Interactive video-enhanced tutorials (IVETs) are designed for online learning environments and based, in part, on the problem-solving tutorials created by the PER group at the University of Pittsburgh. The tutorials are adaptive and provide various levels of guidance and scaffolding depending on students' needs. Previous research found the tutorials to be effective when students used them as intended under the supervision of a researcher, i.e., properly engaged with the guidance, but less effective when assigned as homework, suggesting that students do not always mentally engage at the level necessary for learning on their own. This presentation will discuss how the tutorials were redesigned for web-based delivery, such that they can be assigned by instructors along with the regular end-of-chapter homework problems. Preliminary results regarding the behaviors of students as they engage with IVETs at home, as well as impact of these behaviors on their subsequent learning, will be presented.

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Interactive Video-Enhanced Tutorials on Problem-Solving in Physics: Preliminary Results

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Where do students go for help with homework?

When stuck on homework problems, which **ONE** did you use most?

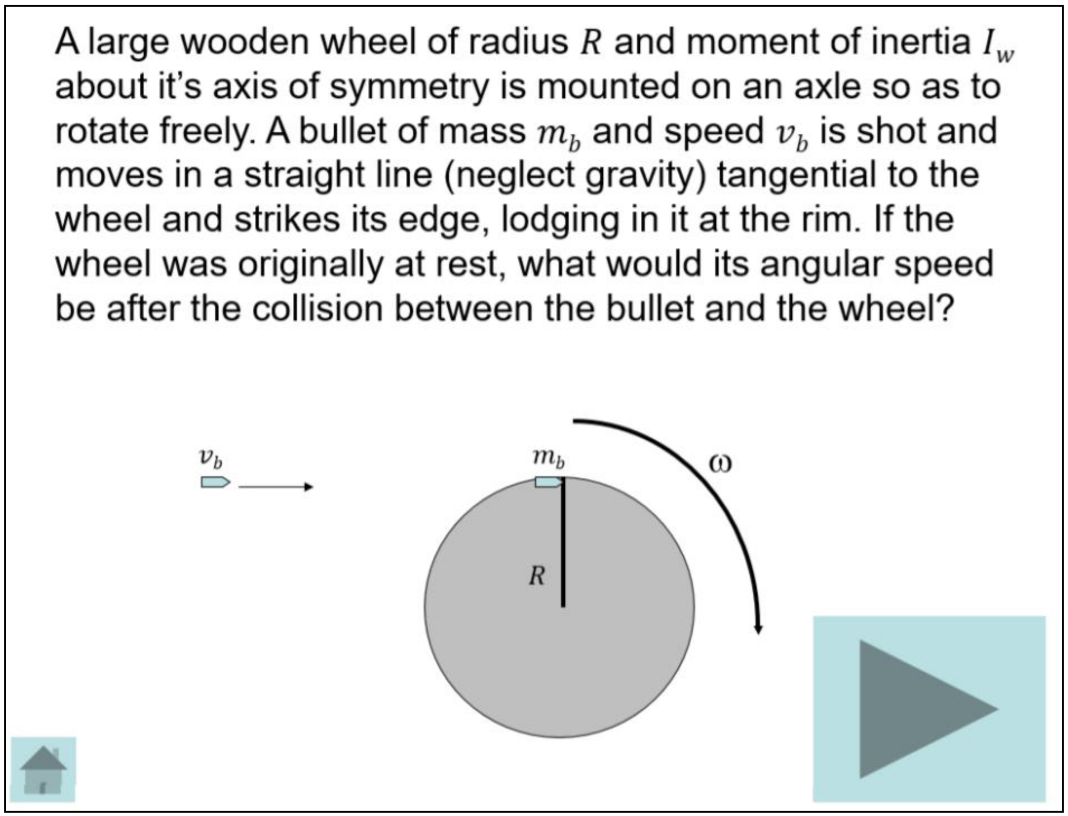
	Spring 2019
Google (ex. Chegg.com)	47%
Other students	23%
Khan or other online videos	15%
Textbook	8%
Physics Learning Center	2%
Office hours	1%
Supplemental Instruction Sessions	1%
Didn't seek help or other	3%

85% of students

See low correlation between student HW scores and exam scores.

