Worksheets and Activities in Large First-Year Physics Lectures

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Thank You

- Carl Wieman – Learning goals workshop, reading group
- Sarah Gilbert – Reading group, NOJO group
- Jim Carolan, Peter Newbury – Interviews in Phys 101
- Carl Wieman and Jim Carolan - Phys 100 course design
- Sandy Martinuk – Phys 100 tutorials, student project, contributions to changes in Phys. 100.
- Peter Newbury – Phys 101 labs, Phys 102 labs, support with Phys 101 worksheets
- Ido Roll and Jim Carolan - Reform of Phys 100 Labs
- Louis Deslauriers – Help with design of pre-reading, lecture activities based on clickers and worksheets, lecture reflection sheets, Louis' rule.
- Cynthia Heiner – Gets involved in Phys 101 this summer.

My Classes

- Phys 100, Phys 101, Phys 102
- N = 150 – 250
- Non-Physics Majors
- Required courses for most students
- Large lectures in Hebb Th

- How did my teaching change?

Before CWSEI:

- Since 2002: clickers and ‘peer instruction’.
- Typical lecture: ~ 15-minute blocks
  - Introduction of a new concept
  - some derivations of equations
  - and a worked example, maybe a lecture demo
  - clicker question: assessment of how many students understood the presented concepts.

Before CWSEI:

- Clicker results often surprisingly disappointing.

- Students forget quickly. Not able to explain main concepts two weeks after final exam.

  (Jim's and Peter's interviews in my Phys 101, 2007)

What Has Changed?

The course content is defined by learning goals

No more lecturing. Instead:

- Pre-Reading Assignments – new content
- Interactive lectures: worksheets and clickers. Sense making, checking of understanding, motivation

What Has Changed?

- Tutorials – problem solving skills
- Mastering Physics online homework – problem solving practice
- Labs – Experiments, skills, understanding data

Major Change in 2010

- Introduced worksheets.
- Inspired by Louis' amazing result in the Phys153 mini-transformation in 2009W.

- I am now teaching by Louis' rule:

  "Whenever you need to present (explain a difficult concept, the expert solution of a problem, a nice application or demo,…), students' brains need to be prepared for this."

Preparing Students' Brains

- Targeted pre-reading with online reading quizzes

  (vs. assuming that students read the textbook)

- In-class worksheets and clicker questions preparing for expert explanations and problem-solving strategies.

  (vs. lecturing first, then questions and examples)

Benefits of Worksheets

- Student can work at their own pace.

- Walk around in class,
  - talk to student groups,
  - get a better feel for the class,
  - give hints if needed,
  - discussion and feedback (often combined with clicker questions)

Benefits of Worksheets

- TA in lecture
  - help with student questions during activities and after class
  - feedback on activities, technical difficulties,
  - lecture demos

Example: Handout

- Students were asked in an e-mail
  - to bring their notebook computers to class.
  - to do the pre-reading assignment.

- The example is from the second lecture.
  - Students have already qualitatively explored the simulation in lecture 1.

Phys 100 – 2010 Mechanical Energy

Lecture 2 Worksheet **Name:**

Energy Skate Park – Part 2 **Student ID:**

Instructions:
You will work again in groups of 2-3 students but each student should fill out his or her own worksheet.
Go to http://phet.colorado.edu/en/simulation/energy-skate-park and open the simulation.

1. Mechanical Energy (15 min.)
Select "Bar Graph" and observe the changes in energy while the skater moves up and down the track. (Keep the default setting.)

a) Why is "Total" not changing?

b) How can you measure the total energy just by using the "Measuring Tape" or "Show Grid" option? What is its value for the default setting (clickers)?

c) What is the maximum speed of the skater for the default setting? (clickers)

2. Reference (15 min.)
a) Using the default setting, at some moments the kinetic energy is zero but the potential energy does not go to zero. Why?

b) What is the meaning of the blue dotted line?

c) Grab the blue dotted line with the mouse and move it around.
What is the effect on the kinetic energy?

What is the effect on the potential energy?

What is the effect on the total energy?
Is mechanical energy conserved? Explain.

3. Friction (10 min.)
Every real skateboard has some friction so to make the simulation more realistic, turn on the track friction to the first (small) tick.
Now turn the bar graphs back on and observe the energy during consecutive runs of the skater.

