Learning physics using multimedia resources

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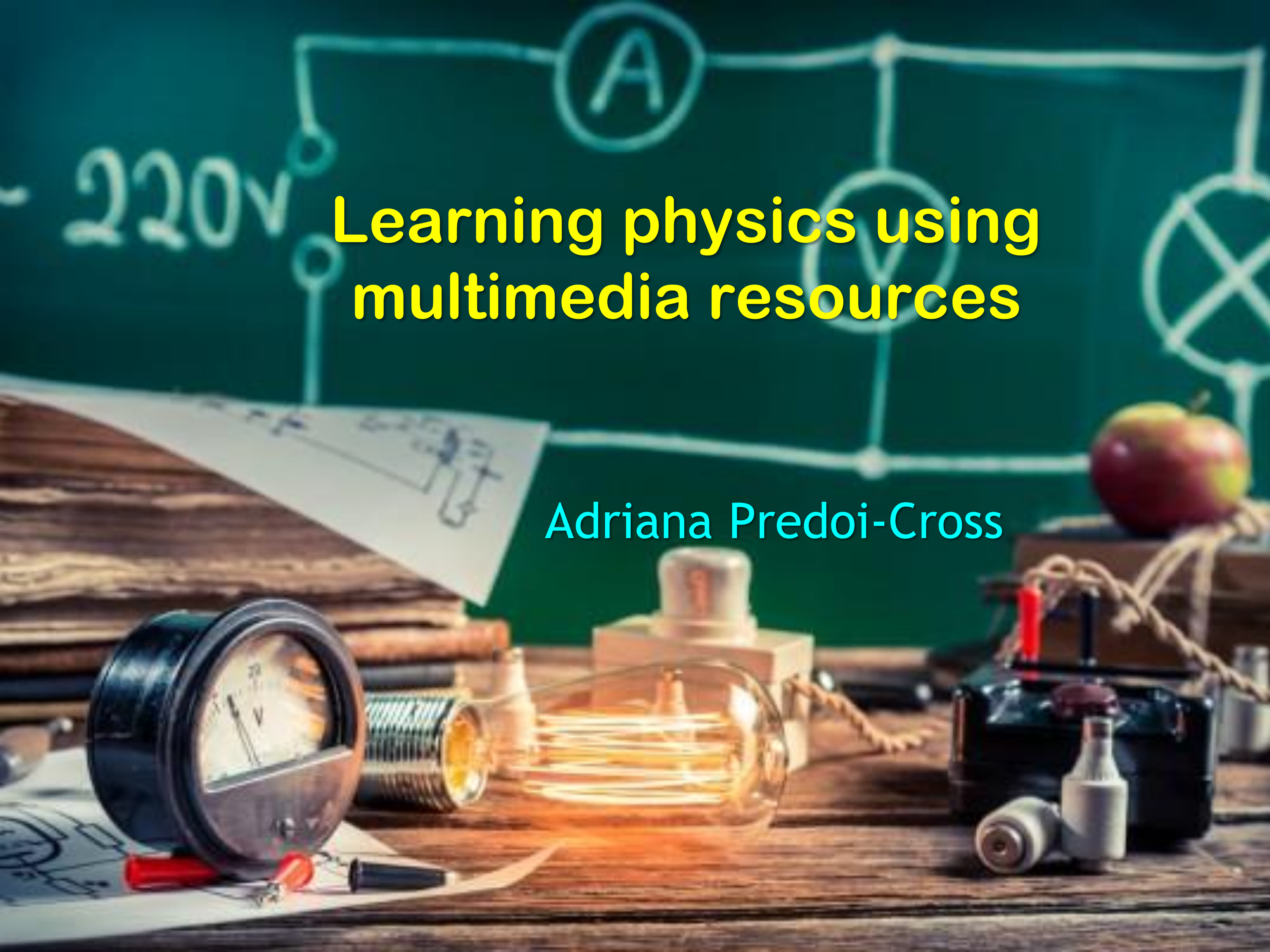
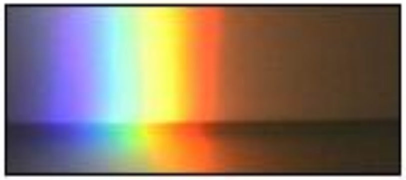
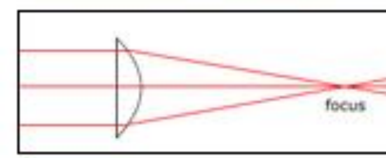
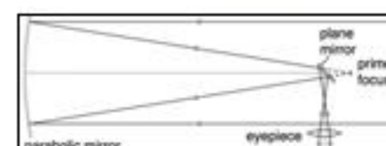


Talk Outline



- Motivation
- Elements of my teaching approach
- Examples of instructional animations, physlets, physclips, videos used during lectures
- “Multi-level homework”
- Concluding Remarks
- References