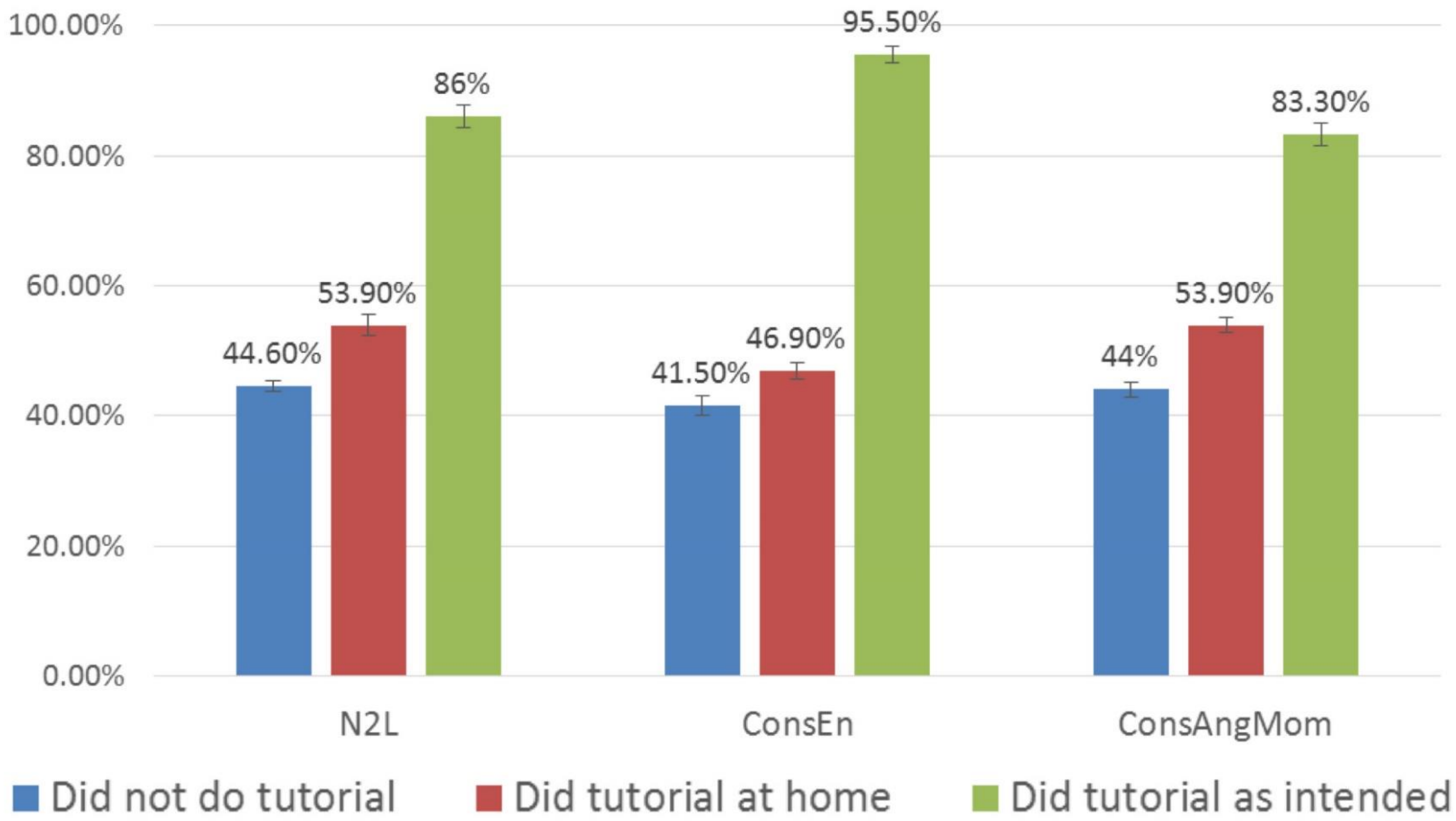
Problem Solving Tutorials – Univ of Pittsburgh

DeVore and Singh developed ~20 tutorials introductory physics.



