Learning Introductory Mechanics Via Pre-lecture Online Quiz, Multimedia Animation, Demonstrations and Video-tapes of the Demonstrations

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ABSTRACT

Pre-lecture online quizzes encourage students to read the text before the lectures in order to change their mode of study to active learning. Physical phenomena are shown, whenever possible, by live demonstrations every week. The change of physical variables, such as position, velocity and acceleration, based on simplified and idealized models are shown in pictorial as well as numerical representation via web-based interactive multimedia animation and video recording. Preliminary feedback from the students is quite positive.

Keywords

Pre-lecture online quiz, interactive animation, demonstrations, video-tapes

INTRODUCTION

The basic laws and principles in classical mechanics, abstracted from subtle physical phenomena, are not easily observed in daily life. To make matter worse, these phenomena are described by mathematical formulae or equations. Very often, students get bogged down by the mathematics, and lose sight of them. It is therefore very important that the students know the details of the physical phenomena before proceeding to mathematical formulation. This can be accomplished by using interactive multimedia animation, in class demonstration and video imaging. The physical process is broken down into steps and the forces influencing the physical variables of motion are identified in animation and demonstration. The value of class demonstrations has long been recognized. Recent advances in information technology make it easy to disseminate interactive multimedia animation and video imaging online. Although we cannot see phenomena lasting for less than one tenth of a second or less, the physical process can readily be video-taped. Details of it will be visible when the videos are played back in slow motion. Also, recent research studies in physics education in the USA have led to the promotion of active learning as opposed to passive teaching to effectively correct many common misconceptions in physics[1]. As a first step, pre-lecture online quizzes have been implemented in PHYS011, an introductory mechanics course. These encourage students to read the text before attending lectures. That way students will be able to get more out of them. The emphasis is to help students develop the active mode of learning. Physical process and problems are interpreted in pictorial form before converting to

mathematical equations. After the numerical solutions have been obtained, they are also given a physical interpretation.

PROMOTING ACTIVE LEARNING WITH PRE-LECTURE ONLINE QUIZZES

Online quizzes constitute 20% of students' final grade. They take an online quiz each week on the chapter covered, on or before the completion of the lectures on that chapter. Multiple choice problems are selected randomly from the quiz bank provided by the textbook publisher in WebCT platform. The quiz is marked immediately after submission so students who are not satisfied with their performance can do it again immediately or later on. They are allowed to do a quiz three times, the highest score being counted. We found students take these quizzes seriously and read the text before the lecture, as suggested.

INTERACTIVE MULTIMEDIA ANIMATION AND VIDEOS

The influence of an external force on the variables of motion, position, velocity and acceleration, of an object can be shown clearly using multimedia animation. These animations are kept in the *active figure* section in the course website. These figures are supplemented by movies of videos of real events in the *movie* section. The availability of interactive animations allows students to change different variables and see how the development of the phenomenon is dependent on them. This is most helpful in clarifying the subtlety of various physical phenomena. The active figures and movies are provided by the publisher. We have also found a number of websites with useful animations or videos[2]. Links and clips obtained from the internet are grouped in the *lecture notes* section of the course website. The most spectacular video is that of the catastrophic collapse of the Tacoma Bridge in 1940. Other interesting videos include the bed of nails and the shattering of a vibrating wineglass. As these can be played back at low speed, phenomenon too fast to be seen normally can be viewed clearly. Moreover, sports which usually capture the attention of the students provide good illustrations of motions of various kinds. A spectacular image of a sporting event is most captivating. Such images can be found on the internet. An example is the high speed photograph of a racket hitting a tennis ball. It is a pleasure and a surprise to see the severe deformation of the tennis ball. We have recently taken such high speed images with a Canon camera flash light (Speedlite 580EX). We have also taken pictures to illustrate how an athlete can clear a high jump with the "Fosbury Flop" with her/his center of mass below the height. Thus a classroom with internet access is very important. This is not a problem here since most of HKUST's rooms have internet access.

LIVE DEMONSTRATIONS IN CLASS

Recent advances in multimedia animation have led some people to downgrade the importance of live demonstrations in class. The lack of purpose-built lecture theatres for demonstrations in HKUST is a reflection of this sentiment. Although students can follow the successive stages of an event step by step in animation, they do not necessarily feel connected to reality. Live demonstration in class lets them see for themselves what happens. That way they can understand the physical concept by relating the equation to reality. Furthermore, in-class demonstrations can break the monotony of lecturing and help sustain the students' attention. Sometimes, it is even possible to involve them in a demonstration. However live

demonstration, though very desirable, is very demanding in terms of resources and logistics. Setting one up is often quite time consuming. Moving the set-up to the lecture venue can sometimes disturb accurate alignments. For logistical reasons, all demonstrations of a given topic are shown once a week, usually on Wednesdays. When regular demonstrations were first introduced last year, we asked a project assistant to help with the implementation. This year we have an extra teaching assistant to do that. The demonstrations, including both expected and unexpected features, have been well received and appreciated by the students. They enjoy the following most:

- Motion of a slinky
- Collision of two suspended masses with a ratio of 1 to 3
- Gyroscopic precession of a wheel
- Singing rod

We have also video-taped the demonstrations. Interactive features have been incorporated into some of the tapes to actively engage the students. The tapes are posted in the course website and can be repeatedly accessed in the *demo & video* section.

There is room for improvement. More engaging demonstrations should be developed and at least one lecture theatre converted to facilitate live demonstrations.

TRANSFERABLE SKILLS OF SIMPLIFICATION AND IDEALIZATION

The majority of the students taking PHYS011 are engineering students. Less than 10% are physics students. The emphasis of this course is more on understanding the physical concepts and less on mathematical computation. The value of this introductory mechanics course lies in acquiring skills, such as simplification, idealization, approximation, pictorial and mathematical representation and modeling, transferable to other disciplines. The following problem solving strategy is employed. A model is introduced after making simplification and idealization and neglecting less important factors. The solution so obtained is a first approximation. A more accurate solution can be obtained by identifying and including the next important factor in the model. The analysis is then repeated.

This course is taken by two groups of students with very different backgrounds. Whereas the majority is from China, a small group are international students. The Chinese students, who are high achievers, generally are more used to a mathematical approach. Textbooks and instruction in English are a challenge to them. On the other hand, the course is quite challenging to the international students. Both groups are very motivated and find the approach acceptable and the course interesting. Feedback as judged from course evaluation and course grades has been very positive so far.

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