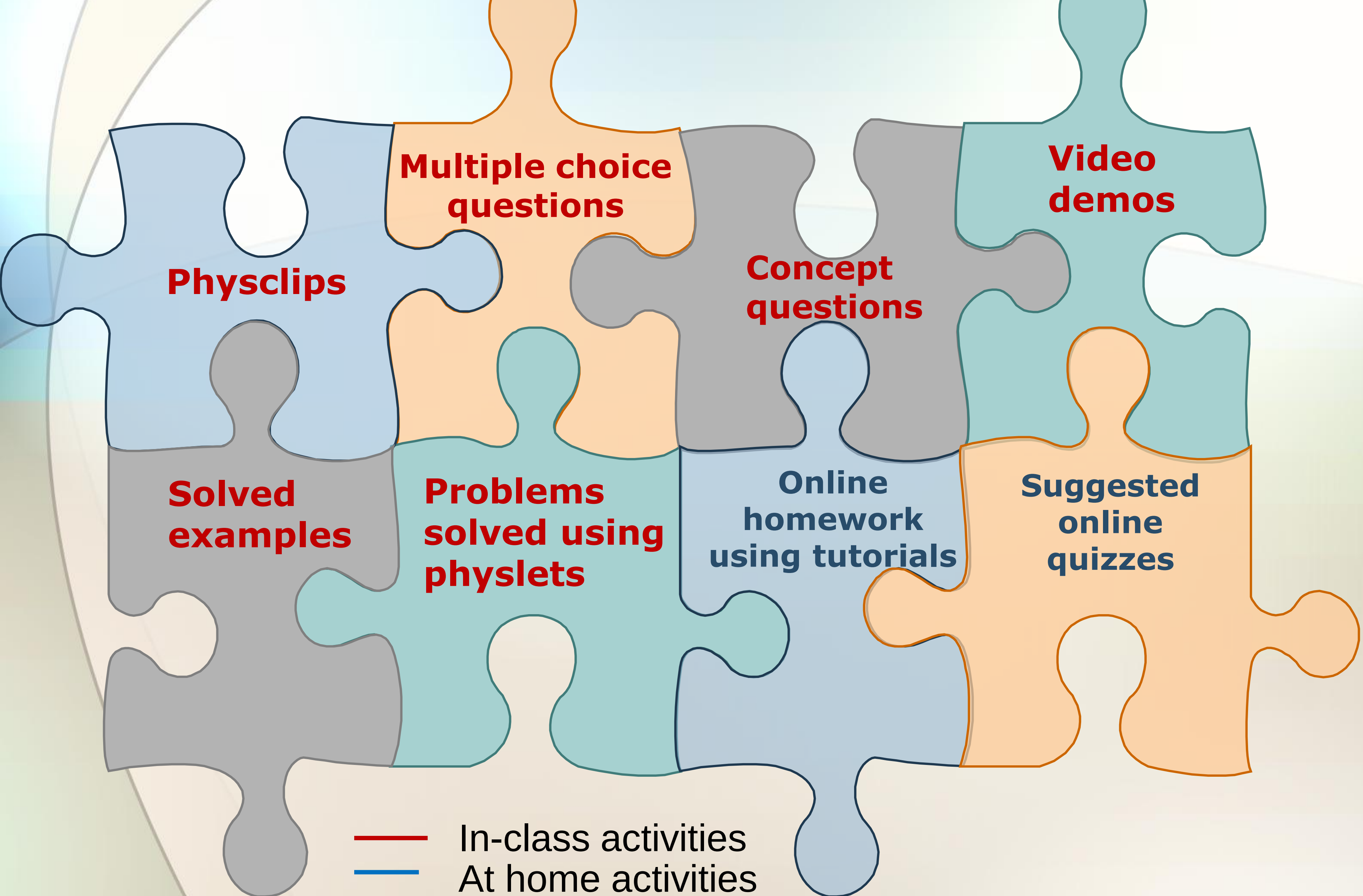
Aims and Motivation

- He main driver for this work has been a sustained effort on my part to identify that could be the most effective way to teach the content of several introductory Physics courses at University of Lethbridge. A different approach in teaching is implemented to teach senior level courses.
- Tested methods of teaching include: the Socratic method ("we focus on giving students questions, not answers"), the lecture style teaching, teaching with multimedia resources, testing students comprehension of new concepts using in class multiple choice questions, concept questions, solved examples.
- Based on feedback from students and changes in their performance and the way they formulate their understanding of physics concepts, this presentation will highlight what I consider to be the most effective combination of teaching tools.

Introduction

- As teachers we strive to create a stimulating and responsive learning environment that enhances the students' critical thinking, nurtures their interest and curiosity in the topics presented in class.
- We also want to see our students get to a stage where they formulate questions using newly acquired physics concepts, contribute to related class discussions where they share their curiosity, and are ready to expand their knowledge.
- Pedagogical research studies [1,2] have concluded that the traditional class environment is not enough to achieve these goals, when compared with "responsive simulation environments" of reality. It is acknowledged that "computational models controlling the simulations may contain idealization or limited accuracy – leading to misrepresentation of physical reality" [2].