Implemented through Powerpoint and designed to carefully guide students to a solution through the use of branching questions.

Effectiveness of Tutorials



S. DeVore, E. Marshman, and C. Singh, "Challenge of engaging all students via selfpaced interactive electronic learning tutorials for introductory physics," *Phys. Rev. ST Phys. Educ. Res.* **13** 010127, 1-18 (2017).

Features of Design of IVETs

- Developed based on multimedia learning principles (Mayer) and research on human learning and memory (Bransford)
- Problems challenge students while providing support designed to stretch students' zone of proximal development
- Student support delivered through mini-lectures, hints, or encouragement (affect) by a tutor (a real person in a video)

Interactive Video Vignettes (IVVs)

Designed to teach **concepts** for which students are known to struggle.

www.compadre.org/ivv or WebAssign

Project Goals

- Create and evaluate a set of 30 IVETs
- Conduct research on
  - impact of IVETs on student problem solving abilities
  - techniques that motivate appropriate student behavior when using IVETs
- Disseminate through ComPADRE, etc

Features of Design of IVETs

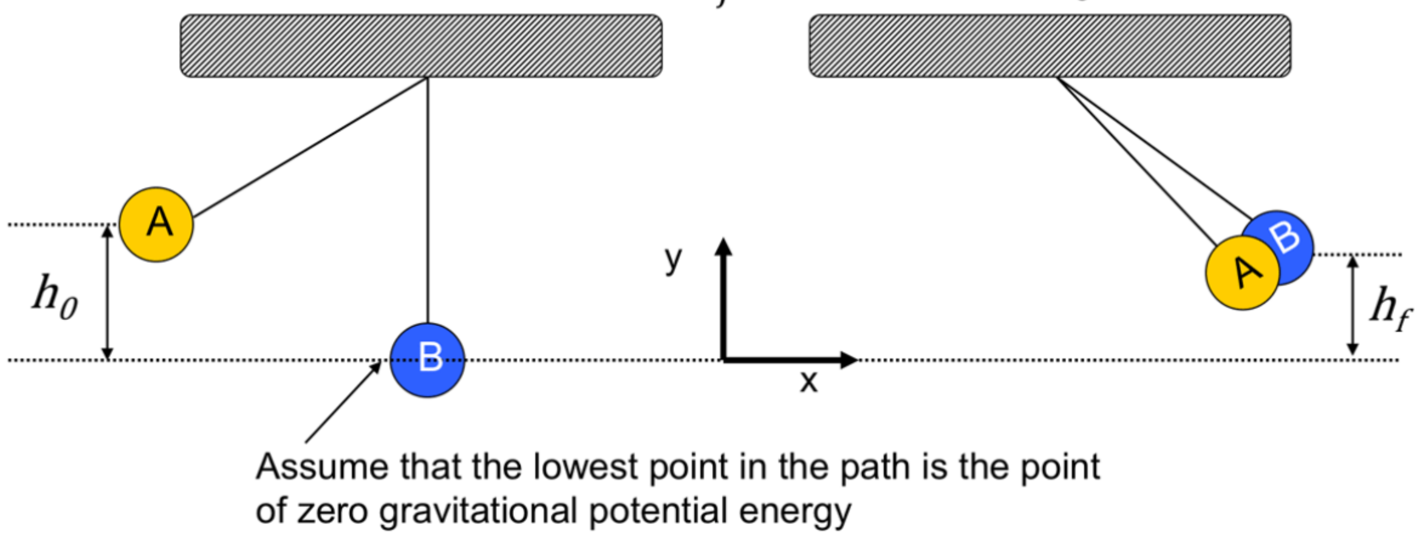
- Multiple-choice questions guide students through an **effective problem-solving approach** (e.g., define a coordinate system, draw a force diagram, etc.)
- Questions branch based on student responses, providing relevant feedback for incorrect (and correct) answers
- Self-paced such that students who need less support can navigate through it quickly and vice versa
- 5-10 minutes to complete

Example IVET

LINEAR MOMENTUM AND ENERGY — INTERACTIVE VIDEO-ENHANCED TUTORIALS

Two small spheres of putty, A and B, of equal mass m, hang from the ceiling on massless strings of equal length. Sphere A is raised to a height h_0 as shown below and released. It collides with sphere B (which is initially at rest). The two spheres stick and swing together to a maximum height h_f. (Assume a completely inelastic collision with the two spheres sticking together after the collision.)

