Abstract

Interactive video-enhanced tutorials (IVETs) involve web-based activities which lead students through a solution using expert-like problem-solving approaches, such as those needed for solving problems using Newton's Second Law. The IVETs, which are based in part on the tutorials created at the University of Pittsburgh, are designed using multimedia principles of learning and research on human learning and memory. The tutorials are adaptive and provide different levels of scaffolding depending on students' needs. They are also affect-adaptive, such that additional guidance is provided to students who indicate they are confused, frustrated, or bored while completing the IVET. This presentation will showcase one of the IVETs and its various design features.

Interactive Video-Enhanced Tutorials: Design to support effective problem-solving strategies

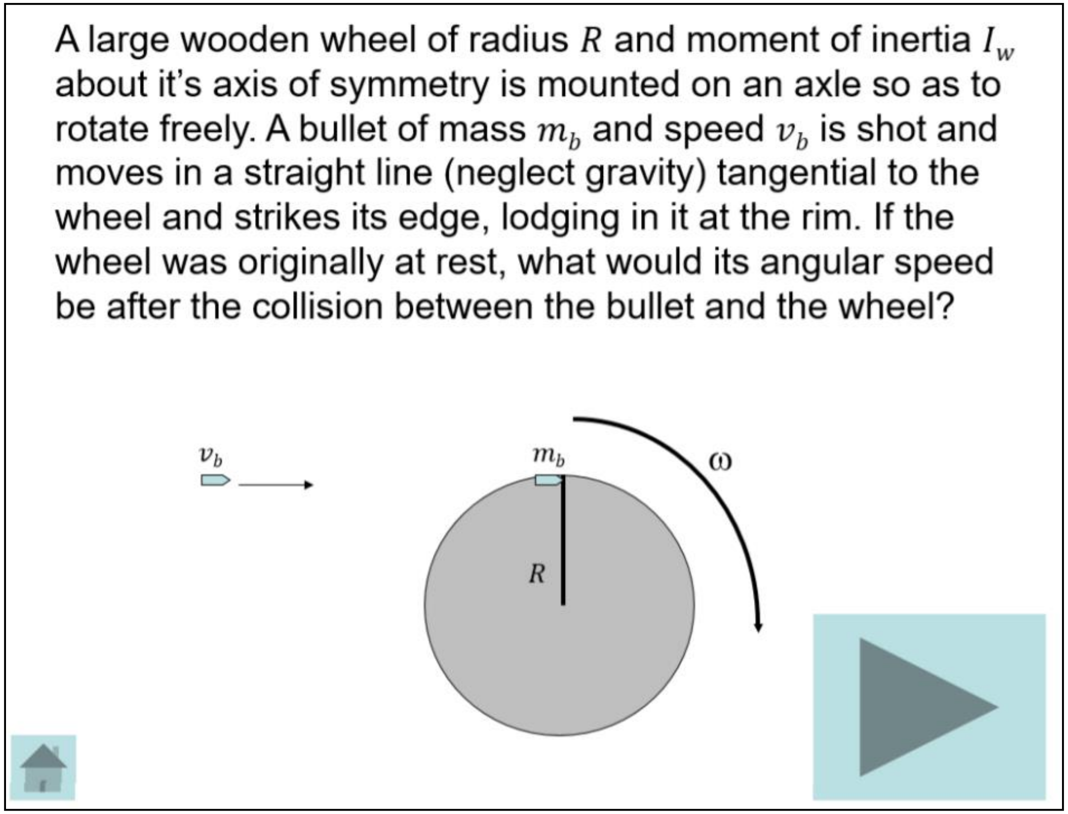
ALEXANDRU MARIES, KATHLEEN KOENIG, & JOE ROSS, UNIVERSITY OF CINCINNATI

ROBERT TEESE & MICHELLE CHABOT,
ROCHESTER INSTITUTE OF TECHNOLOGY

NSF IUSE DUE-1821396 NSF IUSE DUE-1821391

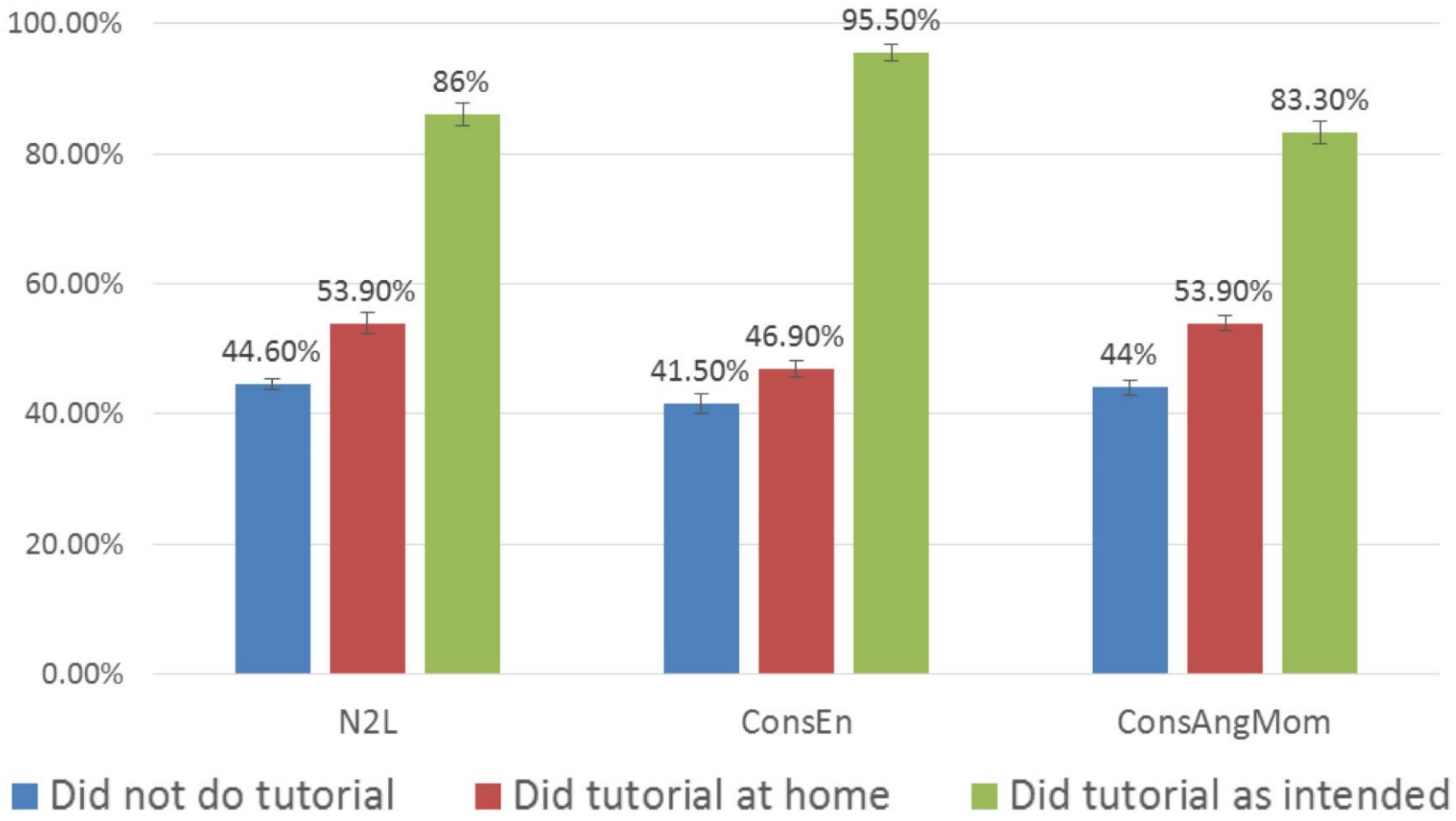
Problem Solving Tutorials – Univ of Pittsburgh

DeVore and Singh developed ~20 tutorials for 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).