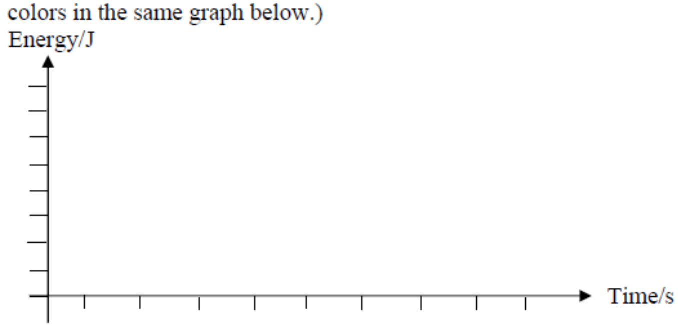
a) What is the effect of friction on the total energy?

b) What is the effect of friction on potential and kinetic energy?

c) Is energy conserved?

d) What is the approximately the amount of mechanical energy (in joules) that is dissipated during the first cycle if you start the skater near the top of the track? (Clickers)

4. Energy graphs (10 min.)
Observe the simulation using the default setting (after "Reset").
a) Draw a graph that qualitatively shows the total energy, the kinetic energy, and the potential energy as a function of time. (You can draw the three curves with different colors in the same graph below.)



b) Run the simulation again. This time turn on the "Energy vs. Time" option and compare the result with your drawing. Discuss with your group and try to make sense of the graph. I will ask a clicker question about it.

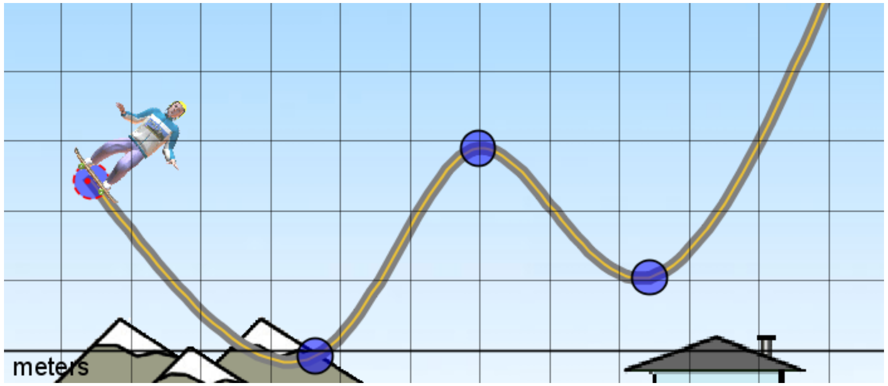
c) Run the simulation again and look at the "Energy vs. Position" graph. Discuss with your group and try to make sense of the graph.

Mechanical Energy 2007

- Energy Skate Park   Link

Question

Do you think the Skater will make it over the first hump?



A. No.
B. Yes.
C. Depends on the friction on the track.

Kinetic Energy

- A moving object or person like the skater has kinetic energy, defined as

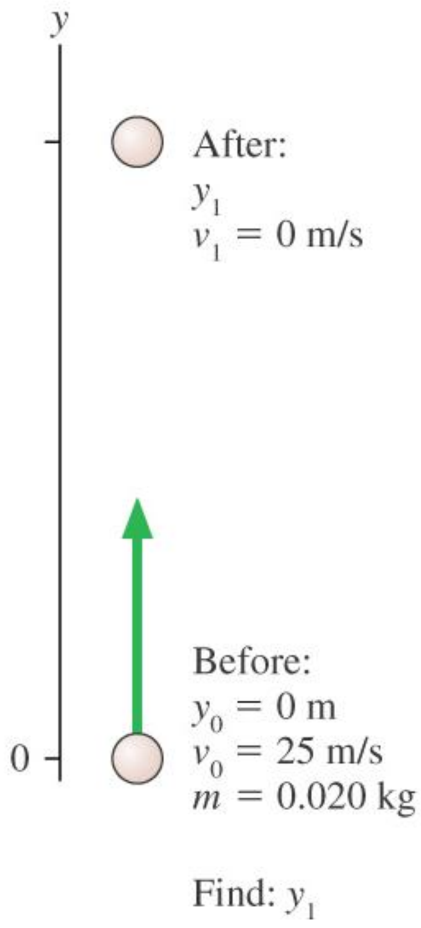
$$K = \frac{1}{2}mv^2$$

- Where v is the velocity of the object and m is its mass.
- Changing the kinetic energy of an object means changing its speed.