Find the height h_f in terms of h_0.



Question 1

Show Problem Statement

Choose all of the following physics principles we should use to solve this problem:

- [x] A. Conservation of Total Mechanical Energy
- [ ] B. Conservation of Momentum
- [ ] C. Newton's 2nd Law

Feedback is provided for all incorrect as well as correct responses.

INCORRECT

Show Problem Statement

Your choice is correct, but it is not the only principle that we need to apply.

We will need to apply this principle twice to examine the conversion of gravitational potential energy to kinetic energy:

- first to find the speed of putty ball A right before it collides with putty ball B
- later to find the maximum height to which the two putty balls stuck together rise before stopping

What principle will help us relate the velocity of putty ball A right before the collision to the velocity of the two putty balls together right after the collision?

Click the *Previous Page* or *Next Page* button to go back to the question and change your answer.

Question 2

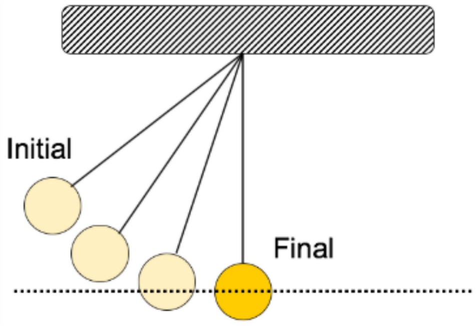
Show Problem Statement

Assume that ball A is released from rest, and its height is zero at the lowest point of its trajectory.

- What type(s) of initial mechanical energy does ball A have when it is released?
- What type(s) of final mechanical energy does ball A have just before it strikes ball B?

Choose *all that are not zero*:

- A. Initial Kinetic Energy
- B. Initial Gravitational Potential Energy
- C. Final Kinetic Energy
- D. Final Gravitational Potential Energy



Question 3

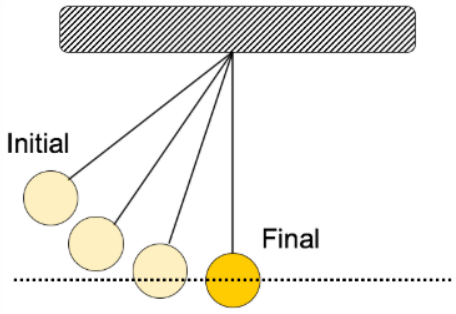
Show Problem Statement

Applying the law of conservation of energy to ball A gives which one of the following expressions for the speed of ball A right before it collides with ball B?

A. $v_A = \sqrt{2gh_0}$

B. $v_A = \sqrt{gh_0}$

C. $v_A = \sqrt{\frac{gh_0}{2}}$



Question 7

Show Problem Statement

Use the relations we found in previous questions to find an expression for the maximum height of the two balls together (h_f) in terms of the initial height of ball A (h_0).

Which of the following expressions is correct?

- A. $h_f = 2h_0$
- B. $h_f = \dfrac{h_0}{4}$
- C. $h_f = \dfrac{h_0}{2}$

Your Choice: B. **CORRECT** Show Problem Statement

Reasoning:

From our previous expressions:

$$v_A = \sqrt{2gh_0} = 2v_{AB}$$

We see that:

$$v_A^{\ 2} = 2gh_0 = (2v_{AB})^2$$

$$v_{AB}^{\ 2} = \left(\frac{v_A}{2}\right)^2 = \frac{2gh_0}{4}$$

$$h_f = \frac{v_{AB}^{\ 2}}{2g}$$

$$h_f = \frac{\left(\frac{gh_0}{2}\right)}{2g}$$

$$h_f = \frac{h_0}{4}$$

The two putty balls will reach a maximum height that is 1/4th of ball A's initial height.