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

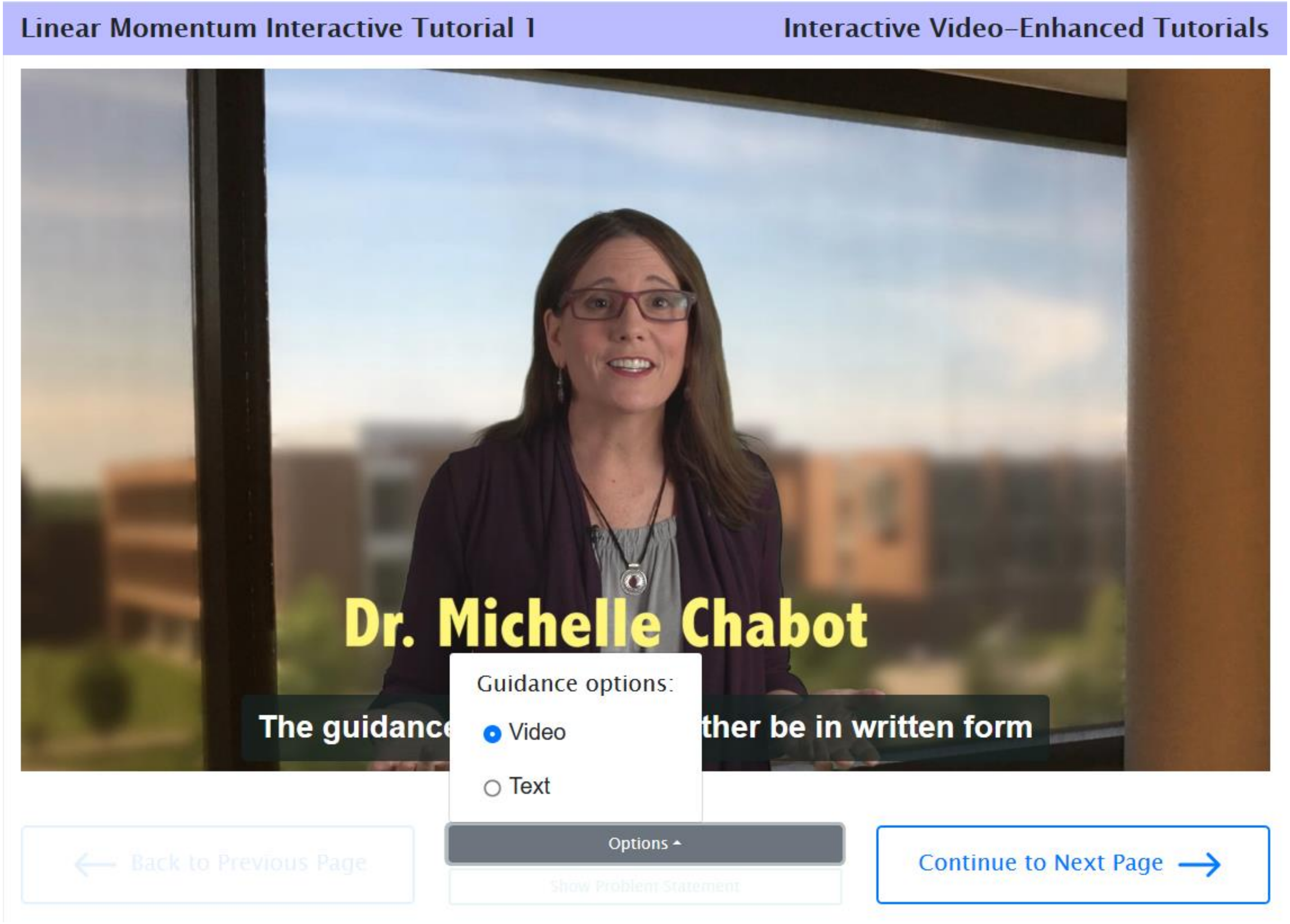
Features of Design of IVETs

- 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)

Features of Design of IVETs

- Multiple-choice questions guide students through an **expert-like problem-solving approach** (e.g., decide on what laws/principles are applicable, 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
- 5-15 minutes to complete

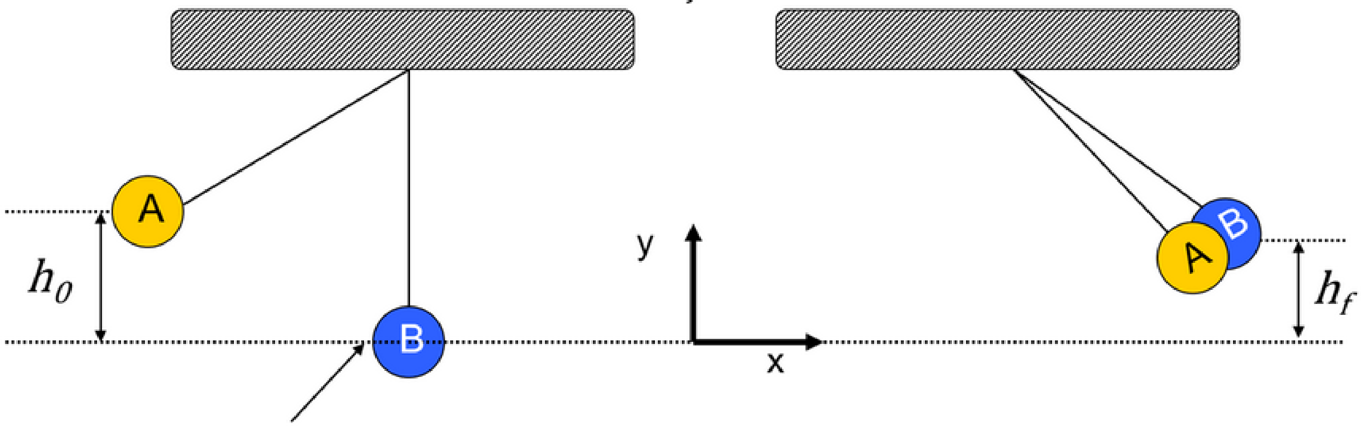
Example IVET – Linear Momentum and Energy



Text option: Page presents problem to be solved.

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.)

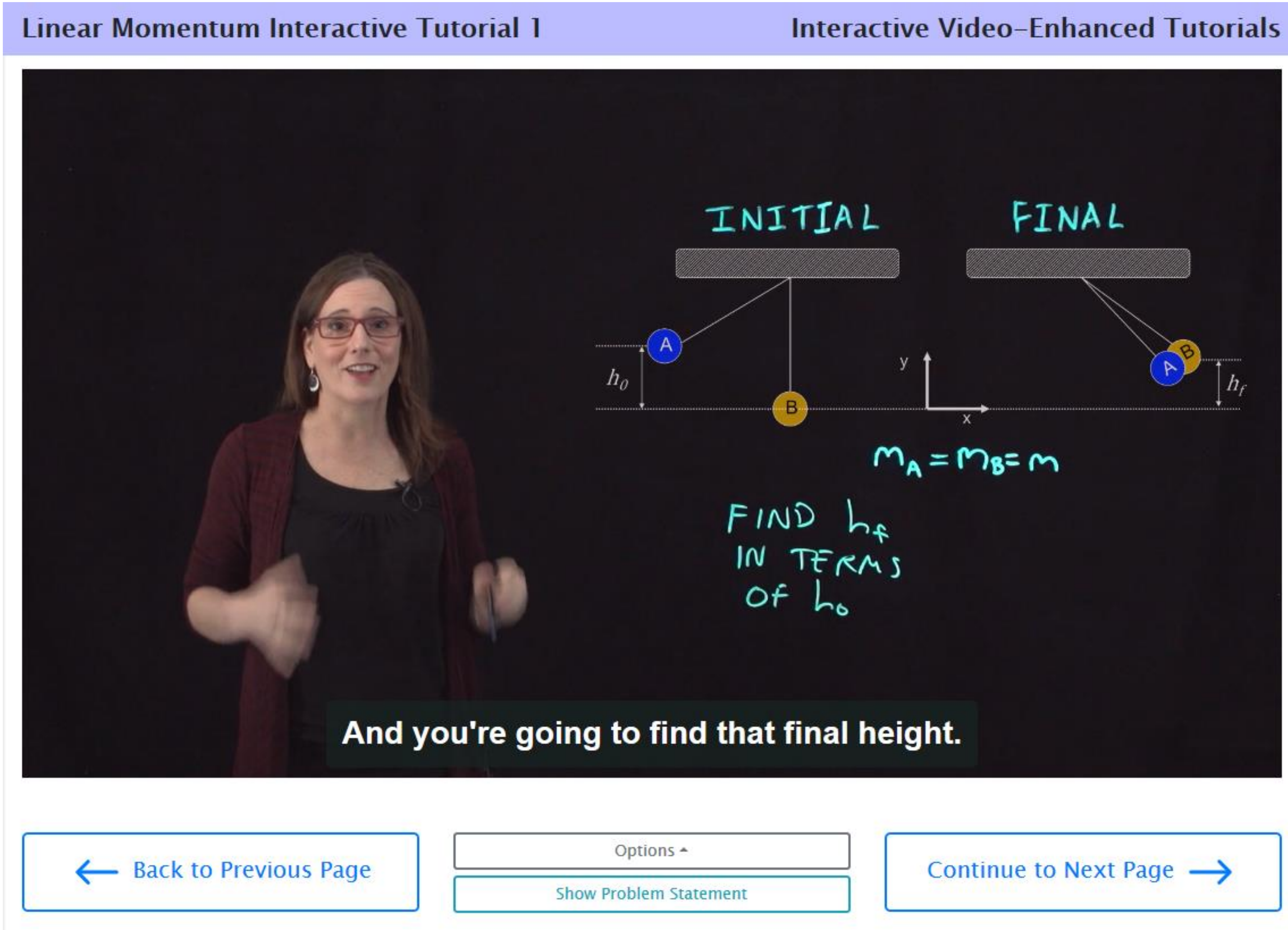
Find the height h_f in terms of h_0.

