Reforms to PHYS 102

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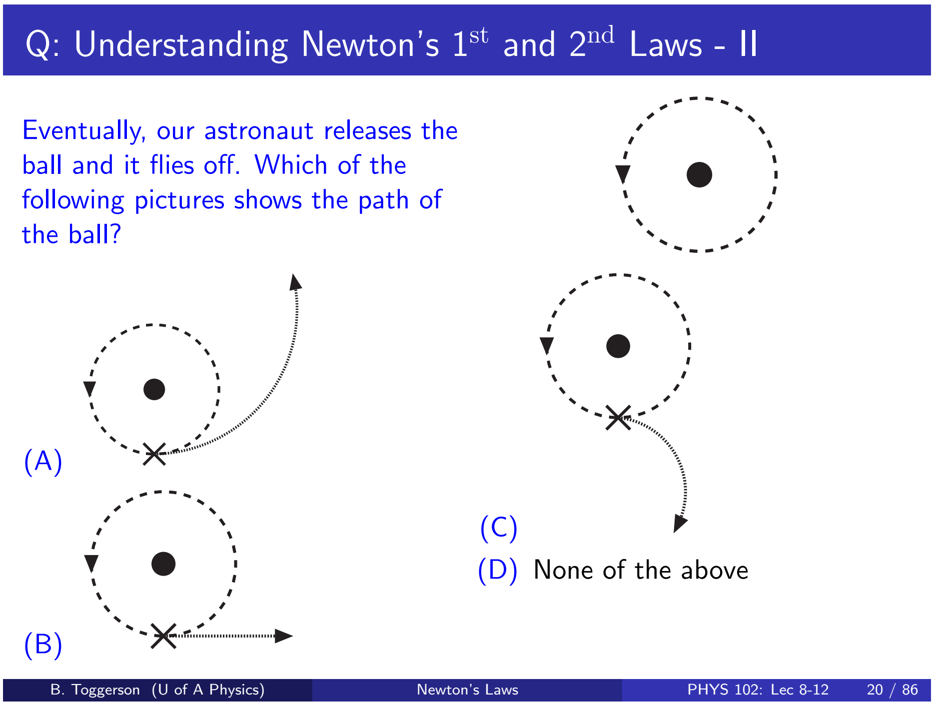
I am currently introducing several reforms into PHYS 102, an algebra-based course introducing the principles of mechanics and thermodynamics. The students in this course are predominately juniors and seniors majoring in the life sciences with a significant fraction in pre-medical programs. Each of the three sections is run by a graduate student TA who deliver lecture materials that I have prepared. In my materials, I have made several reforms which have increased the number and variety of interactive strategies which specifically target the needs of this population.

One of my reforms is the inclusion of think-pair-share and ranking activities during classroom time that emphasize conceptual understanding. At the beginning of my preparations, I reached out to faculty from my students' home departments to determine what skills they thought were important for their students to take away from PHYS 102. The faculty who responded and I agree that a solid conceptual understanding of the fundamental principles of physics is a critical goal. Throughout each unit, and especially during the introduction of a new topic, students are presented with conceptual multiple choice questions such as those in figure below. The number of questions per classroom session averages about eight. For each question, students are given a chance to think individually and answer using a simple folding paper card. If there is a large variation in responses, students are then given about thirty seconds to converse with their neighbors, after which they are given the opportunity to vote again. Teacher-Course Evaluations from previous courses in which I have employed a similar technique, such as my PHYS 103 course last spring, indicate that students, "loved the collaborative teaching style that involved participation and critical thinking from everyone."



Beyond think-pair-share activities, I have also enacted reforms to enhance existing problem solving days through the addition of a problem solving framework which students use to solve problems in groups of three. As discussed in the work of Heller & Heller[1], students often try to approach physics problems through a pattern-matching type approach wherein they try to "learn the pattern of equations to solve different classes of problems. Each class of problems is characterized by a literal feature of the problem, such as the specific action of the objects involved." For example, in this strategy, there are "inclined plane problems" and "tension problems." In contrast, people with expert-style thinking will say that these are all "force problems," as expert-style thinking begins with fundamental principles. To encourage students to begin with physics concepts, students are required to complete the problem on a problem solving worksheet (attached) which I piloted in my PHYS 241 course this past summer and is based upon the work of Heller & Heller. This worksheet has designated space for thinking about the problem in words and pictures before progressing to mathematical thinking.

