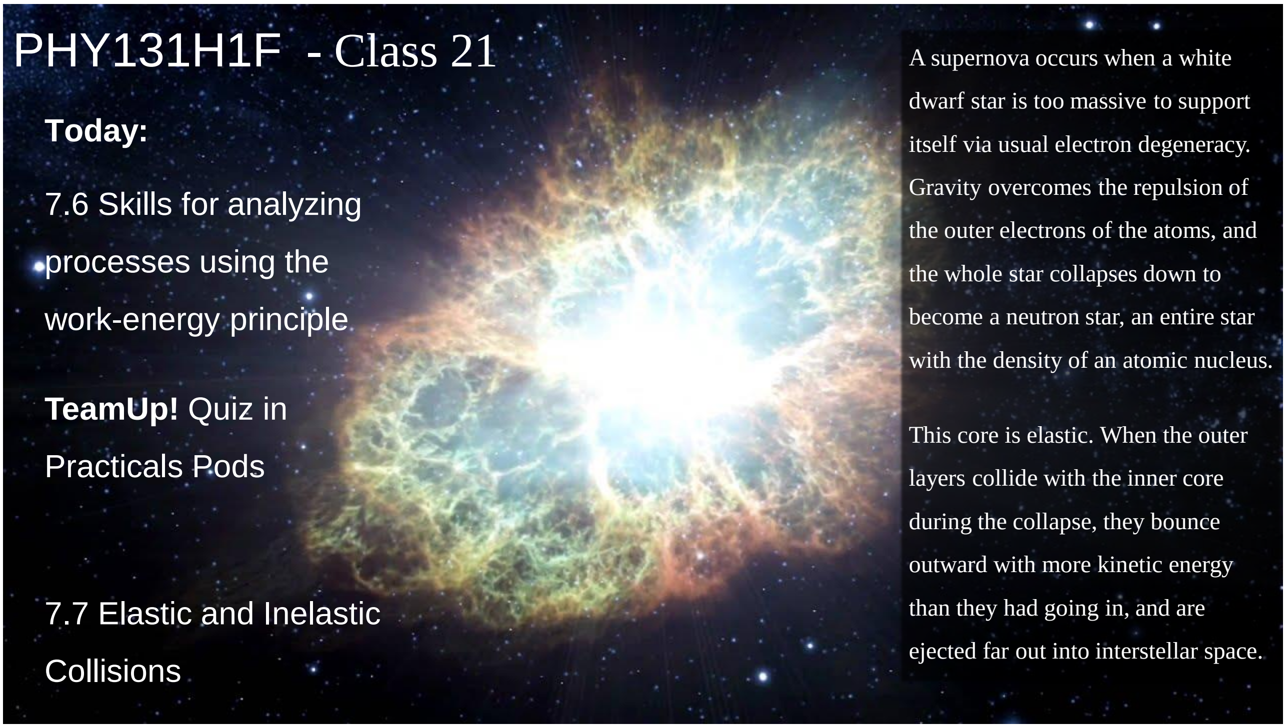


PHY131H1F - Class 21

Today:

7.6 Skills for analyzing processes using the work-energy principle

TeamUp! Quiz in Practicals Pods

7.7 Elastic and Inelastic Collisions

A supernova occurs when a white dwarf star is too massive to support itself via usual electron degeneracy. Gravity overcomes the repulsion of the outer electrons of the atoms, and the whole star collapses down to become a neutron star, an entire star with the density of an atomic nucleus.

This core is elastic. When the outer layers collide with the inner core during the collapse, they bounce outward with more kinetic energy than they had going in, and are ejected far out into interstellar space.

Poll

Crazy Friday: Let's Choose a Zoom-Filter my face today

What Studio Filter would you prefer on my face today?