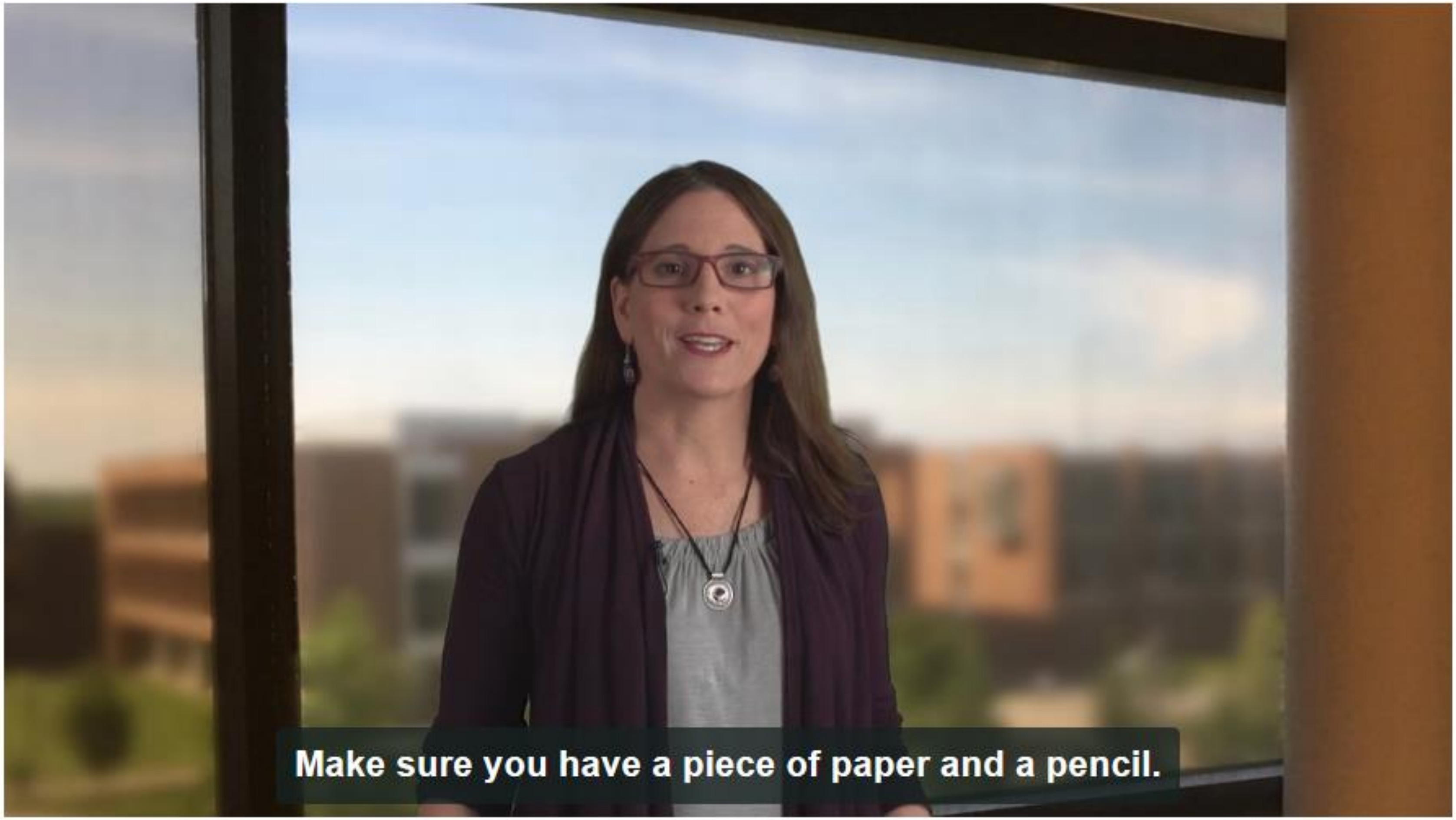


Assume that the lowest point in the path is the point of zero gravitational potential energy

Back to Previous Page
Options
Show Problem Statement
Continue to Next Page

Video option: Narrator presents problem to be solved.





Keep good notes as you go though this tutorial. You will need them.
Briefly summarize your plan for solving the problem in the box below:

Solution Plan

← Back to Previous Page

Continue to Next Page →

Tutorial often starts by asking which physics principles are applicable

Linear Momentum Interactive Tu

Before starting any physi
needed. If you want to se
button at the bottom of th

Q1: Choose *all* of the following phys

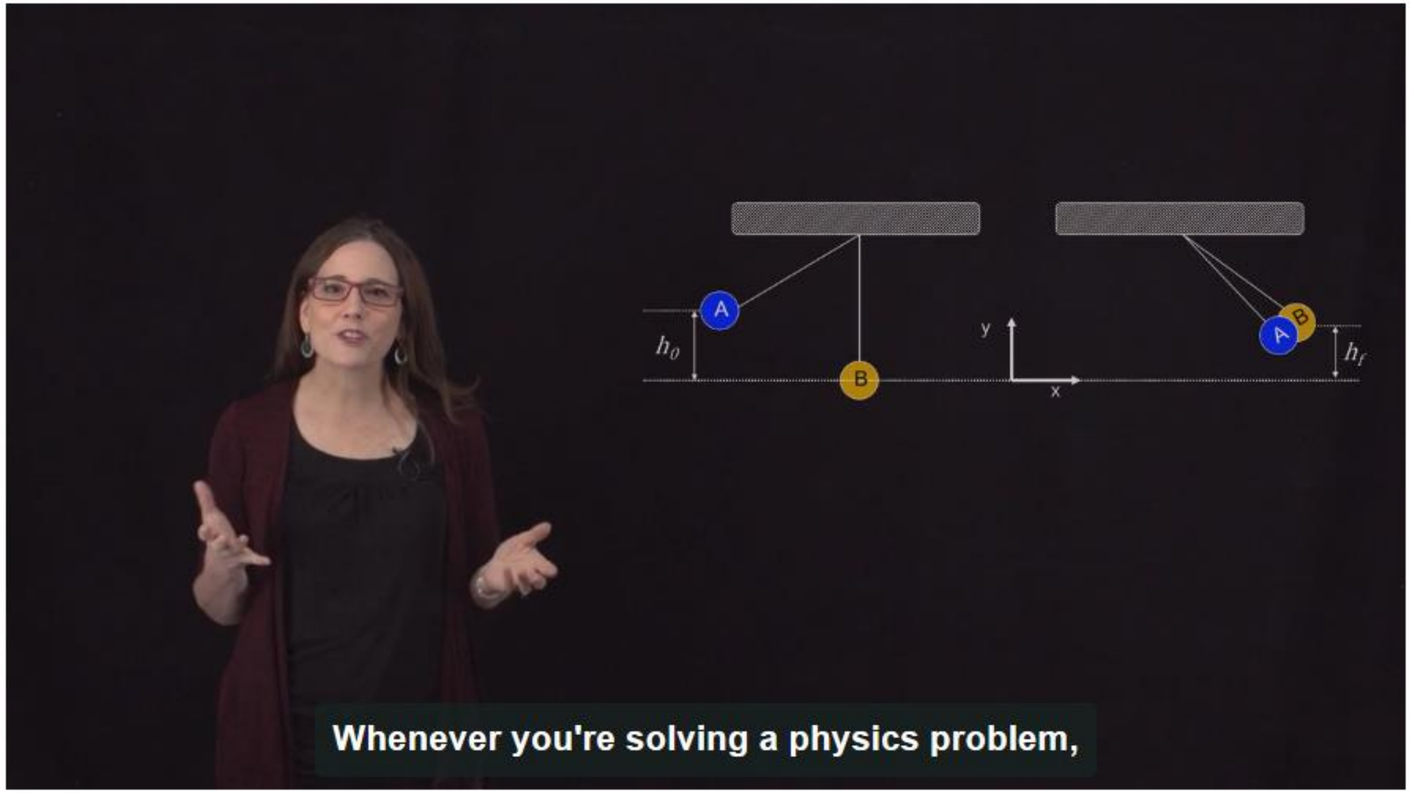
☐ A. Conservation of Total Mechani

☐ B. Conservation of Momentum

☐ C. Newton's 2nd Law

← Back to Previous Page

Linear Momentum Interactive Tutorial 1 | Interactive Video–Enhanced Tutorials



Q1: Choose *all* of the following physics principles we should use to solve this problem:

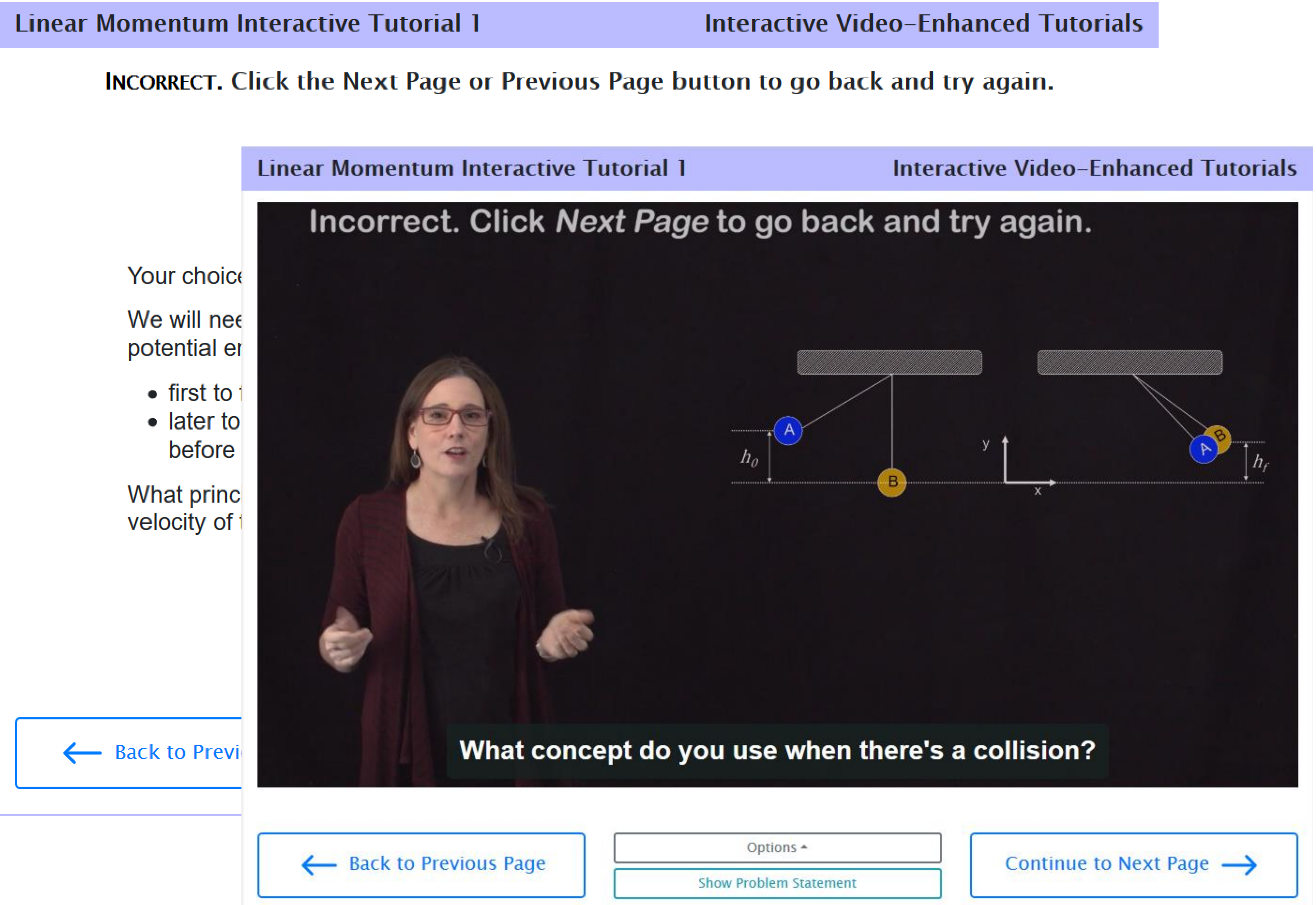
☐ A. Conservation of Total Mechanical Energy

☐ B. Conservation of Momentum

☐ C. Newton's 2nd Law

← Back to Previous Page | Options ▴ / Show Problem Statement | Continue to Next Page →

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



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

Linear Momentum Interactive Tutorial 1 Interactive Video–Enhanced Tutorials

CORRECT. Click the Next Page button to continue.

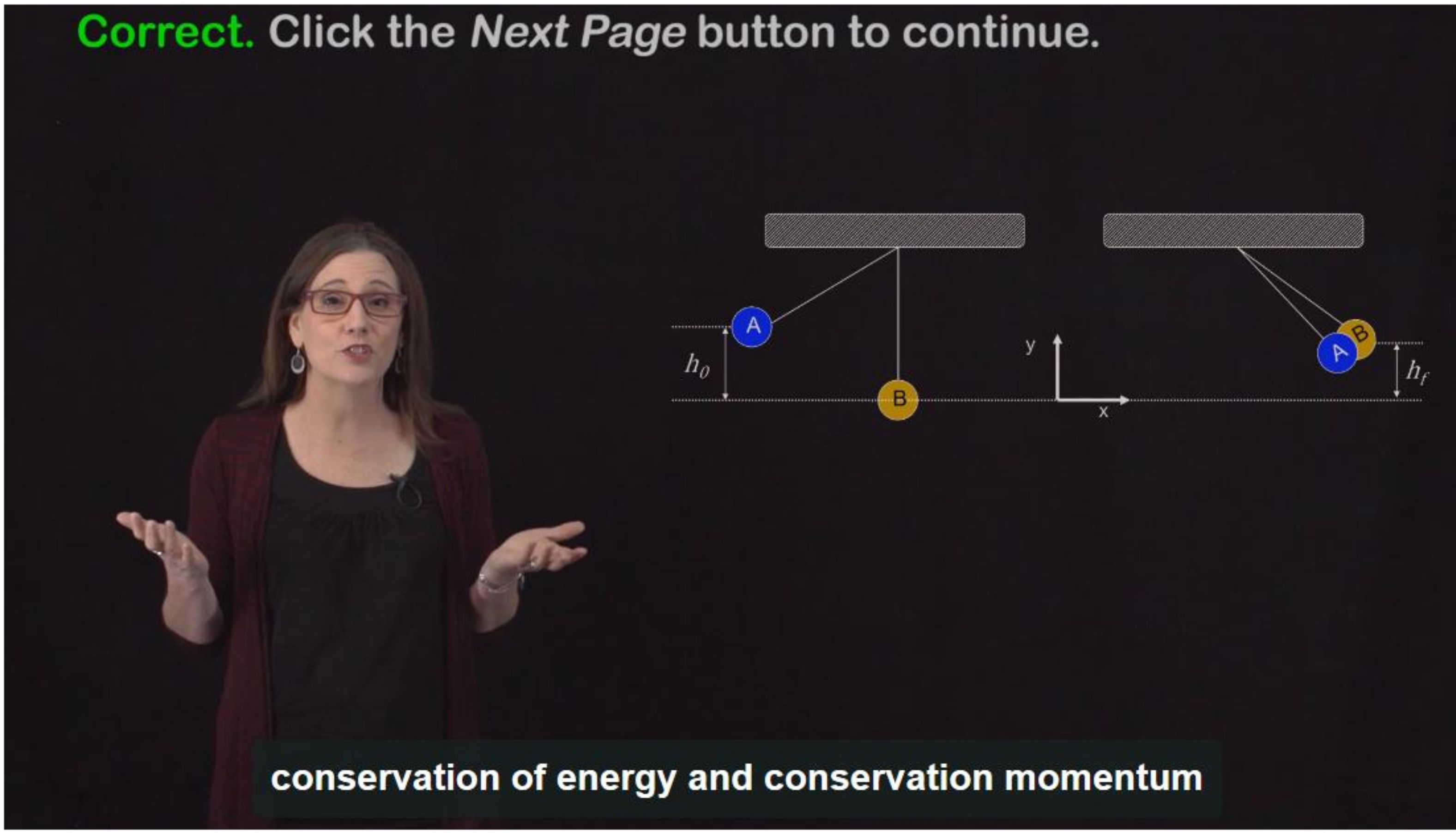
Right!