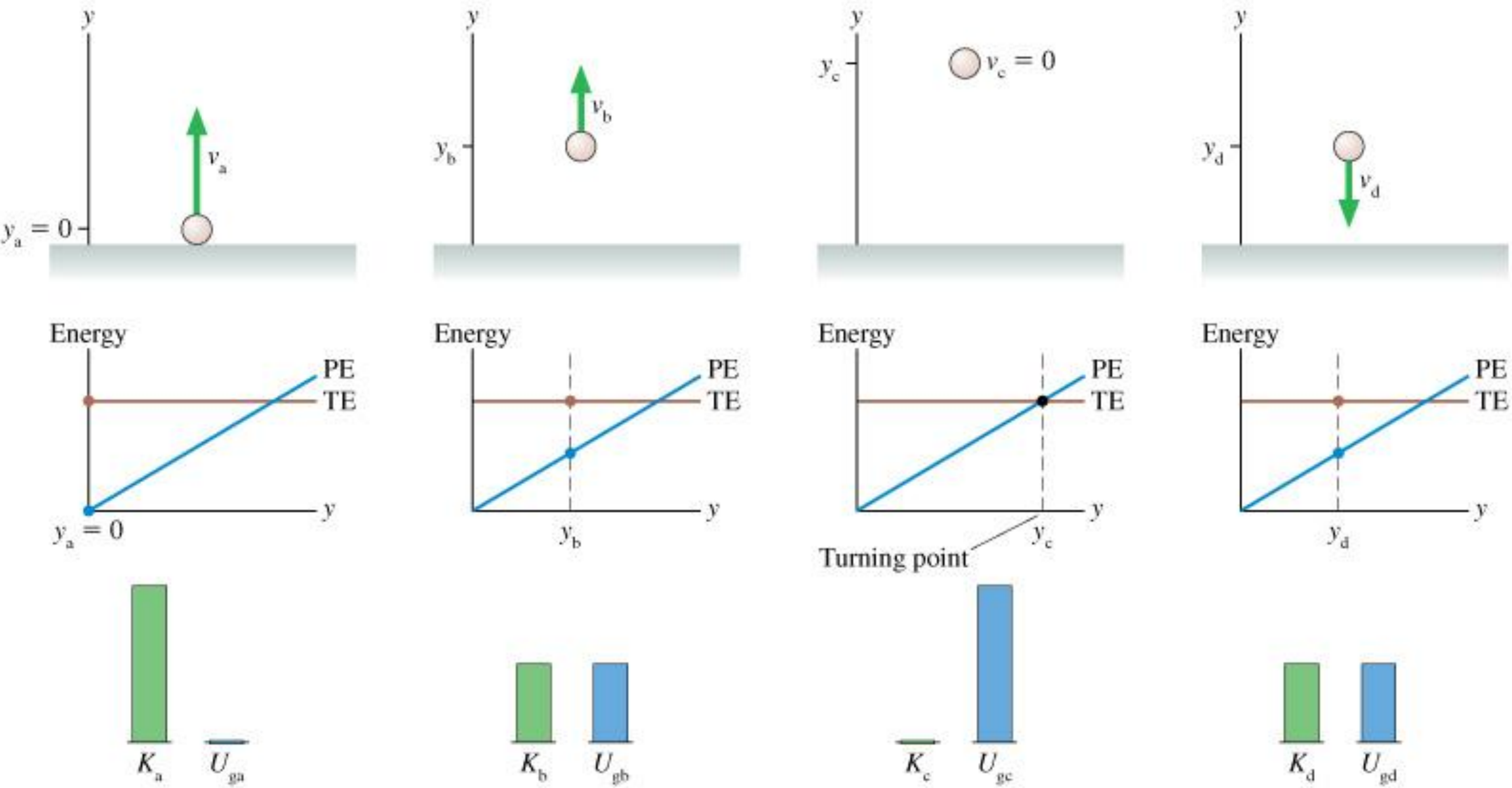
Gravitational Potential Energy

- $U_g = m\ g\ h$

- With mass m, acceleration due to gravity g (9.8 m/s^2), and height difference h ($= y_1 - y_0$).
- Example: In a ball toss, the total mechanical energy is (approximately) constant: $E = K + U$
- The kinetic and the potential energies are not constant during the toss.