In addition to the problem solving framework worksheets, I am also reforming the questions posed on problem solving days. In past iterations of this course, students would spend problem solving days working with traditional textbook problems. Such problems typically contain pictures or "physics words" such as "friction-less" or "ramp" that can provide clues for students who engage in a pattern-matching method of solving problems. The content-rich problems predominately used in my class avoid such words and often provide extraneous information to make such pattern-matching strategies difficult. By making pattern-matching difficult, I hope to drive students to a more concept-based problem solving strategy.

To provide support to students during in-class activities and problem solving days, I have added preceptors to the course for the first time. In the past, problem solving days would be staffed by all three TAs, which resulted TA fatigue by the end of the third consecutive section by which point they had seen over 400 students. Beyond in-classroom support, my preceptors have, just this week, begun holding additional help sessions, some of which are later in the evening than traditional office hours, adding flexibility to times during which students can get dedicated PHYS 102 help.

Of course, all of these in-class activities take time that has traditionally been used for content delivery, which, given that the same material is a semester and a half at the calculus-based level, is already at a premium. In order to compensate, I have partially flipped my classroom moving some of the content introduction into online videos that I have made and posted to a course YouTube channel: http://www.youtube.com/user/UofAzPhys102. As an example, students were introduced to the ideas of vectors and vector components in class. Between that class and the next, students watched a seven minute video demonstrating that to add vectors one should add the x-components and the y-components separately, and took a simple three-question quiz on this information. By teaching this concept in a video, I was then able to spend more time in the next class on a concept with which students typically struggle: discussing the graphical interpretation of vector addition. As of today, students have had a total of 20 hours of classroom time and have watched and been quizzed on a total of 1.5 hours of video. All three sections combined contain a total of 422 students as of the first exam. By looking at the analytics provided by Google, I know that my videos are typically watched on 388 different devices, meaning that a large fraction of the class is watching the videos. The retention rate is also quite high with students watching on average 80.2% of the five most recent videos. This technology has been instrumental in keeping the class on-track to cover all of the material and, while this is not a scientific result, several students have provided unsolicited positive feedback.

As previously discussed, data on the impact of these reforms is limited due to the fact that this is my first time teaching this course. However I do have data from my first exam which took place at

[1] Heller K, Heller P. *Cooperative problem solving in physics a users manual: Why? What? How?* In: AAPT New Faculty Conference. 2010 URL:
http://www.aapt.org/Conferences/newfaculty/upload/Coop-Problem-Solving-Guide.pdf .

the beginning of October. The table below summarizes the average and standard deviation on the first exam for each section, compared with two previous iterations of the course: Prof. Sean Fleming's course from the spring of 2014 and Dr. Ingrid Novodvorsky's course from spring of 2008. These are the three versions of the course for which I have data. I have neither the TA names nor the standard deviation for the spring 2008 class. Note, the exams are not the same as each instructor wrote their own exam. All grades are normalized to a 100 point scale. Even with these caveats, the 2:00pm and 3:00pm sections seem to suggest some improvement. Furthermore, the difference between the 1:00pm section and the 3:00pm section has decreased.

	Spring 2008	Spring 2014		Fall 2014	
Section	I. Novodvorsky	S. Fleming		B. Toggerson	
Start time	Exam I	TA	Exam I	TA	Exam I
1:00pm	62	R. Cross	69 ± 21	M. Formanek	67 ± 16
2:00pm	56	M. Roberts	56 ± 22	M. Kirby	63 ± 21
3:00pm	53	N. Lysne	49 ± 25	R. Cross	57 ± 18

I plan to collect more data as the semester progresses. Some planned activities include measuring performance on standard Force Concept Inventory questions, as well as an anonymous midterm course evaluation to determine student opinion of some of these specific reforms such as the problem solving framework and the YouTube videos. I am looking forward to the results of these data collection efforts and plan to make adjustments accordingly.