Click the *Next Page* button to go to the next question.

IVETs end with an opportunity for students to practice what was learned.

Reflection Questions:

Answer this question again in these situations for balls of differing masses:

- $m_B = \frac{m_A}{2}$
- $m_B = 2m_A$

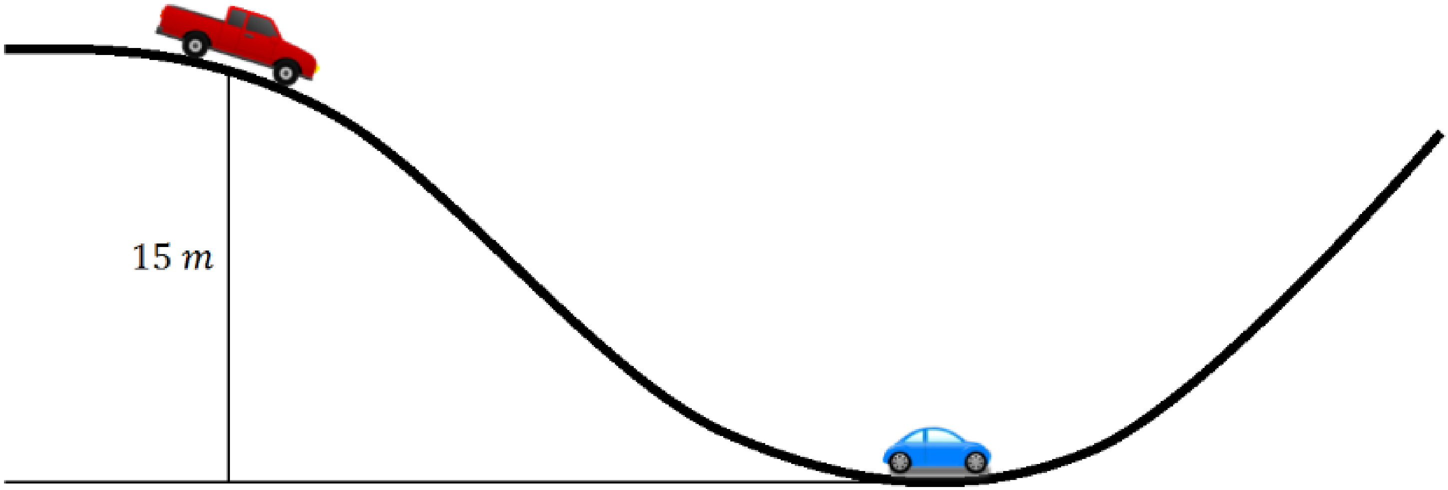
List what things you learned from this tutorial.

Also, the developers would appreciate any feedback about how well the activity worked (technical problems, for example).