Instructional elements used in introductory physics teaching activities



Physclips

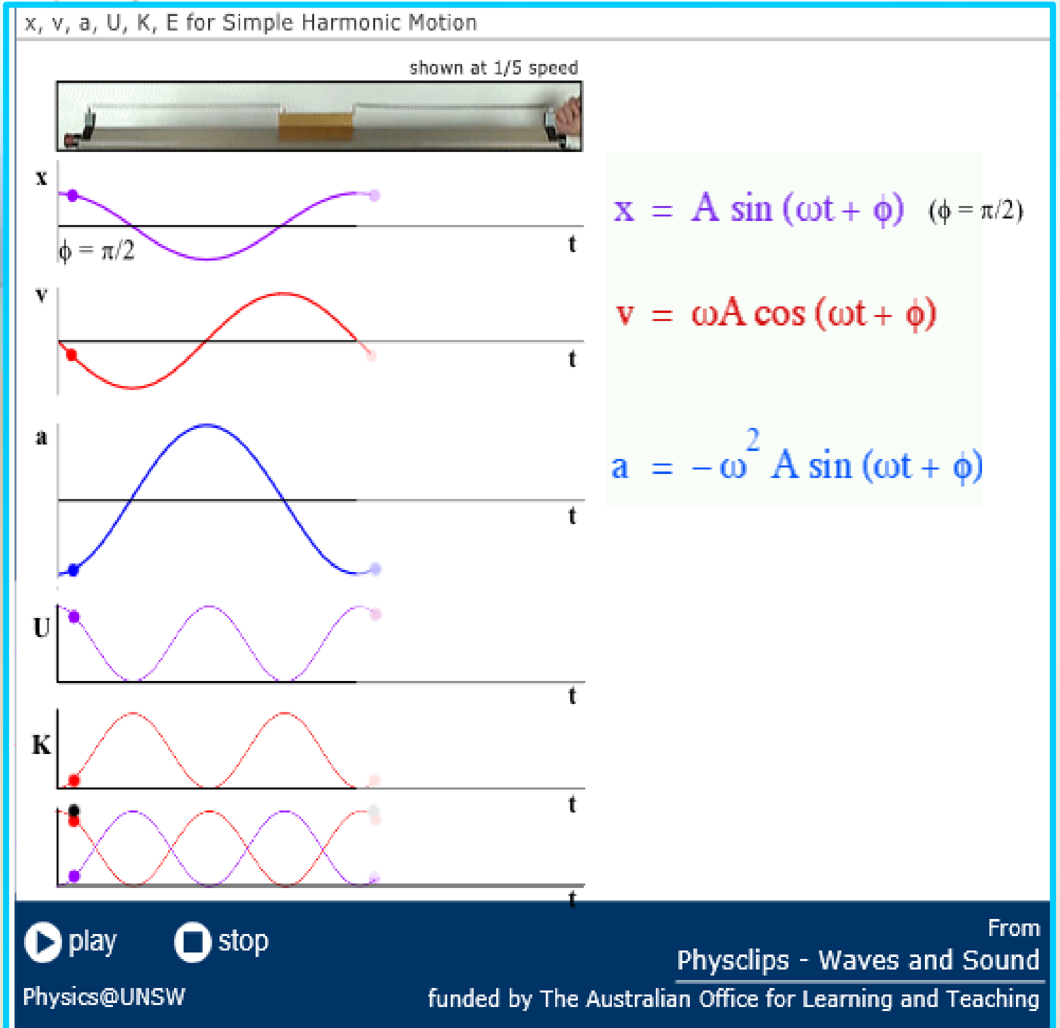
Physclips

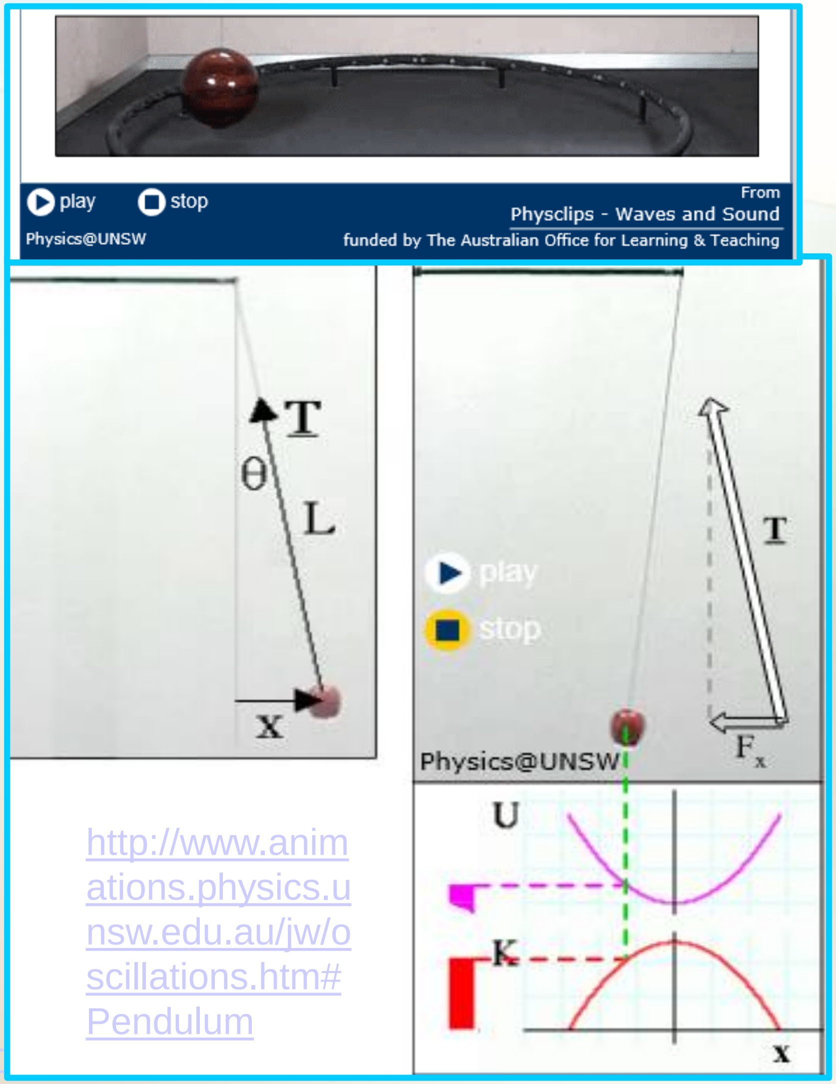
Their role is to be part of a "modified curriculum design that better accommodates the teaching of these "conceptual portals", without which meaningful progress in the discipline is unattainable." [3,4]