- W
  to
- W
  rel
  tw

Now c

← Back to

Linear Momentum Interactive Tutorial 1 Interactive Video–Enhanced Tutorials



← Back to Previous Page

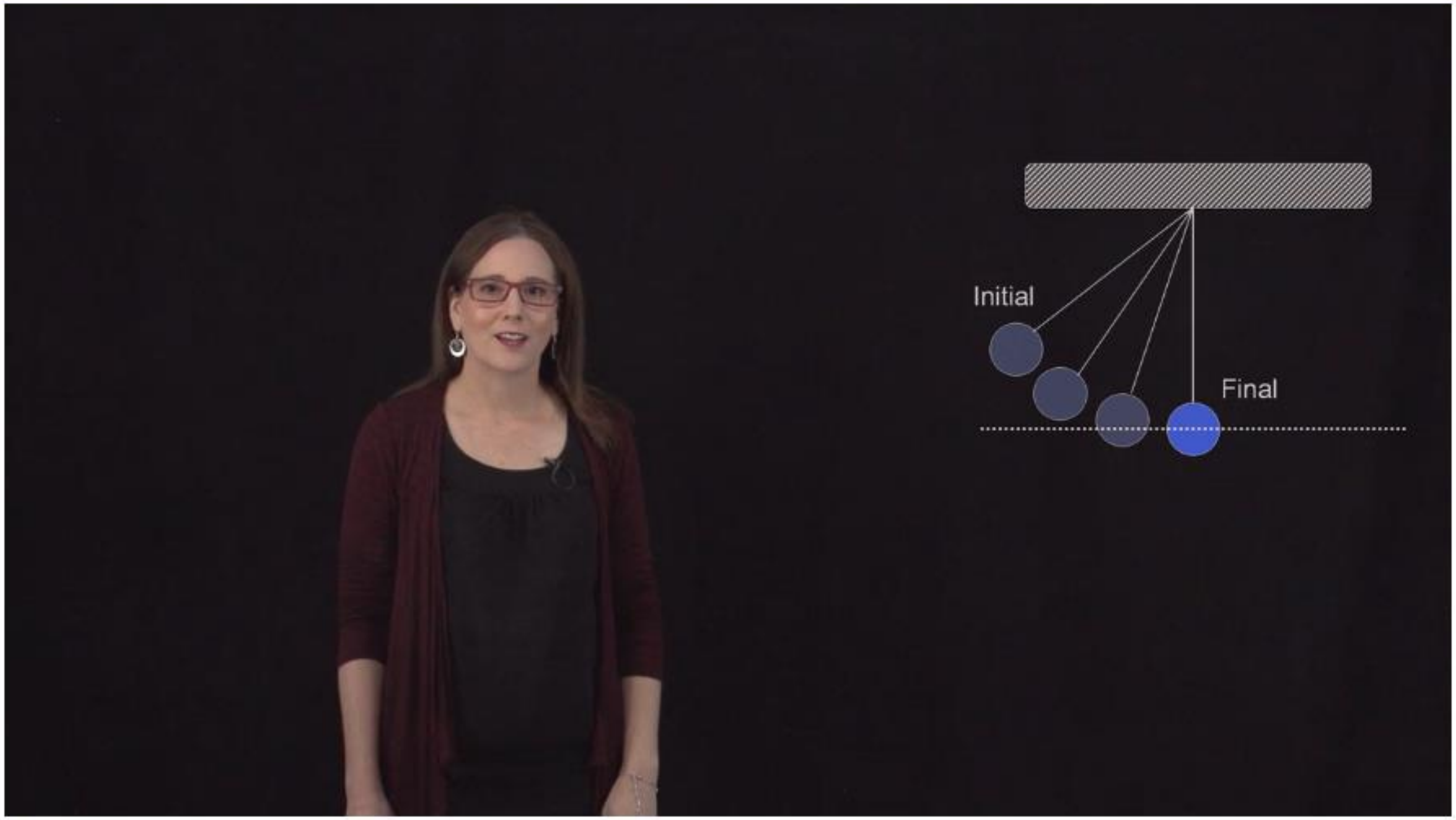
Options ▴

Show Problem Statement

Continue to Next Page →

Multiple select questions used to engage students and reduce guessing.

Linear Momentum Interactive Tutorial 1 | **Interactive Video–Enhanced Tutorials**



Q2: 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

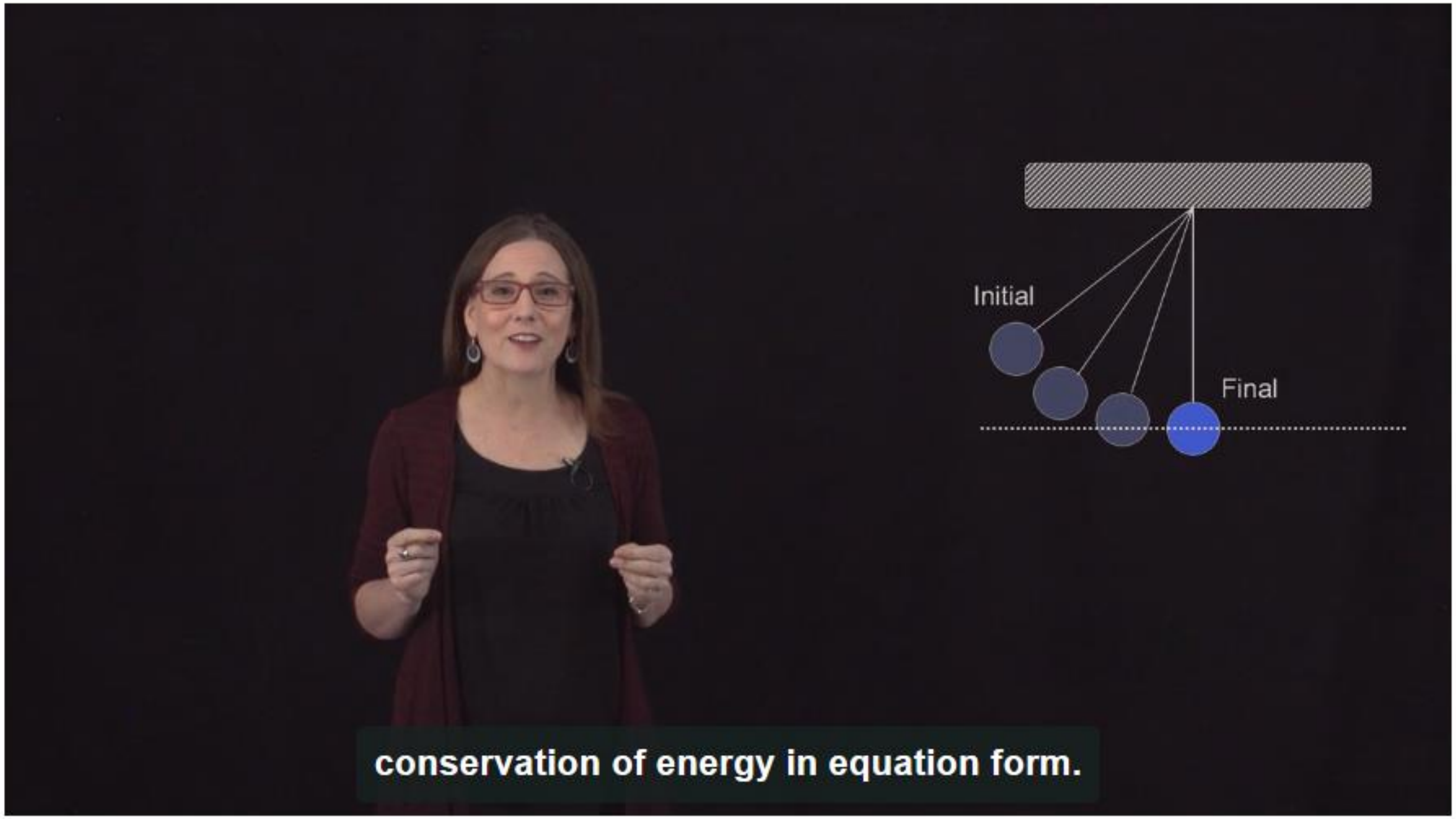
☑C. Final Kinetic Energy

☐D. Final Gravitational Potential Energy

Feedback is aligned to choices made.

Students are expected to work problem out on paper along with IVET.

Linear Momentum Interactive Tutorial 1 **Interactive Video–Enhanced Tutorials**



Q3: Which one of the following expressions for the speed v_A of ball A right before it collides with ball B is correct?

Incorrect answer selected.