A. Black Lipstick

B. Pirate Hat and Eyepatch

C. Heisenberg Hat

D. Movember Preview

E. Flowers in Hair

Movember

Watch this Space

- I shaved my upper lip this morning.
- Next time I'll do that is Tuesday, Dec. 1. (The same day as Midterm Assessment #5! – a multiple choice test on Chapters 9 and 10..)
- https://www.facebook.com/harlowphysics/
- https://movember.com/m/14289186

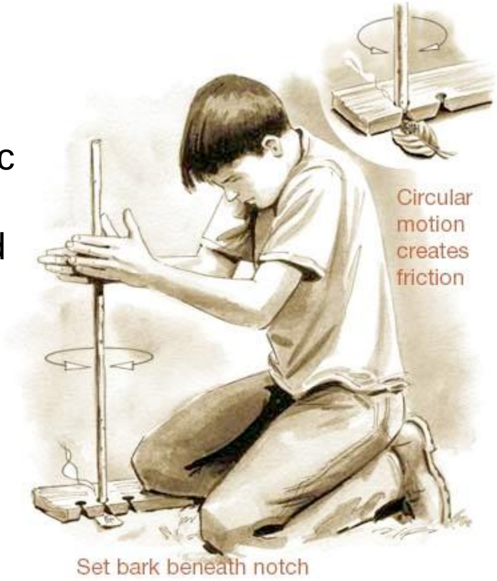
crowdmark https://crowdmark.com/

- Last night you all should have received an email at your mail.utoronto.ca account from Crowdmark Mailer that there is a new assignment waiting for you.
- You must open your email, click on Go to Assignment, which will take you to a utoronto login page, and then to Crowdmark, where you will see the Ch.7 Pre-Quiz.
- It's two questions in a very similar format to Midterm Assessment 4 which will be on Nov.17.
- Just like for Midterm 2, you need to write your answers out on an Answer Template Sheet, and then upload PDF or JPEG images of your work.
- This assignment is 5 days + 35 minutes long.
- A very similar assignment will be emailed to you on Tue. Nov.17 at 8:10pm, and you will only have exactly 35 minutes, maximum, to upload your files to Crowdmark. So this Ch.7 Pre-Quiz is a practice-run for that. But it's also worth 16 homework credits for your completion.

Internal Energy

- Dissipative forces transform macroscopic energy (kinetic), into internal thermal energy.
- Internal energy is the microscopic energy due to random vibrational and rotational motion of atoms and molecules.
- For kinetic friction:

$$\Delta U_{\text{int}} = f_k\, d$$



Conservation of Energy

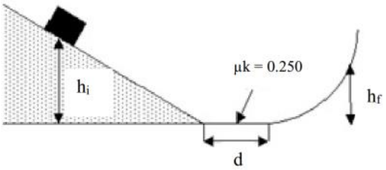
- If no external work is done on the system, and no heat is exchanged between the system and its environment, then:

$$K_{\text{i}} + U_{\text{i}} = K_{\text{f}} + U_{\text{f}} + \Delta U_{\text{int}}$$

- K is the kinetic energy of the system.
- ΔU_{int} is the increase in internal energy of the system.
- If the internal energy is increasing due to kinetic friction which acts opposite to the displacement d, then there is the equation $\Delta U_{int} = |f_k d|$.

Do the DEMO! Before the thermal camera overheats!!

- A small box of mass $m = 10.0$ kg is released from rest at an initial height of $h_i = 2.00$ meters on a frictionless incline as shown. At the bottom of the ramp, it encounters a rough surface with length $d = 1.00$ m and $\mu_k = 2.50 \times 10^{-1}$, and then a **frictionless** circular rise.
- At what height h_f does the box stop on the circular rise?



SKETCH & TRANSLATE.