Physclips

- Animations and short (~ 1 min long) videos are used when introducing new concepts along with my slides, and to visualize mathematical expressions

Simple Harmonic Motion | **Pendulum mechanics**





http://www.animations.physics.unsw.edu.au/jw/oscillations.htm#Pendulum

http://www.animations.physics.unsw.edu.au/jw/oscillations.htm#Ener

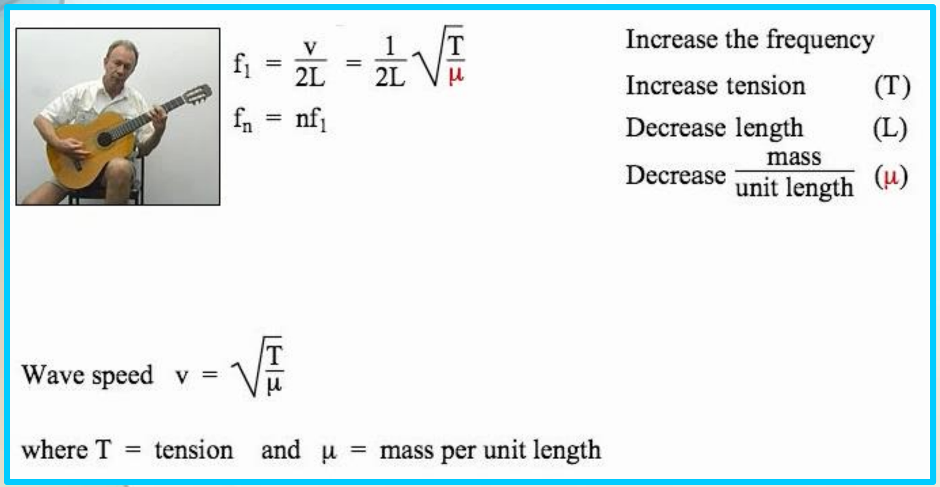
PHYSCLIPS
A multi level, multi-media resource

Physclips

UNSW
School of Physics
Sydney, Australia

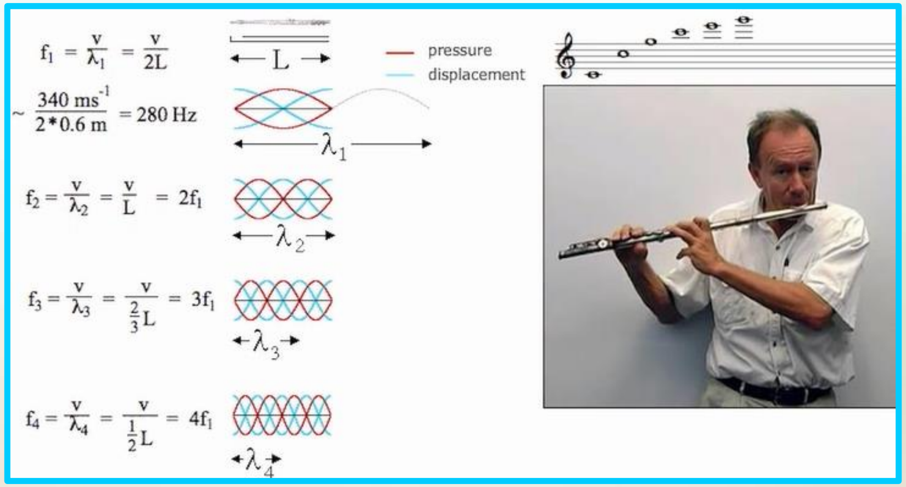
- All animations and videos presented in class are available to students through physclips that combine concepts, examples, animations, videos. The physclips are available online and the slides posted on the class's Moodle website include links to them.
- I use the physclips in class to summarize the new concepts introduced during the lecture

Strings and harmonics



http://www.animations.physics.unsw.edu.au/waves-sound/standing-waves/index.html#8.4

Waves in pipes



http://www.animations.physics.unsw.edu.au/waves-sound/standing-waves/index.html#8.5

Why Physclips Are an Effective Teaching Tool?

- “Most of today’s scientific (and non-scientific) communication is based on visual language. Consequently, teaching materials nowadays also increasingly exploit images and animations in order to improve students’ understanding of scientific concepts” [5].
- ”Still images are the most elementary components of visual language used in the teaching of science. [..] At university level, science communication exploits more schematic and technical images” [5] that “do not guarantee greater effectiveness in communicating science contents since students need to know how to interpret the visual language of an image so that they can correctly infer its content (Roth, Bowen & McGinn, 1999; Roth, Pozzer-Ardenghi, & Han, 2005). “[5]
- ‘According to other studies, images sometimes produce an effect contrary to that intended by the authors themselves, undoing the intention of the images in helping the explanation of a concept (Reid, 1990; Reid & Beveridge, 1990). “ [5]

Video demos

Videos of online demonstrations

Example of a lecture slide that incorporates a short video that can be watched in class and a link for a longer exploratory video that students can watch at home.

