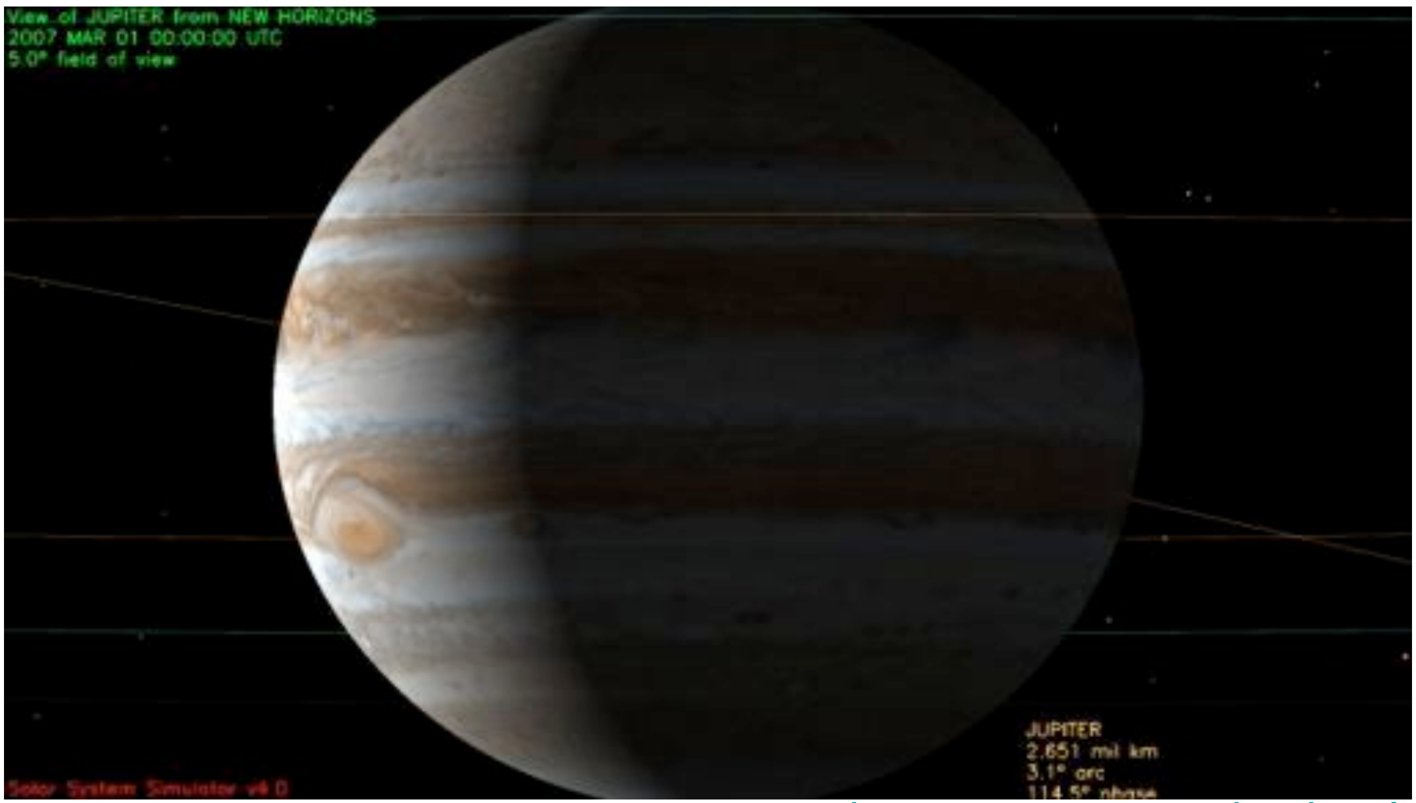
1) **The collision is completely inelastic.**
2) **The collision is elastic and $M_1 < M_2$.**
3) **The collision is elastic and $M_1 > M_2$.**
4) **Either 1 or 2.**
5) **Either 1 or 3.**
6) **M_2 will always rise above the initial height of M_1.**

Analysis of Double Ball Drop

http://hyperphysics.phy-astr.gsu.edu/HBASE/doubal.html http://www.spacedaily.com/reports/Jupiter_Encounter_Begins_For_New_Horizons_Spacecraft_On_Route_To_Pluto_999.html

New horizon spacecraft article removed removed

Source: NASA



http://www.nasa.gov/mission_pages/newhorizons/main/index.html

Colliding bodies in 2 dimensions

A collision of two objects (1 and 2) occurs in a plane defined by the directions of two initial momentums $\boldsymbol{p}_{1i}$ and $\boldsymbol{p}_{2i}$.