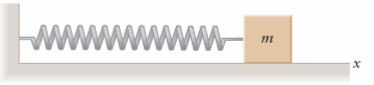
SIMPLIFY & DIAGRAM

REPRESENT MATHEMATICALLY

SIMPLIFY & DIAGRAM

REPRESENT MATHEMATICALLY

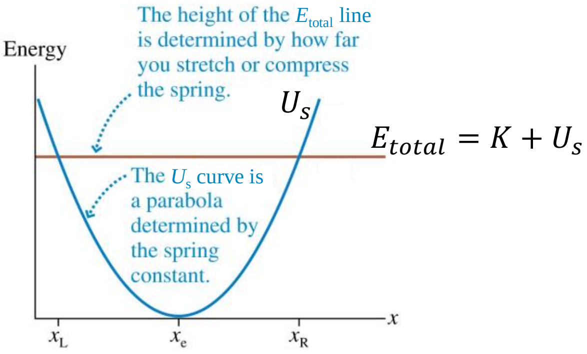
SOLVE & EVALUATE



- Shown is the energy diagram of a mass on a horizontal spring.
- The potential energy is the parabola:

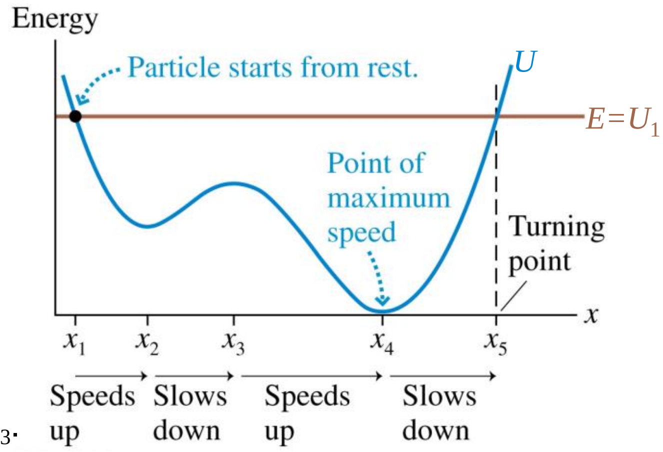
$$U_s = \tfrac{1}{2}k(x - x_e)^2$$

- The U_s curve is determined by the spring constant; you can't change it.



- You can set the total energy E to any height you wish simply by stretching the spring to the proper length at the beginning of the motion.

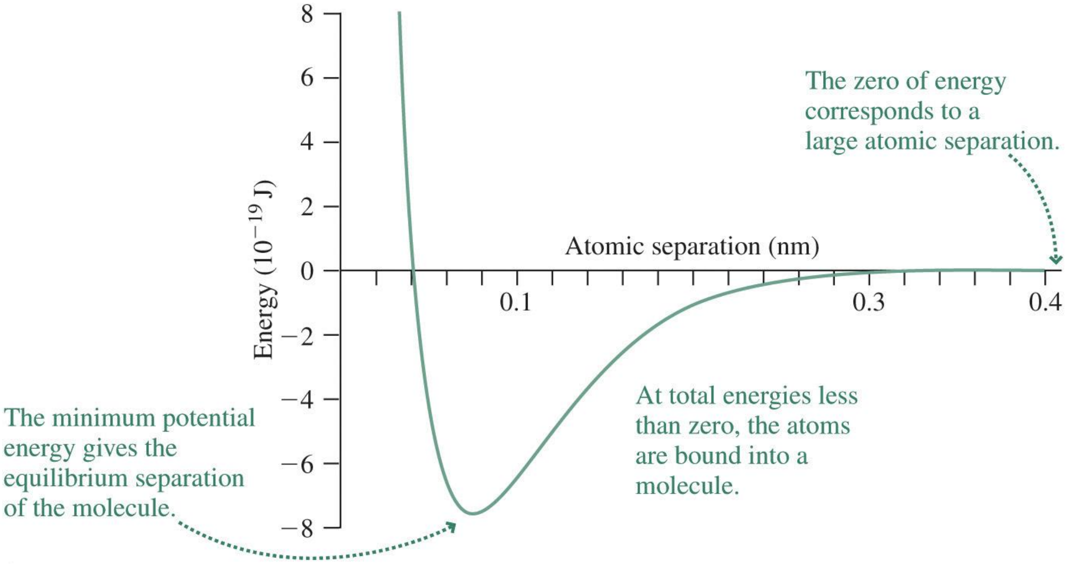
- Shown is a more general energy diagram.
- The particle is released from rest at position x_1.
- Since K at x_1 is zero, the total energy $E = U_1$ at that point.
- The particle speeds up from x_1 to x_2.
- Then it slows down from x_2 to x_3.