Resonance and sound

- The frequency of the sound from this trumpet exactly matches one of the normal-mode frequencies of the goblet.
- The resonant vibrations of the goblet have such large amplitude that the goblet tears itself apart.

https://www.youtube.com/watch?v=17tqXgvCN0E

Please watch: The Coolest Things Sound Waves Do

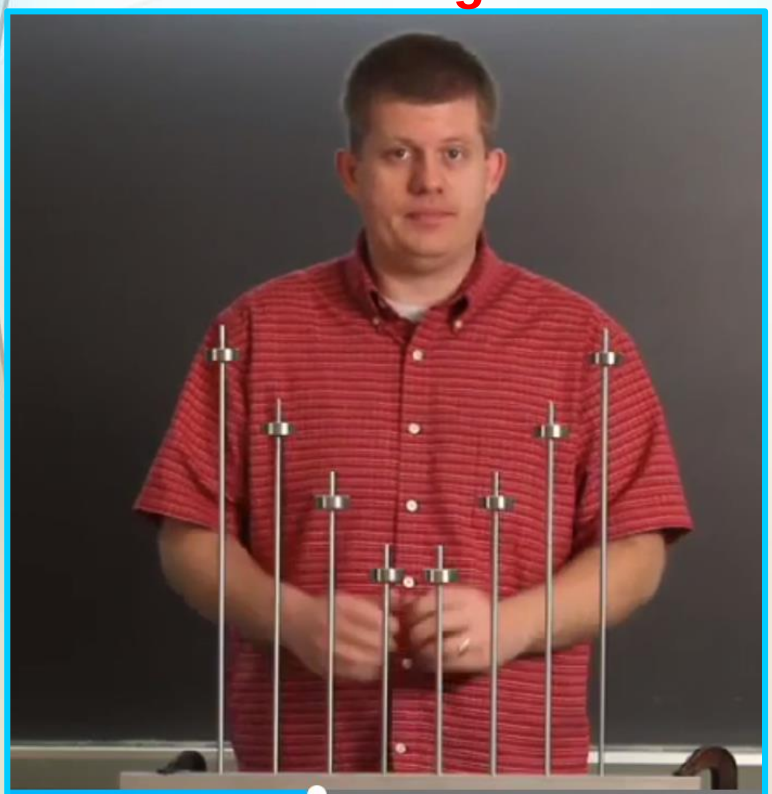
https://www.youtube.com/watch?v=Ude8pPjawKI

Video demos

Video demonstrations

Videos of short experiments available through Mastering Physics as “Video Tutor Demonstrations”. They can be presented in class or watched at home. Links for them are available in the lecture slides.

Vibrating Rods



https://mediaplayer.pearsoncmg.com/assets/secs-vtd26_resonancerods

Resonance of Everyday Items

https://mediaplayer.pearsoncmg.com/assets/secs-vtd50_everydayresonance

Why Online Demonstrations Are an Effective Teaching Tool?

- “Performing experiments is the basic and most common method of scientific research and education. […] Experiments are typically the foundation for determining the laws of physics and chemistry, and are the only (exclusive) tool for validating these deduced laws, hypothesises and theories. They also serve as the diagnostic tool for the limits of their validity.” [6] “It clearly shows how important scientific experiments are in our physics education but that they are also a key part of keeping students motivated.” [7]

- “Considerable previous work (de Jong & Njoo, 1992; Jimoyiannis & Komis, 2001; Finkelstein *et al.*, 2005; Zacharia *et al.*, 2008) has shown that typical “on-site” practical science (PS) is more effective when preceded by online experiments (OEs). Some research has even suggested that equivalent or superior learning outcomes result when students conduct an experiment virtually (Martínez-Jiménez *et al.*, 2011) or remotely (Corter *et al.*, 2004), rather than from the same physical location as real-world laboratory equipment. “ [8].

Multiple choice questions

Multiple Choice Questions

- Available as instructor resources in Mastering Physics (Pearson Education)
- Used in class to emphasize the new concepts introduced during the lecture and to test the students' understanding of these concepts
- Many students respond and if the proposed answers are different, the students discuss their choices in a friendly atmosphere

The air in an organ pipe is replaced by helium (which has a lower molar mass than air) at the same temperature. How does this affect the **normal-mode *wavelengths*** of the pipe?

✔ A. The normal-mode wavelengths are unaffected.

B. The normal-mode wavelengths increase.

C. The normal-mode wavelengths decrease.

D. Some normal-mode wavelengths increase, while others decrease.

E. The answer depends on whether the pipe is open or closed.

The air in an organ pipe is replaced by helium (which has a lower molar mass than air) at the same temperature. How does this affect the normal-mode *frequencies* of the pipe?

✔ A. The normal-mode frequencies are unaffected.

B. The normal-mode frequencies increase.

C. The normal-mode frequencies decrease.

D. Some normal-mode frequencies increase, while others decrease.

E. The answer depends on whether the pipe is open or closed.

Concept questions

Concept discussion questions

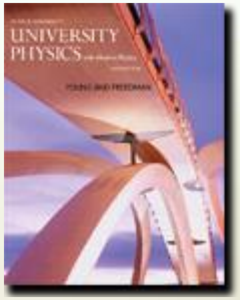
- Available in the textbook or online
- Used in class discussions to generate a conceptual understanding of new concepts and to generate discussions among students
- The lecture slides I post on Moodle include the written solutions to the concept questions

Examples of discussion questions for "Periodic Motion"

Q14.10 If a pendulum has a period of 2.5 s on earth, what would be its period in a space station orbiting the earth? If a mass hung from a vertical spring has a period of 5.0 s on earth, what would its period be in the space station? Justify your answers.