When no external forces act on the pair, then ***each component*** of the total momentum is conserved

$$(m_1 v_{1x} + m_2 v_{2x})_f = (m_1 v_{1x} + m_2 v_{2x})_i$$

$$(m_1 v_{1y} + m_2 v_{2y})_f = (m_1 v_{1y} + m_2 v_{2y})_i$$

Since there are four unknowns and only two equations, more constraints are needed. As in the 1D case:

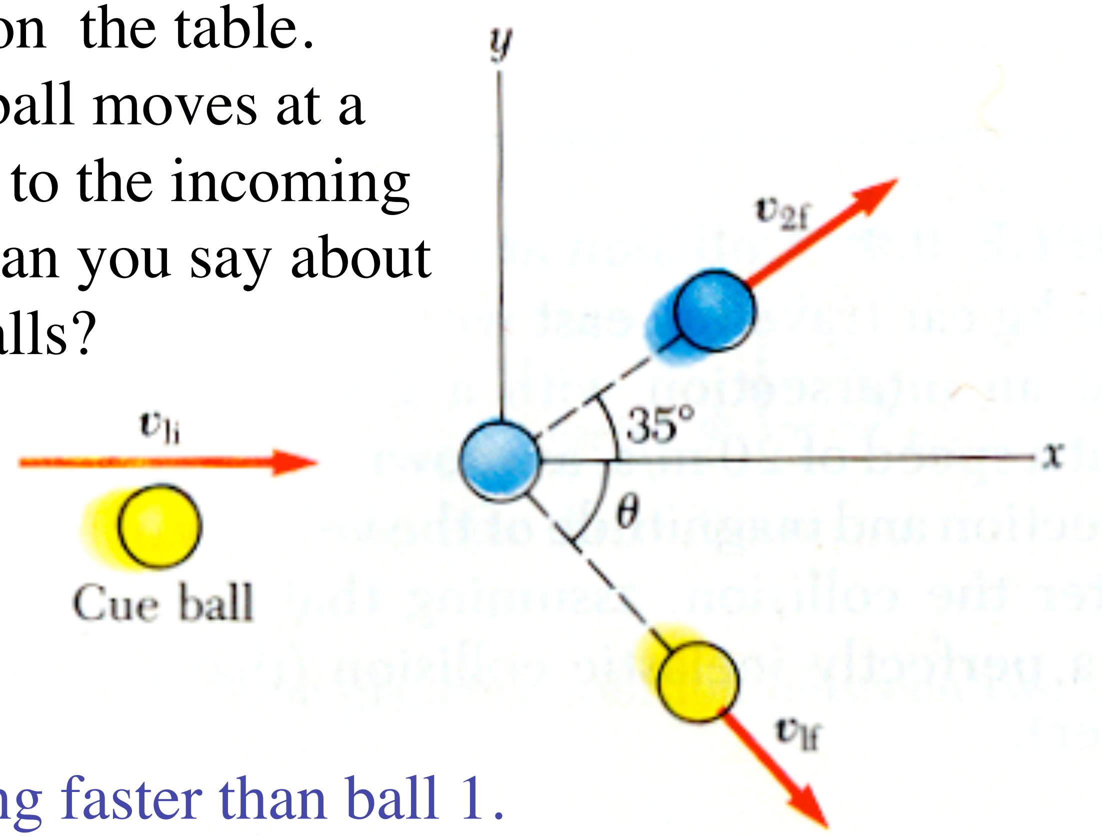
- elastic encounters conserve total kinetic energy (1 added eqn)

$$(K_1 + K_2)_f = (K_1 + K_2)_i$$

- completely inelastic encounters stick together (2 added eqn's)

$$\boldsymbol{v}_{1f} = \boldsymbol{v}_{2f} = (\boldsymbol{p}_{1i} + \boldsymbol{p}_{2i})/(m_1 + m_2) \qquad [= \boldsymbol{v}_{com}]$$

A cue ball (yellow) collides with an equal mass nine (blue) ball at rest on the table. After the collision, the nine ball moves at a 35 degree angle with respect to the incoming cue ball's direction. What can you say about the final speeds of the two balls?



1) ball 2 is moving faster than ball 1.
2) ball 2 is moving slower than ball 1.
3) the balls have equal speeds.
4) more information is needed.

You are in a boat resting on a lake on a perfectly calm day. You fall asleep and lose your oars overboard. Spying two large but unequal size rocks lying in your boat (for ballast? for hitting carp?), you get the brilliant idea of throwing the rocks from the boat away from shore so that your boat will recoil and drift into port. If you throw the rocks with some fixed velocity v_{rel} (relative to you), what scheme will end up giving you and your boat the fastest trip back to shore?

1. throw both rocks simultaneously.
2. throw the lighter, then the heavier.
3. throw the heavier, then the lighter.
4. it doesn't matter how you throw them.