- The particle reaches maximum speed as it passes x_4.
- When the particle reaches x_5, it turns around and reverses the motion.

Potential-Energy Curve for an H_2 Molecule

- The potential-energy curve for a pair of hydrogen atoms shows potential energy of the **covalent bond** as a function of atomic separation.



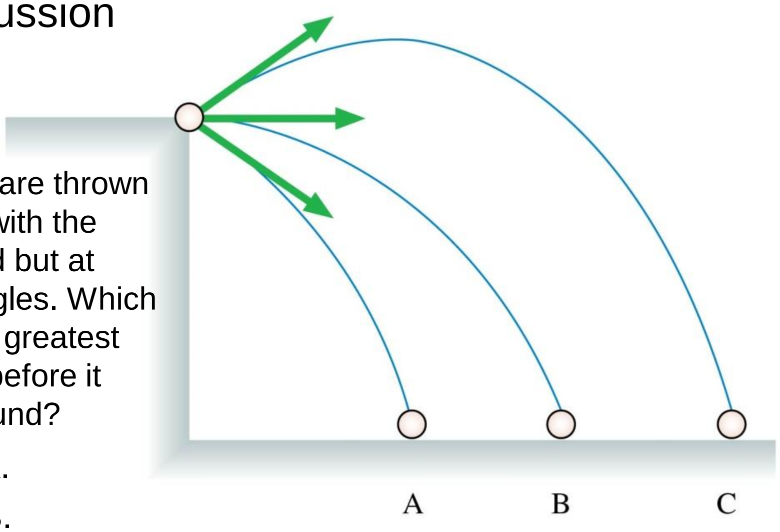
TeamUp Time!!

- Today you will be doing three multiple choice questions, all from Chapter 7, as a team of 2-4 students in your Practicals Pod.
- Your pod-team shares the mark!
- I’m going to mute here for 10 minutes; right now you should open Microsoft Teams and someone (most recent Facilitator) should place a **video call** to all 3 or 4 members of your Pod-Chat.

Now: TeamUp! You have 10 minutes

- The first step is to decide who will be the TeamUp **Driver**
- All students must log-in to Quercus [You will now have three windows open: my zoom lecture, Microsoft Teams, and Quercus]
- **Non-drivers**: Wait!
- **Driver**: Go to the TeamUp Quiz Ch.7 in Module 4, click Go to Tool, then Create a Group. Let everyone in the Breakout Room know the session ID. Then WAIT – don't drive off alone!
- **Non-drivers**: Once you get the session ID, go to the TeamUp Quiz in this module, click Go to Tool, then Join Session and type the ID you were given.
- Once everyone in your room arrives in TeamUp, start going through the questions. Please **achieve consensus** before the driver submits.
- YOU MAY BEGIN! I'm going to go on mute for 10 minutes. Note: if your pod-mates are available on Microsoft Teams right now, go to the PHY131 Help Centre and I'll set up breakout rooms there. Zoom Meeting ID: 938 0964 2256, Passcode: 723874

Question 1 Discussion



Three balls are thrown from a cliff with the same speed but at different angles. Which ball has the greatest speed just before it hits the ground?

A. Ball A.
B. Ball B.
C. Ball C.
D. All balls have the same speed.

Question 2 Discussion

A hockey puck sliding on smooth ice at 4 m/s comes to a 1-m-high hill. Will it make it to the top of the hill?