Q14.11 A simple pendulum is mounted in an elevator. What happens to the period of the pendulum (does it increase, decrease, or remain the same) if the elevator (a) accelerates upward at $5.0\ m/s^2$; (b) moves upward at a steady 5.0 m/s; (c) accelerates downward at $5.0\ m/s^2$; (d) accelerates downward at $9.8\ m/s^2$? Justify your answers.

Q14.12 What should you do to the length of the string of a simple pendulum to (a) double its frequency; (b) double its period; (c) double its angular frequency?



University Physics with Modern Physics

14 edition
Young & Freedman

Pearson Education Inc.

Solved examples

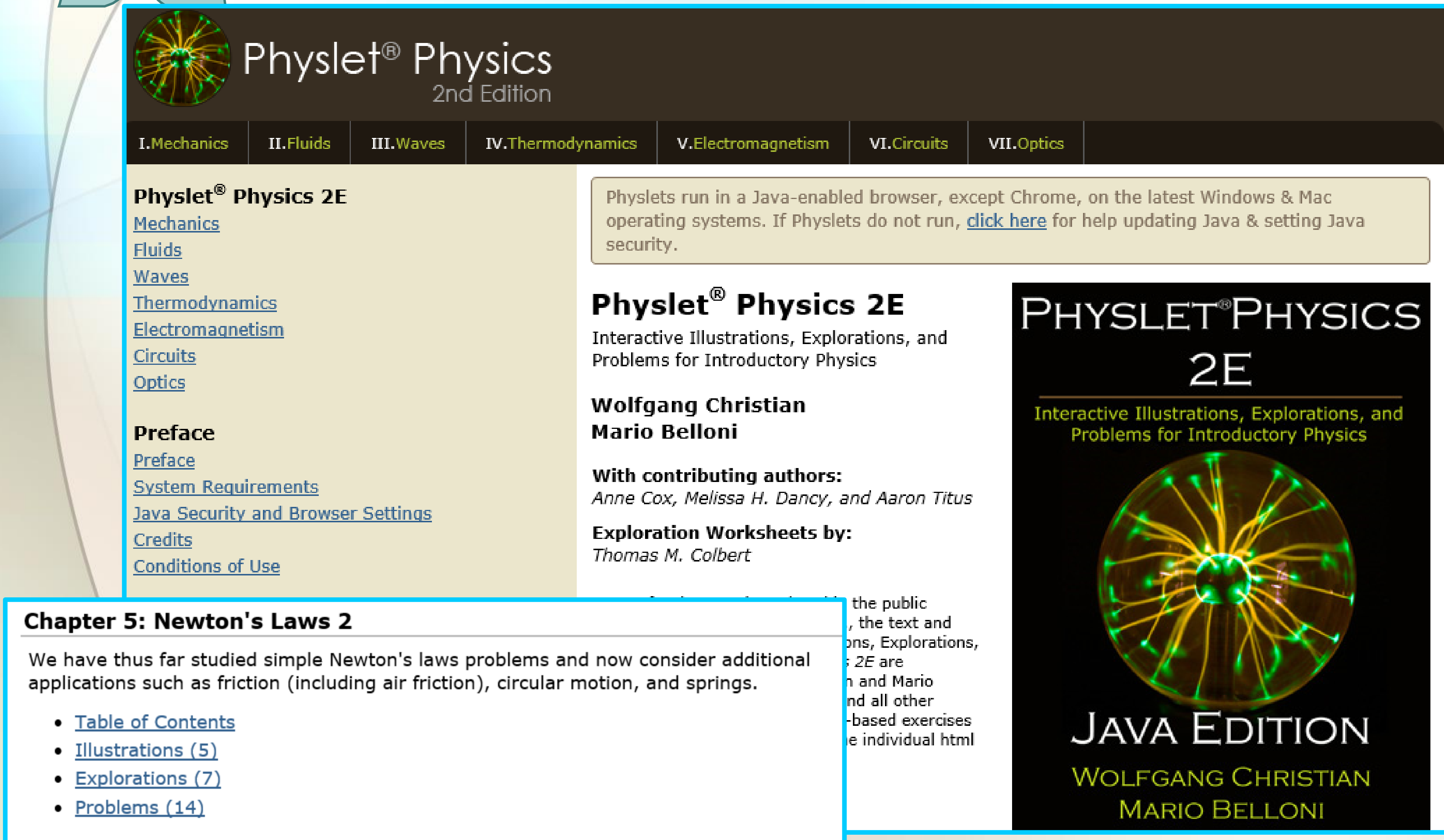
Exercises solved in class or during tutorial sessions

- Selected problems from the textbook are solved in class or during tutorial sessions in an effort to get students to interact with their peers and offer collaborative answers/suggestions that guide the professor
- If the class size is not above 15 students, I offer the students handouts with the problems to be solved both in class and at tutorials.Before exams I offer formula sheets as handouts, as well
- The lecture slides I post on Moodle include the written solutions to the problems solved in class.
- The resources related to tutorials available on the website include worksheets with and without solutions. Samples of midterm exams with and without solutions are also available on the class website.