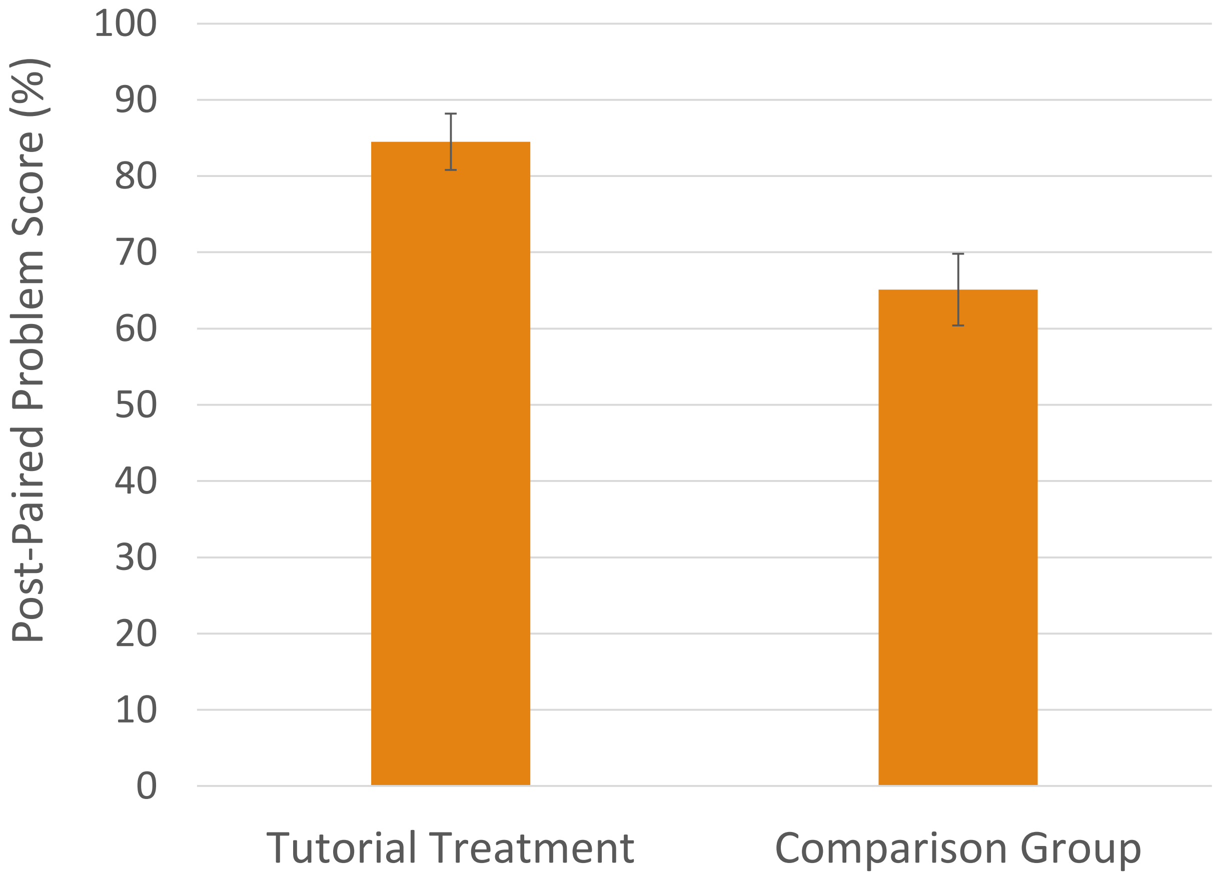
Then click the *Next Page* button in the lower right corner to finish.

Assessing Impact: Paired Problem

A 2000 kg truck starts at rest 15 m above the bottom of a hill. It rolls down the hill and at the bottom the truck collides and locks bumpers with (sticks to) a 1500 kg car which is at rest at the bottom of the hill in a completely inelastic collision. The two vehicles then roll together up a second hill. Assuming that both vehicles are in neutral and roll without energy loss due to friction or air resistance, how high up the second hill will the two vehicles travel before stopping?



Impact on student problem solving abilities



Alg-based Physics classes taught by 2 different instructors

Treatment (n=65): Completed tutorial at home as IVET

Comparison (n=69): Instructor talked thru solution in class

Effect size = 0.57

Student comments about IVETs

This was a really cool, interactive experience that explained the thought process behind each step.

This tutorial was very helpful. By giving hints it allowed me to see what I was doing wrong in order to fix it.

It was like having a personal tutor online.

I learned how to derive different information from the equations we are given.

This tutorial is a good way of showing how to conceptualize a problem by first creating a model of what is happening rather than just plugging numbers in immediately.

Student comments about IVET logistics

The activity worked well, and I liked how you could access the problem statement whenever you needed to.