○A. $v_A = \sqrt{2gh_0}$

◉B. $v_A = \sqrt{gh_0}$

○C. $v_A = \sqrt{\frac{gh_0}{2}}$

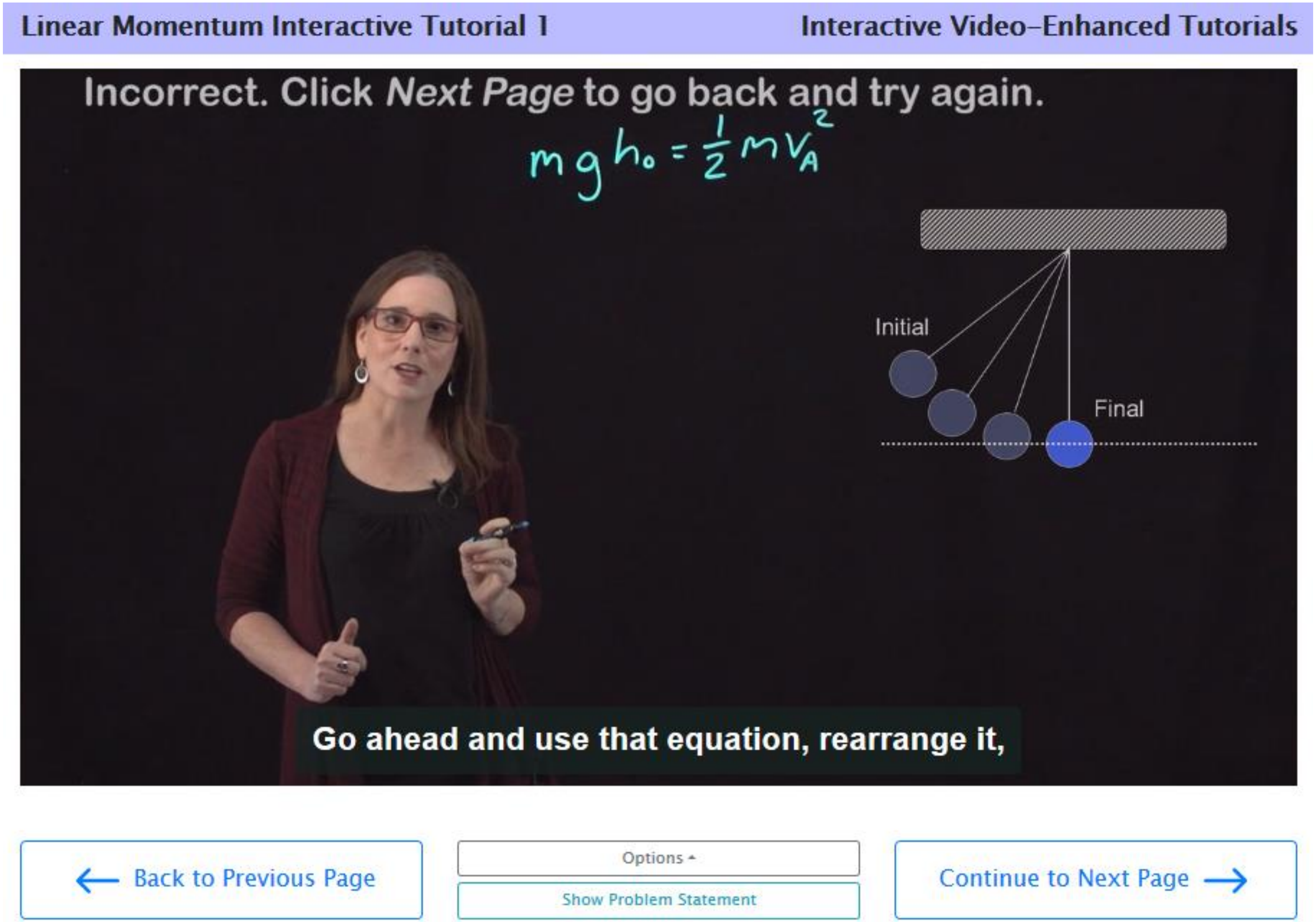
← Back to Previous Page

Options ▴

Show Problem Statement

Continue to Next Page →

Feedback is provided to get student started in addressing this part of problem.



Students get brief summary even when correct.

Linear Momentum Interactive Tutorial 1 Interactive Video–Enhanced Tutorials

Correct. Click the *Next Page* button to continue.

Linear Momentum Interactive Tutorial 1 Interactive Video–Enhanced Tutorials

CORRECT. Click the Next Page button to continue.

Reasoning:

Initial gravitational potential energy	=	Final kinetic energy

$$\cancel{m}_A g h_0 = \frac{1}{2}\cancel{m}_A v_A^{\,2}$$

$$g h_0 = \frac{1}{2} v_A^{\,2}$$

$$2 g h_0 = v_A^{\,2}$$

$$v_A = \sqrt{2 g h_0}$$

← Back t

← Back to Previous Page

Options ▴

Show Problem Statement

Continue to Next Page →

Throughout the IVET, emphasis is placed on solving the problem in parts to reduce cognitive load. Here, tutorial moves on to the 2nd part of the problem

Linear Momentum Interactive Tutorial 1 **Interactive Video–Enhanced Tutorials**

We just used conservatio before it hits ball B. Now concept(s) do we need?

Q4: Which of the following principles is balls (v_{AB}), in terms of the speed that b