Exercises solved in class or at home using physlets

Problems solved using physlets

- Several online resources for physics physlets exist such as: http://www.compadre.org/physlets/

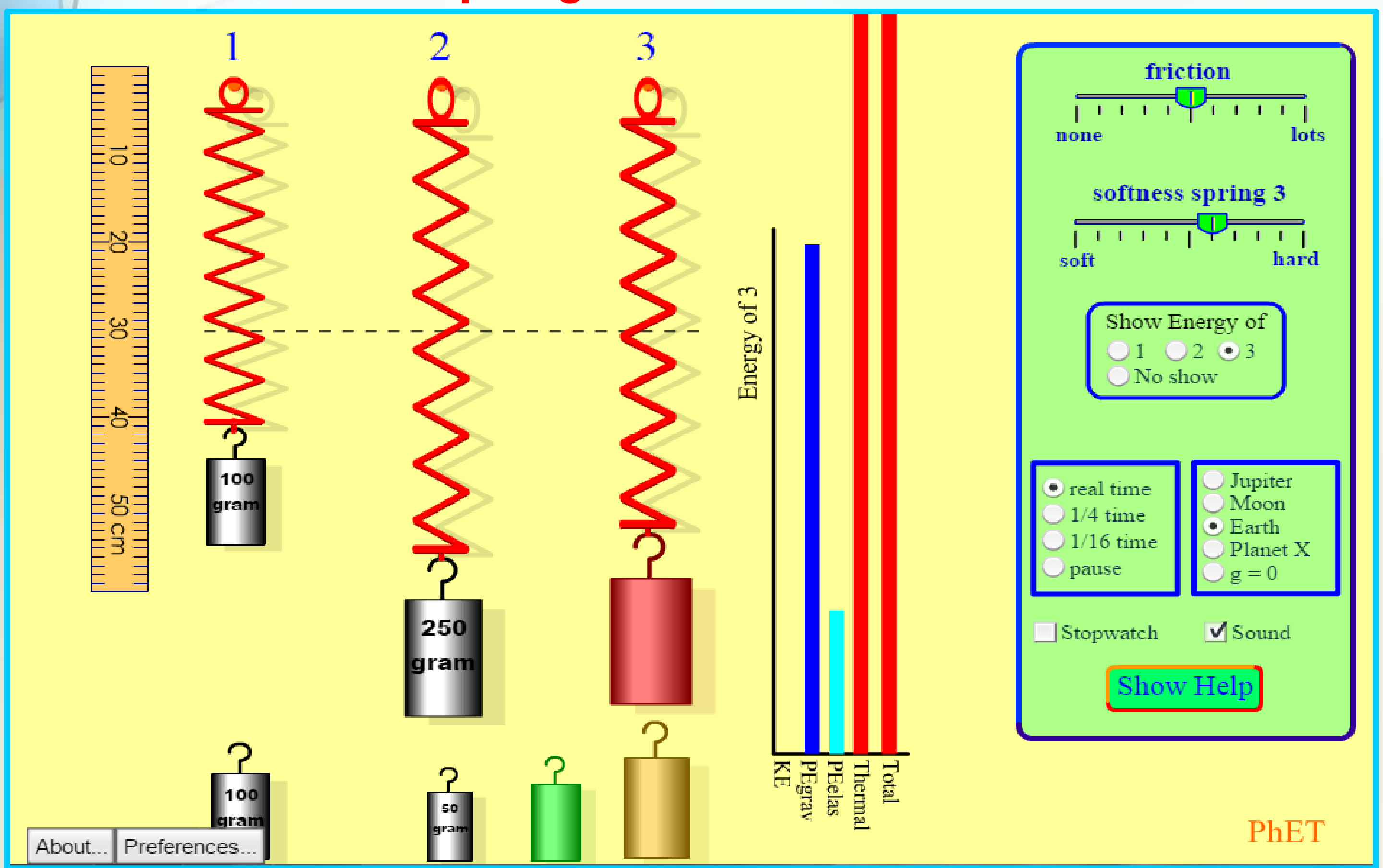


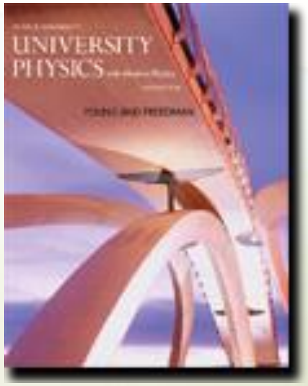
Physlets or PhET

Exercises solved in class or at home using physlets

- Available to students as *PhET Simulations* in the "Study Area" of Mastering Physics.
- Help students enhance their learning of concepts introduce in the class through explorations of interdependencies of physical variables

Masses and springs





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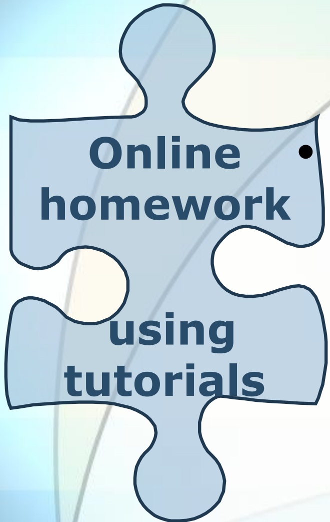
http://media.pearsoncmg.com/aw/aw_0media_physics/phet/sims/mass-spring-lab/mass-spring-lab.html

Online homework



- Consists of a set of 6-9 exercises assigned through Mastering Physics. The problems selected are of medium and sometimes high difficulty with randomizable variables and that are available on mobile devices.
- The learning outcomes are always considered are (i) ”Demonstrate the ability to think critically and employ critical thinking skills.” (ii) “Demonstrate the quantitative skills needed to succeed in Introductory Physics.”
- As shown by my observations and in [9] “Scores are not significantly different for online based homework. Students can work with each other, but direct copying is not possible since each student receives different values “. Having several allowed attempts and the availability of hints enables many the students to gradually obtain the correct answer.