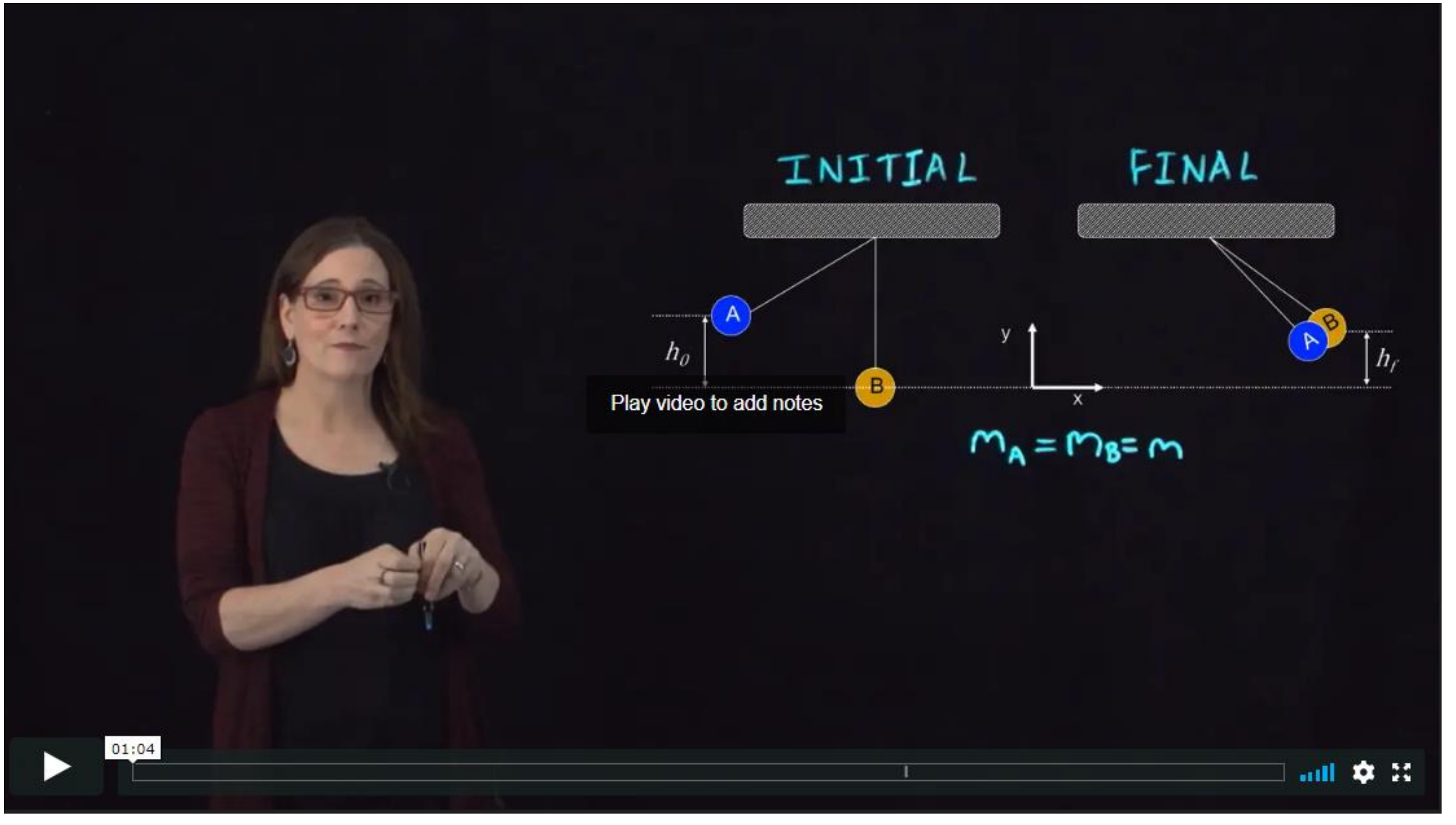
I liked how it gave feedback to correct or incorrect answers.

Would be better if you could see previous answers and the pictures easier and not have to change windows.

It is a little slow but okay besides that.