A. Yes.

B. No.

C. Can’t answer without knowing the mass of the puck.

D. Can’t say without knowing the angle of the hill.

Question 3 Discussion

Two objects collide. All external forces on the objects are negligible. If the collision is “totally inelastic”, that means

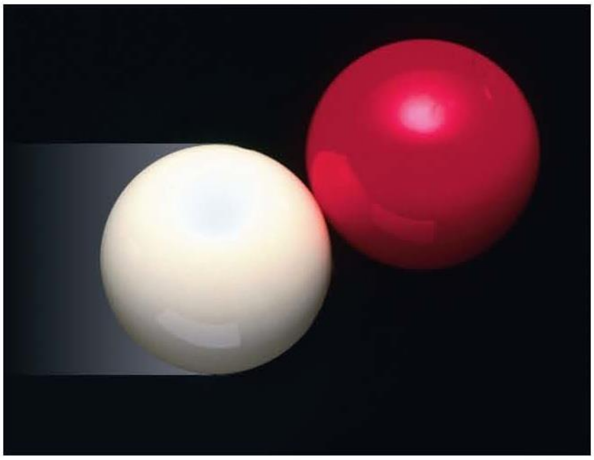
A. momentum is not conserved.

B. the final kinetic energy is zero.

C. the objects stick together.

D. one of the objects ends with zero velocity.

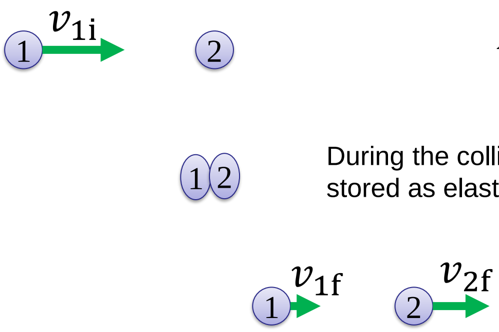
Elastic Collisions



A perfectly elastic collision conserves both momentum and mechanical energy.

Elastic Collision in 1 Dimension when ball 2 is initially at rest.

Consider a head-on, perfectly elastic collision of a ball of mass m_1 having initial velocity v_{1i}, with a ball of mass m_2 that is initially at rest.



Before: K_i

During: During the collision energy is stored as elastic potential energy.

After: $K_\mathrm{i} = K_\mathrm{f}$

The balls' velocities after the collision are v_{1f} and v_{2f}.

Elastic Collision in 1 Dimension when ball 2 is initially at rest.

Momentum conservation: $m_1 v_{1\mathrm{f}} + m_2 v_{2\mathrm{f}} = m_1 v_{1\mathrm{i}}$

Kinetic energy conservation: $\frac{1}{2} m_1 {v_{1\mathrm{f}}}^2 + \frac{1}{2} m_2 {v_{2\mathrm{f}}}^2 = \frac{1}{2} m_1 {v_{1\mathrm{i}}}^2$

There are two equations, and two unknowns: $v_{1\mathrm{f}}$ and $v_{2\mathrm{f}}$.
Solving for the unknowns gives:

$$v_{1\mathrm{f}} = \frac{m_1 - m_2}{m_1 + m_2} v_{1\mathrm{i}}$$

$$v_{2\mathrm{f}} = \frac{2m_1}{m_1 + m_2} v_{1\mathrm{i}}$$

(Elastic collision with ball 2 initially at rest.)

Elastic Collision in 1 Dimension when ball 2 is initially at rest.