Energy Diagrams: Ball Toss



The particle is projected upward. Energy is entirely kinetic.

The particle has gained potential energy, lost kinetic energy.

The energy is entirely potential at the turning point.

The particle gains kinetic energy and loses potential energy as it falls.

Conservation of Mechanical Energy

- Free-fall: The force of gravity is accelerating the ball and the kinetic energy increases: $W_g = \Delta K$.
- At the same time the gravitational potential energy decreases by the same amount.
- Just before hitting the floor all potential energy is transformed into kinetic energy.

$$U_f - U_i + K_f - K_i = 0$$

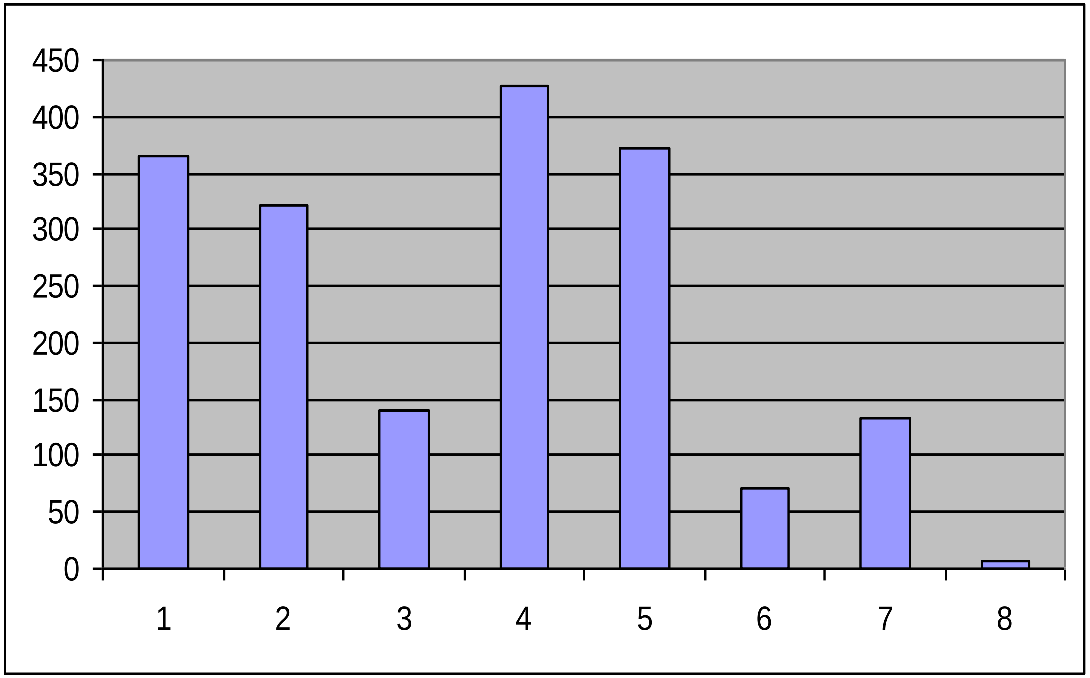
$$\Delta U + \Delta K = 0$$

- During the fall, kinetic energy increases, potential energy decreases.