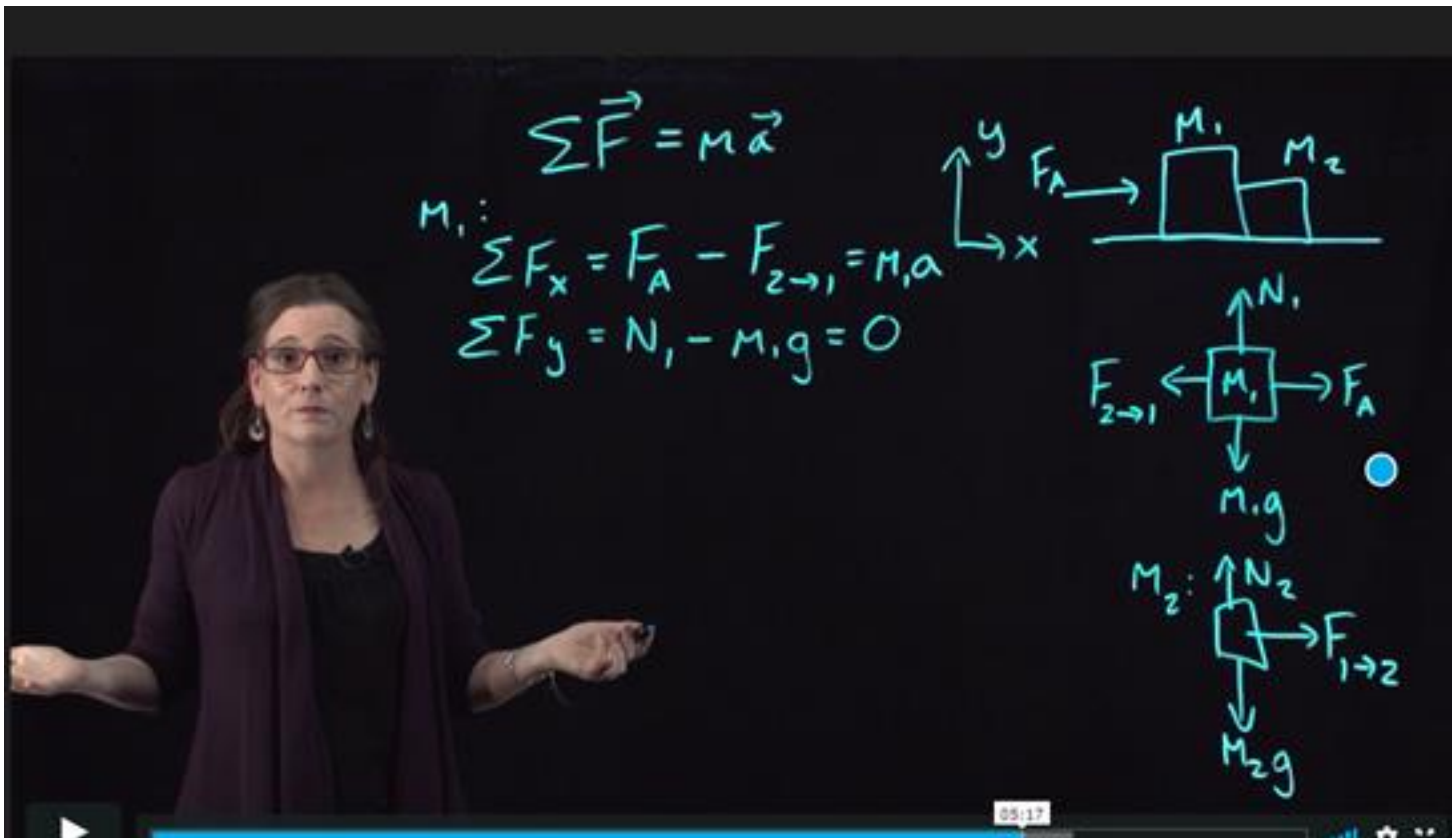
Summer 2019….adding video to IVETs

Give students option to have initial problem statement explained to them.



Summer 2019….adding video to IVETs

Give students option to have hints or summaries explained by a real person.



Next Steps

Identify techniques that motivate appropriate student behavior when using IVETs

- How do we get them to slow down? Mentally engage?

↓

- Use onscreen questions and/or real person to address boredom, confusion, frustration

  Ex. How are you feeling right now?

In Fall 2019, we will evaluate 7 IVETs with videos:

- Projectile motion ("monkey gun" type problem)
- Newton's 2nd Law (force on two blocks)
- Static Equilibrium (person on ladder leaning against wall)
- Conservation of Energy (will string break on tire swing?)
- Linear Momentum and Energy (pendulum balls collide)
- Torque and Rotation (atwood machine)
- Angular Momentum (bullet shot into wheel)

Questions?

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