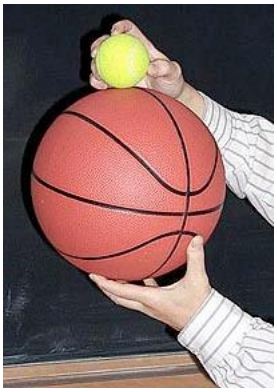
$$v_{1\mathrm{f}} = \frac{m_1 - m_2}{m_1 + m_2} v_{1\mathrm{i}}$$

$$v_{2\mathrm{f}} = \frac{2m_1}{m_1 + m_2} v_{1\mathrm{i}}$$

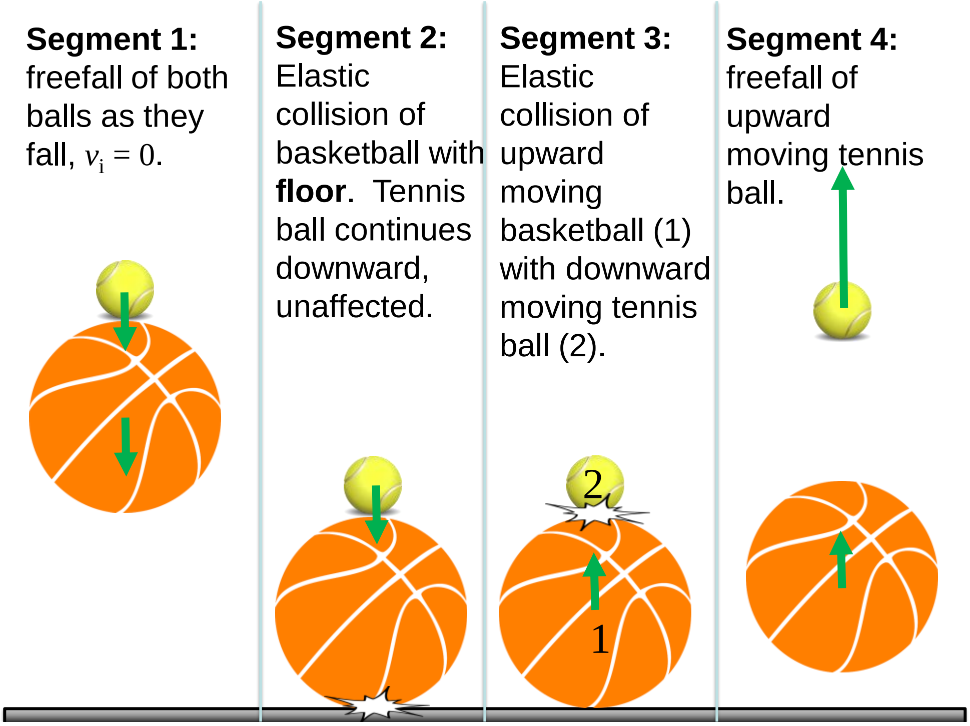
(Elastic collision with ball 2 initially at rest.)

These equations come in especially handy, because you can always switch into an inertial reference frame in which ball 2 is initially at rest!

Demonstration and Example



- A 0.50 kg basketball and a 0.05 kg tennis ball are stacked on top of each other, and then dropped from a height of 0.82 m above the floor.
- How high does the tennis ball bounce?
- Assume all perfectly elastic collisions.



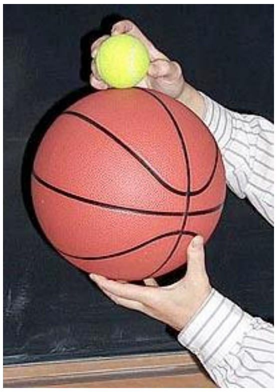
Segment 1: freefall of both balls as they fall, $v_i = 0$.

Segment 2: Elastic collision of basketball with **floor**. Tennis ball continues downward, unaffected.

Segment 3: Elastic collision of upward moving basketball (1) with downward moving tennis ball (2).

Segment 4: freefall of upward moving tennis ball.