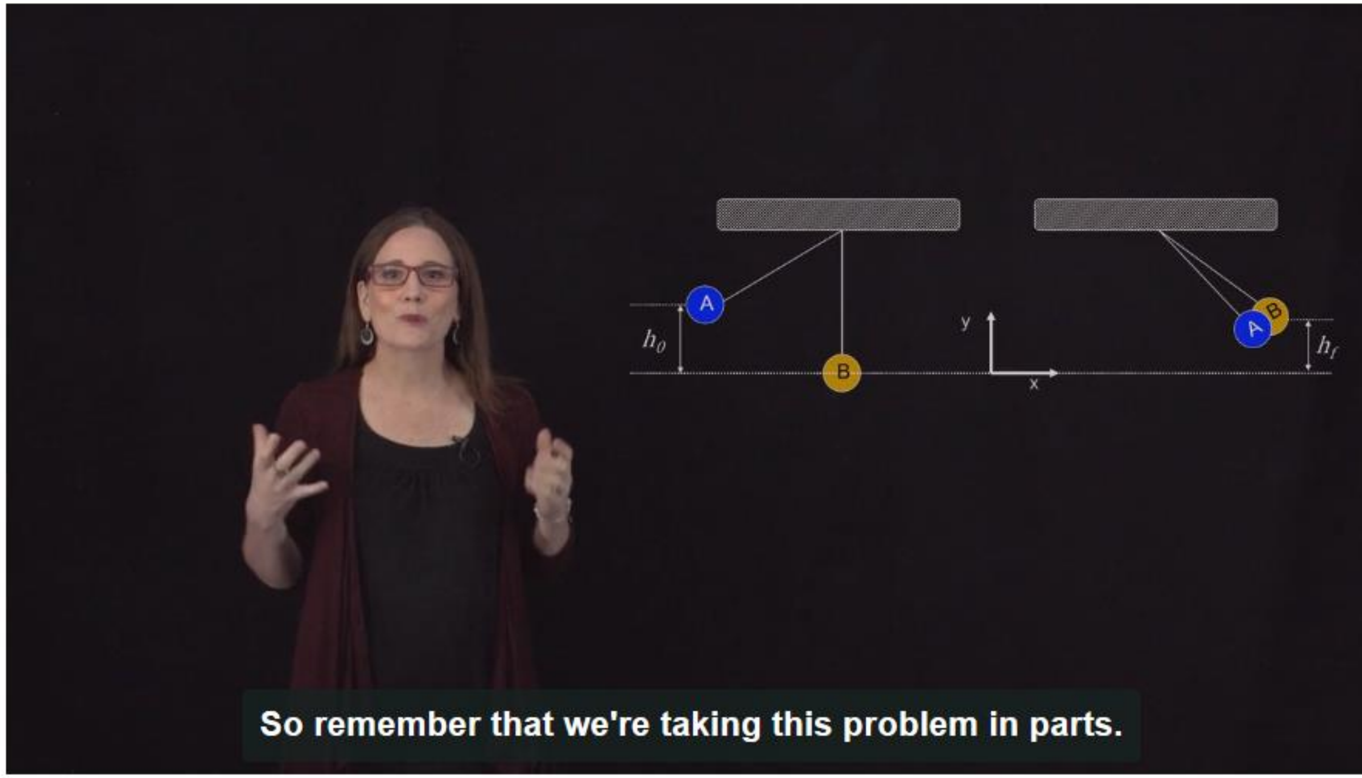
○A. Conservation of Linear Momentur

○B. Newton's Second Law

○C. Conservation of Total Mechanical

← Back to Previous Page

Linear Momentum Interactive Tutorial 1 **Interactive Video–Enhanced Tutorials**



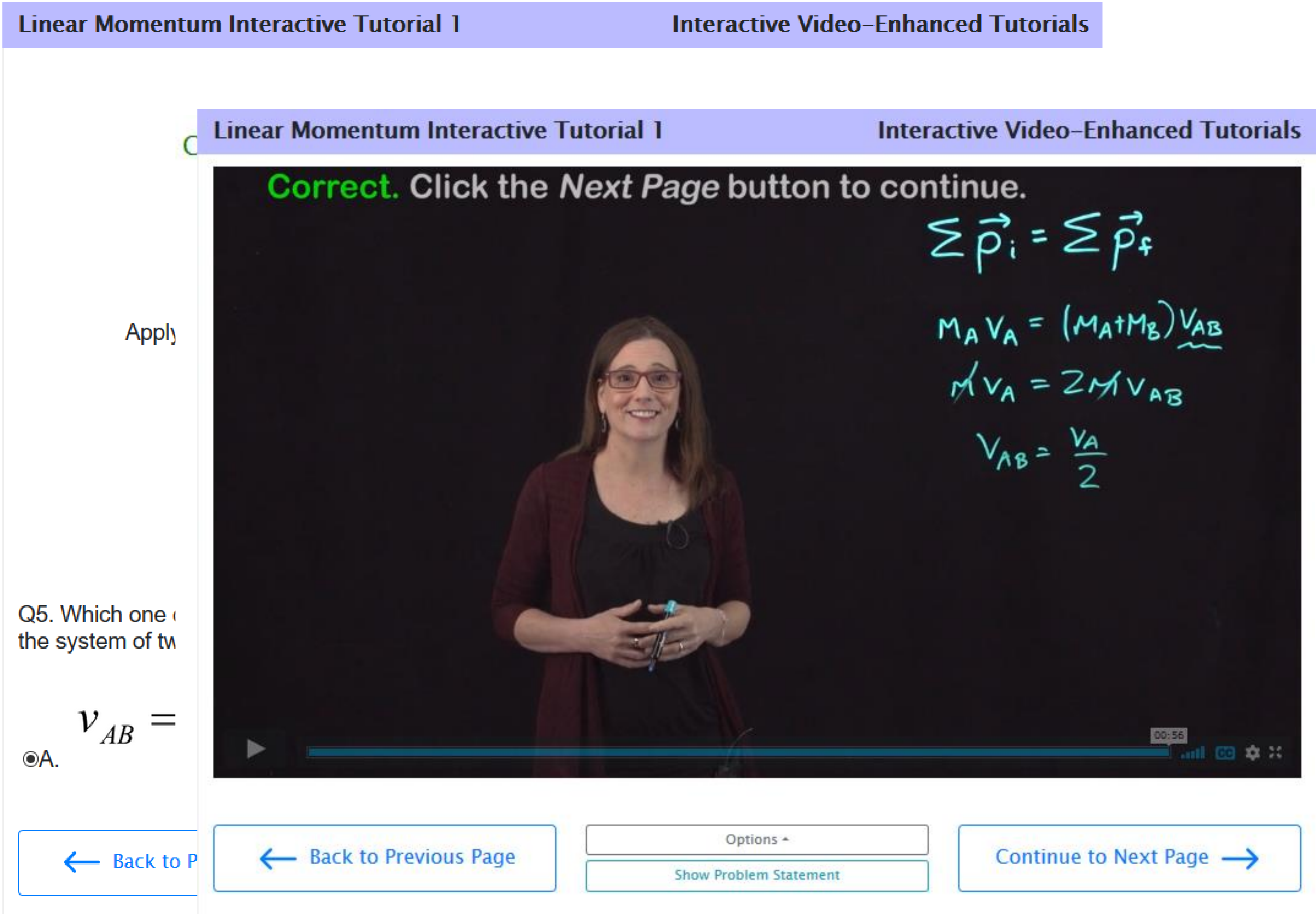
Q4: Which of the following principles is most convenient to find an expression for the speed of the merged balls (v_{AB}), in terms of the speed that ball A had immediately before the collision (v_A)?

○A. Conservation of Linear Momentum

○B. Newton's Second Law

○C. Conservation of Total Mechanical Energy

Students are led to an equation which wraps up the collision part of the problem.



Tutorial responds to student affective states to help with motivation to engage

Linear Momentum Interactive Tutorial 1 | **Interactive Video-Enhanced Tutorials**

How are you feeling right now?

What is this? Why should I answer?

- ○ I feel fine.
- ○ I feel confused.
- ○ I feel frustrated.
- ○ I feel bored.
- ○ I feel worried.
- ○ None of the choices
- ○ I prefer not to answer.

- ○ I feel fine.
- ○ I feel confused.

Please choose the most appropriate response from this list.

- ○ The tutorial is moving too quickly.
- ○ I am having trouble staying focused so I'm not getting the most out of this tutorial.
- ○ This tutorial uses terms that I do not understand.
- ○ The problem-solving approach used here is different from what I learned in class.

- ○ I feel frustrated.

← Back to Previous Page

Options ▴

Show Problem Statement

Continue to Next Page →

Affective responses

- Main goal is to help motivate student to engage properly with tutorial
- Important emotions to respond to obtained from literature on computer tutors and consultation with an expert in computational models of emotion
- Emotions are always validated first, then:
  - Confused: provided advice and more support
  - Frustrated/worried: emotional support and advice where appropriate
  - Bored: reminded that tutorial provides a problem solving strategy applicable to many problems

Affective response: Example

- Confused because tutorial is moving too quickly:
  - Yes, this problem certainly can be confusing and it has many different parts (validation)
  - Here are some things you can do to slow the problem down and regain focus:
    - Reread the problem statement. That will help you remember the end goal of the problem as well as keep the big picture in mind
    - You can also make sure that you are taking clear notes every step of the way; look over them
    - Sometimes, it's also helpful to just take a short break
    - On the next page, we're going to give you the option to watch a summary of what we've done so far. This will help recap the big picture of what we are doing and you should definitely choose that option.

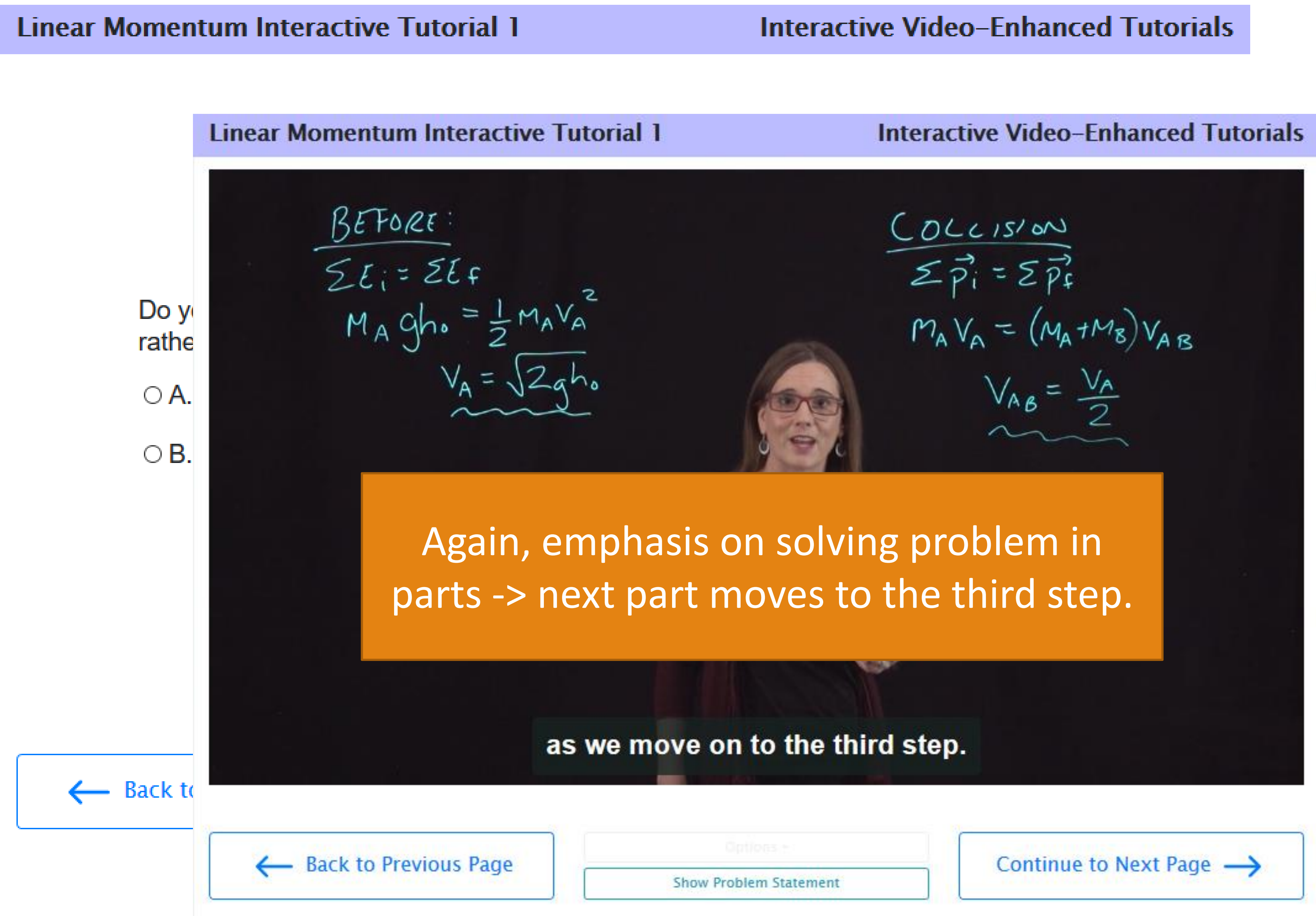
Affective response: Example

- Confused because tutorial is moving too quickly:
  - Yes, this problem certainly can be confusing and it has many different parts (validation)

Similar approach for other affective states.

Content of the feedback (exact words) as well as the demeanor (tone, posture, facial expressions) developed in consultation with the expert in computational models of emotion.

  - Sometimes, it’s also helpful to just take a short break
  - On the next page, we’re going to give you the option to watch a summary of what we’ve done so far. This will help recap the big picture of what we are doing and you should definitely choose that option.