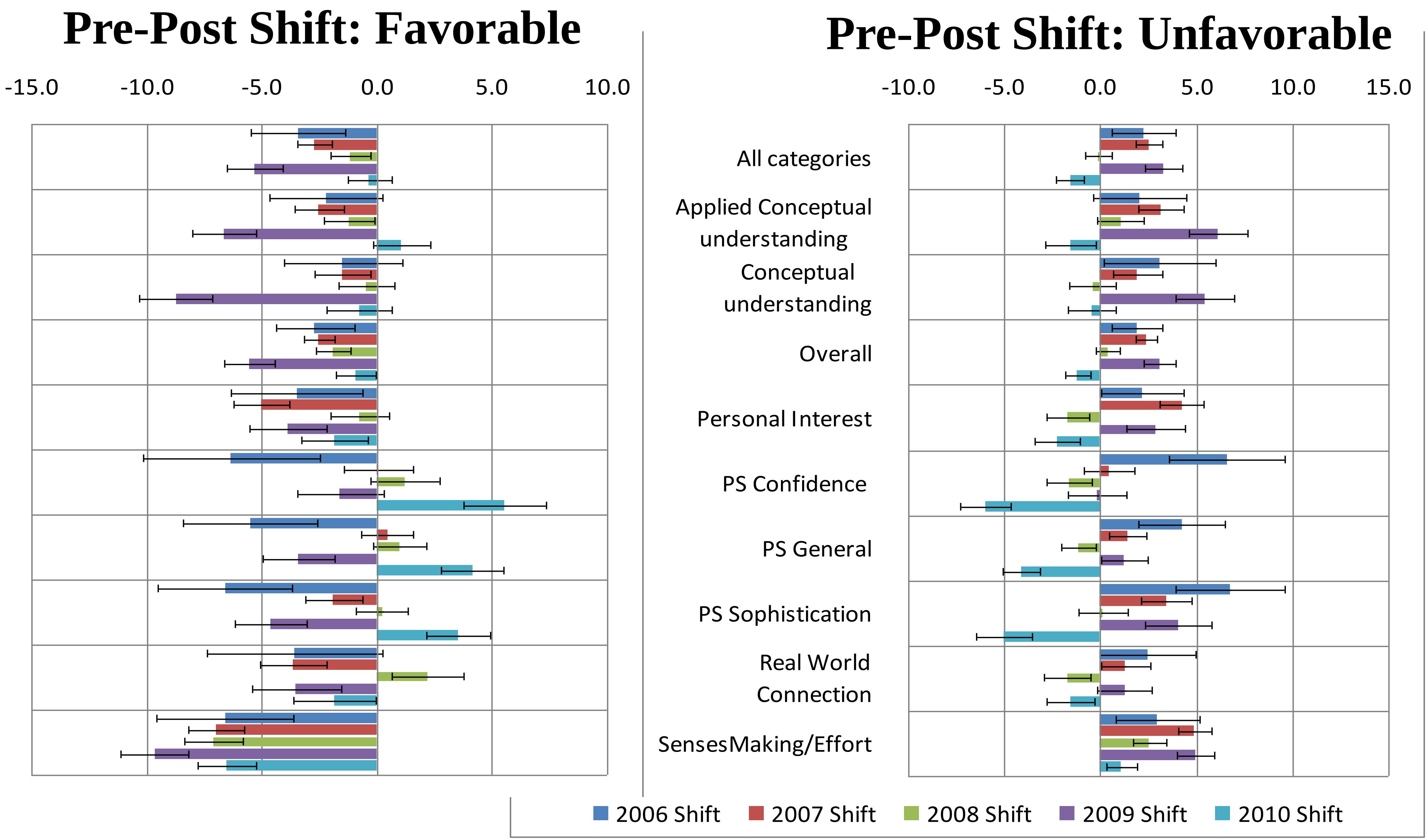
Phys 100 End-Of-Term 2010

- Which of the following Phys 100 course elements were helpful for learning physics or taught you useful skills for other science courses? Choose all that apply. (N = 530)

1. Lecture
2. Tutorial
3. Lab
4. Mastering Physics
5. Textbook Reading
6. Final Project
7. Vista Discussions
8. None of these elements were helpful or useful.