Demonstration and Example



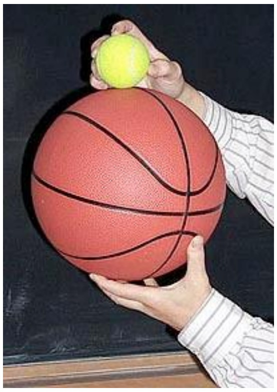
- Divide motion into segments.
- **Segment 1:** free-fall of both balls from a height of h = 0.82 m. Use conservation of energy: $K_i + U_{gi} = K_f + U_{gf}$

$$0 + mgh = \tfrac{1}{2}\, m\, v_f^2 + 0$$

$v_f = \pm[2gh]^{1/2} = -4.0$ m/s, for both balls.

- **Segment 2:** basketball bounces elastically with the floor, so its new velocity is +4.0 m/s.

Demonstration and Example



- **Segment 3:** A 0.50 kg basketball moving upward at 4.0 m/s strikes a 0.05 kg tennis ball, initially moving downward at 4.0 m/s.
- Their collision is perfectly elastic.
- What is the speed of the tennis ball immediately after the collision?

- A 0.50 kg basketball moving upward at 4.0 m/s strikes a 0.05 kg tennis ball, initially moving downward at 4.0 m/s. Their collision is perfectly elastic. What is the speed of the tennis ball immediately after the collision?

$$v_{1\mathrm{f}} = \frac{m_1 - m_2}{m_1 + m_2} v_{1\mathrm{i}} \qquad v_{2\mathrm{f}} = \frac{2m_1}{m_1 + m_2} v_{1\mathrm{i}}$$

(Elastic collision with ball 2 initially at rest.)

SKETCH & TRANSLATE.

SIMPLIFY & DIAGRAM

REPRESENT MATHEMATICALLY

SOLVE & EVALUATE

Demonstration and Example

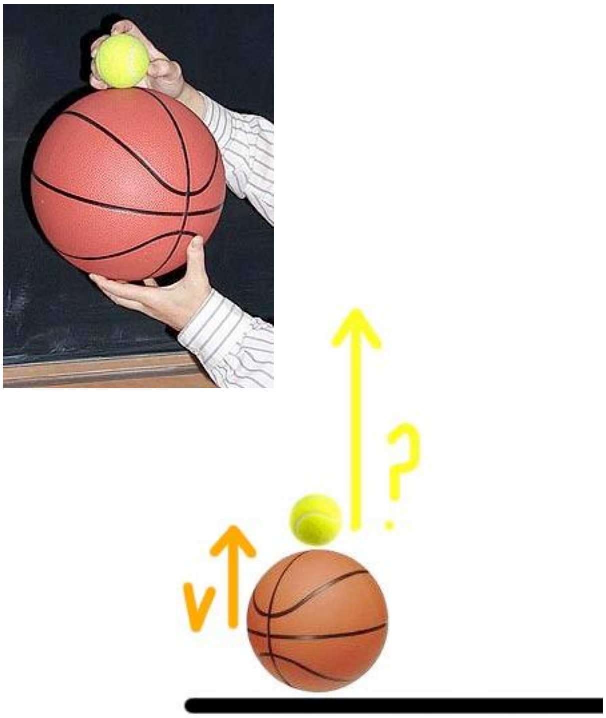
- **Segment 4:** freefall of tennis ball on the way up. $v_{i2} = +10.5$ m/s.
- Use conservation of energy:

$K_i + U_{gi} = K_f + U_{gf}$

$\frac{1}{2} m v_i^2 + 0 = 0 + mgh$

$h = v_i^2/(2g) = 5.6$ m.

- So the balls were dropped from 0.82 m, but the tennis ball rebounds up to 5.6 m! (Assuming no energy losses.)



Before Class 22 on Monday

- Please finish reading all of Chapter 7:
- 7.8 Power
- 7.9 Gravitational Potential Energy **in Space**

- Remember on Tuesday by 8:45pm you have to upload your Ch.7 Prequiz onto the Crowdmark site. It's worth 16 homework credits for good-faith participation by the deadline (this one won't be carefully marked).