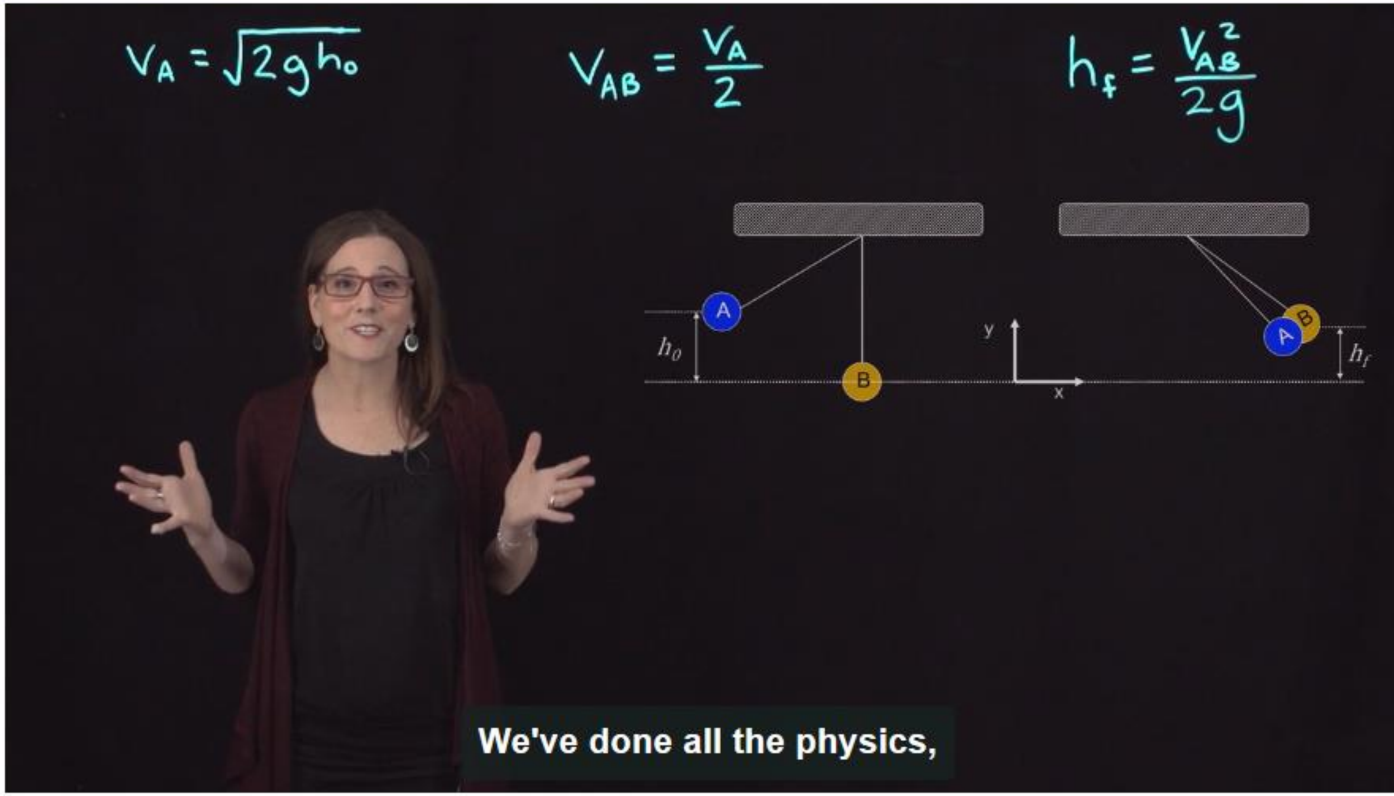
Again, emphasis on solving problem in parts -> next part moves to the third step.

Q6. Which one of the following

○A. $h_f = \frac{{v_{AB}}^2}{4g}$ ○B

← Back to Previous Page

Linear Momentum Interactive Tutorial 1 Interactive Video–Enhanced Tutorials



Q7. Which of the following expressions is correct for the maximum height h_f of the two balls together?

○A. $h_f = 2h_0$ ○B. $h_f = \frac{h_0}{4}$ ○C. $h_f = \frac{h_0}{2}$

← Back to Previous Page

Options ▴

Show Problem Statement

Continue to Next Page →

Students provided option to watch a summary after finishing the problem

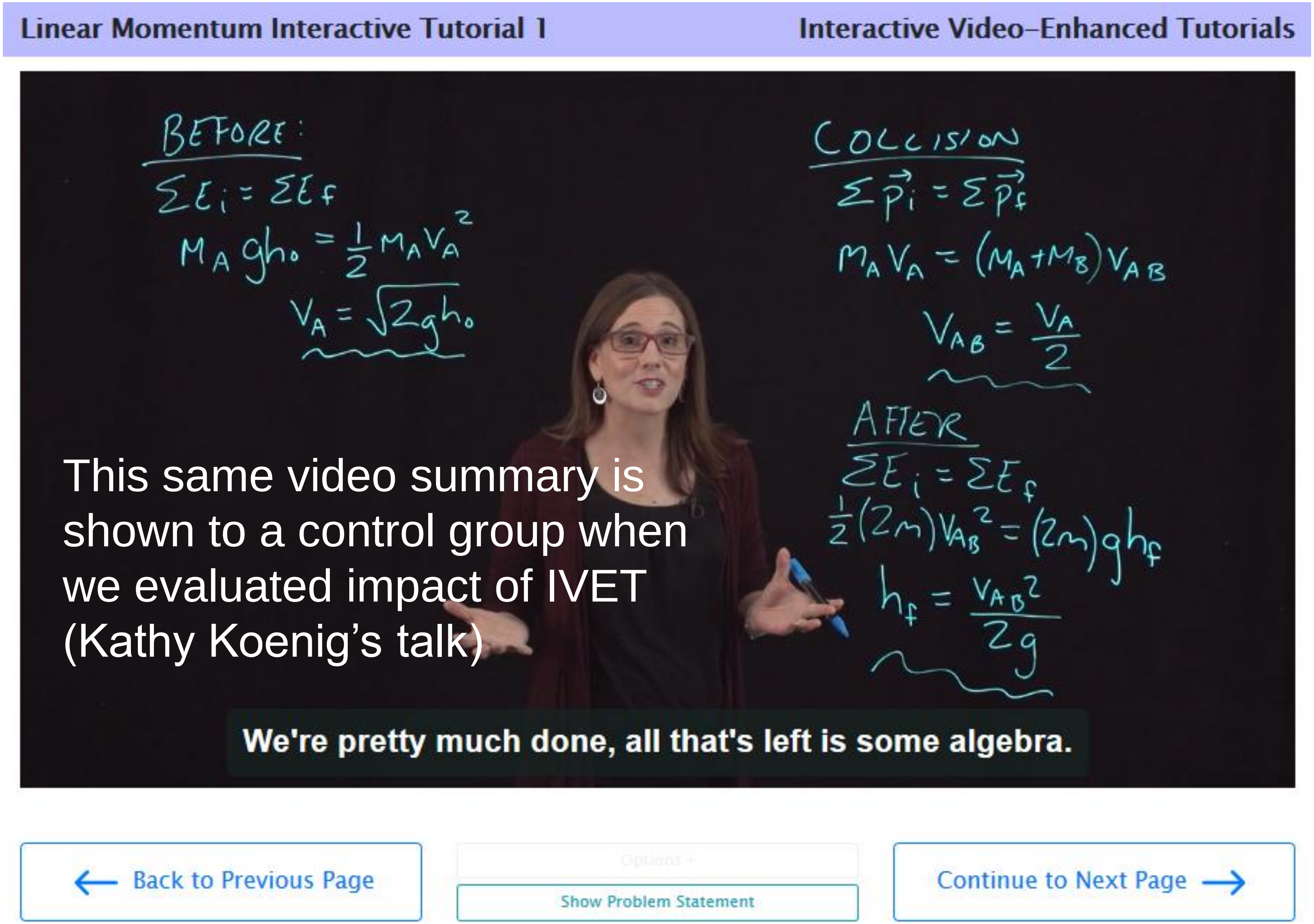
Linear Momentum Interactive Tutorial 1 **Interactive Video-Enhanced Tutorials**

Do you want to see a video summary of what we have done, or would you rather continue with the tutorial?

- ○ Watch a video summary.
- ○ Continue with the tutorial.

← Back to Previous Page | Options ▴ | Show Problem Statement | Continue to Next Page →

Video summary is ~5 minutes long.



This same video summary is shown to a control group when we evaluated impact of IVET (Kathy Koenig's talk)

Reflection

To test your understanding of this type of problem, try solving it again using $m_B = \frac{1}{2}\, m_A$.

The result you should get is $h_f = (4/9)\, h_0$.

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).

(Optional) Please answer the following question to help us improve the tutorial in the future. Your instructor will not see your response.

Midway through this tutorial, you were asked how you feel. Please share your thoughts about being asked this question as well as about the feedback you received after making a selection.

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

Does IVET impact student problem solving ability?

Talk by Kathy Koenig: “Interactive Video-Enhanced Tutorials: Impact on Student Problem-Solving Abilities”

Thank you!

If you are interested in seeing or using the IVETs we have, please email me!

alexandru.maries@uc.edu

IVETs we have developed so far:

- Newton's 2nd Law (force on two blocks)
- Conservation of Energy (will string break on tire swing?)
- Linear Momentum and Energy (pendulum balls collide)
- Static Equilibrium (person on ladder leaning against wall)
- Torque and rotation (two masses hanging from pulley with two radii)
- Angular Momentum (bullet shot into wheel)