CLASS – Phys 100



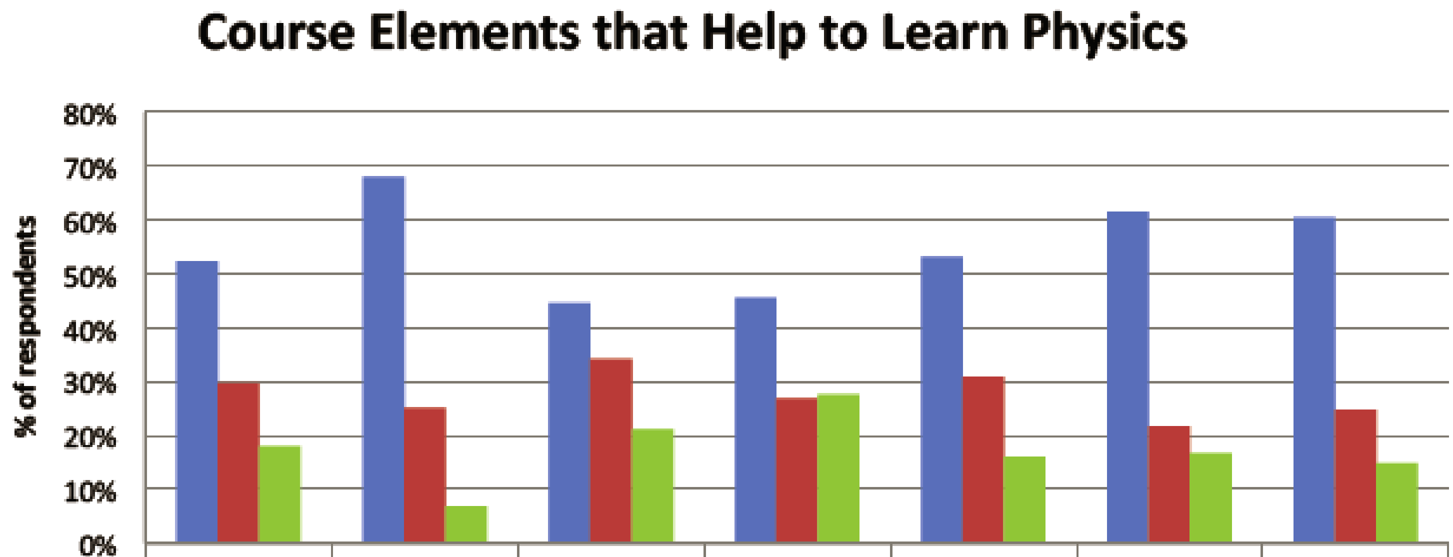
Other Results

- Decreased failure rates
- Positive student comments

Conclusions

- In the past, many students' motivation was very low in these service courses.
- Whereas now, motivation and interest is measurably increased.
- Student success rate measurably increased.
- More satisfying teaching experience.

Phys 100 End-Of-Term 2008



	Lecture	PRS	Labs	Tutorials	Reading Slides	MP	Reading Text
Positive	52%	68%	45%	46%	53%	62%	60%
Neutral	30%	25%	34%	27%	31%	22%	25%
Negative	18%	7%	21%	28%	16%	17%	15%

- 2006: Reading text: only 34% positive (33% neutral, 33% negative)

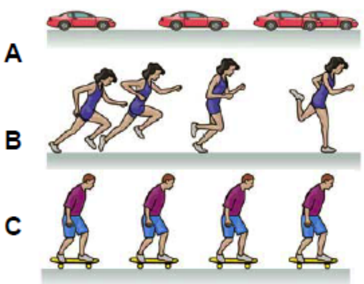
2nd Example: Kinematics

The Moving Man

Instructions:
Discuss each question in small groups. Write on the back or an additional sheet for more space.

1) Motion Diagrams (5 min.):

Which of these motion diagrams shows the person (or the car)…



D None of the above

1) at constant speed
2) at rest
3) slowing down
4) speeding up

Assign the correct diagram to motions 1- 4.

2) Motion (15 min.):
Go to http://phet.colorado.edu/en/simulation/moving-man and open the simulation. Start by dragging the man around with your mouse (or touch pad) and observe the numbers.

a) When is the number for position positive, when is it negative?

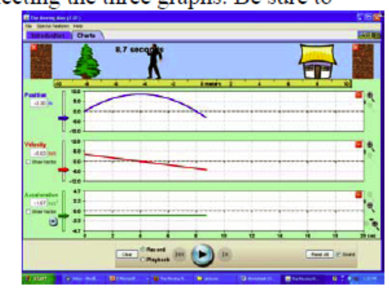
b) When is the number for velocity positive, when is it negative?

You have probably observed that it is hard to follow the acceleration. So let's explore it by entering (small) numbers into the fields.

c) If the man starts from rest, in which direction will he move if you enter a positive acceleration? In which direction will he move if you enter a negative acceleration?

d) Reset the simulation and enter a small postive number for velocity and a small negative number for acceleration. Observe what happens. Do it again and switch on the vectors. Now repeat this simulation and invert the signs for velocity and acceleration. Summarize your observations:
What does it mean if a person is speeding up, slowing down, or moving at constant speed? Use the terms 'velocity' and 'acceleration' in your explanation.

3) Graphs (10 min.):
Now switch on the charts and repeat part d). Observe how the different motions (constant speed, speeding up, slowing down) are affecting the three graphs. Be sure to switch directions. There will also be clicker questions as follow-up.



a) What is the effect of increasing/decreasing velocity?

b) What is the effect of increasing/decreasing acceleration?

c) What is the effect of changing the initial position?

d) What is a reference frame and why do we need one?