Suggested online quizzes

Suggested online quizzes

- Interactive online introductory physics, multiple choice quizzes are for example available through the Mc Graw Hill Education Publisher.
- I encourage my students to make use of these freely available resources to deepen and test their understanding of physics concepts.

Preview Chapter 13:Study Quiz 1

Start again

1 Simple harmonic motion occurs when

Choose one answer.

- a. Any periodic motion is generated.
- b. Motion repeats itself
- c. Periodic motion is generated by a linear restoring force
- d. The restoring force is proportional to the square of the displacement.

2 A spring is stretched 15.0 cm from its rest position. An 84.0 g mass attached to the end of the spring then released from rest makes 18.0 vibrations in 14.6 s. What is the force constant of the spring?

Choose one answer.

- a. 4.09 N/m
- b. 1.56 x 10^{-2} N/m
- c. 5.04 N/m
- d. 8.02 x 10^{2} N/m

3 What was the speed of the mass in the previous question when it was 8.00 cm from the rest position?

Choose one answer.

- a. 1.16 m/s
- b. 0.492 m/s
- c. 1.52 m/s
- d. 0.983 m/s

5 A pendulum has a length of 1.26 m. What must be the mass of the bob if the period is 2.25 s?

Choose one answer.

- a. 1.62 kg
- b. The period does not depend on the mass of the bob.
- c. 84.9 g
- d. 2.86 kg

6 By what amount must you change the length of a pendulum to triple the period?

Choose one answer.

- a. Multiply the length by 9.
- b. Multiply the length by 3.
- c. Divide the length by 3
- d. Divide the length by 9

7 The graph of velocity versus time for an object undergoing simple harmonic motion is a

Choose one answer.

- a. sinusoidal curve
- b. parabola
- c. Straight line
- d. Cubic curve

https://www.mheducation.ca/school/learningcentres/mod/quiz/attempt.php?id=16403

Qualititative feedback received from students

Observations of student’s performance after using the teaching tools discussed here:

- the students curiosity and inquisitive nature is stimulated
- the students give more complex and thorough or precise answers
- the students make more effort to understand physics phenomena and explain them by themselves making reference to physical formulas
- the students are more familiar with mathematical modelling and its uses to better understand physics concepts
- improved overall class performance

https://www.mheducation.ca/school/learningcentres/mod/quiz/attempt.php?id=16403

Summary and directions for future pedagogical explorations

- In long run this approach will help me become a more effective teacher, a teacher that is flexible in her teaching / learning approaches and can adapt easily for example to new tasks such as teaching online courses.

- In the future I intend to:

- create more opportunities for the students to phrase questions for their peers based on the content taught in class,
- to have the students work in small groups with a "spokesperson" for each group that would present the solution
- to stimulate in class discussions by which the students can propose examples or situations relevant to the concepts

References

1. Kaya, S. (2015). The effect of the type of achievement grouping on students' question generation in science. Australian Educational Researcher, 42, 429-441.

2. Langley, D. V., & Arieli, R. (2016). Ask the Simulation: Challenging Questions and Visual Answers for Project- Oriented Learning. In L.-J. Thoms & R. Girwidz (Eds.), *Proceedings of the 20th International Conference on Multimedia in Physics Teaching and Learning* (pp. 31–38). European Physical Society.

3. http://www.animations.physics.unsw.edu.au/

4. Hatsidimitris, G. and Wolfe, J. (2010a),Third Biennial Threshold Concepts Symposium; Exploring transformative dimensions of threshold concepts: The University of New South Wales.

5. Testa, I., Colantonio, A., Galano, S., Leccia, S., & Puddu, E. (2016). Students' Difficulties in Interpreting Images and Simulations About Astronomy Phenomena. In L.-J. Thoms & R. Girwidz (Eds.), *Proceedings of the 20th International Conference on Multimedia in Physics Teaching and Learning* (pp. 39–46). European Physical Society.

6. Encyclopedia of Pedagogy, 1997.

7. Basa, I. (2016). Application of Computer Simulations in Modern Physics Education. In L.-J. Thoms & R. Girwidz (Eds.), *Proceedings of the 20th International Conference on Multimedia in Physics Teaching and Learning* (pp. 47–53). European Physical Society.

8. Brodeur, M., Braithwaite, N., Kolb, U., & Minocha, S. (2016). Improving Undergraduate Engagement with Online Labs: Student Priorities and Strategies for Virtual and Remote Investigations. In L.-J. Thoms & R. Girwidz (Eds.), Proceedings of the 20th International Conference on Multimedia in Physics Teaching and Learning (pp. 71–78). EPS

9. https://www.aapt.org/docdirectory/.../SM14/AAPT-2014July-final-KrisThompson.pdf