Dynamics for D's: Avoiding Multiple Failures in a High Risk Course

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Introduction

Student struggles with dynamics are well documented. At our institution, students often fail the course multiple times, delaying their graduation or even demotivating them to pursue engineering. We postulate that students taking it multiple times may not get much out of having material presented in the same basic linear fashion. To help counter this issue of multiple failures, we offered an invitation-only section to students who had previously received a D, F, W (withdrew) or I (incomplete) in the preceding two quarters. The goals of this project were: 1) to provide the opportunity for students to immediately re-enroll after not passing and 2) to try and prevent students from failing ME212 multiple times by providing a section that focusses on conceptual understanding and problem solving, and 3) to provide students with a stronger background in dynamics for follow-on courses.

Course Cohorts

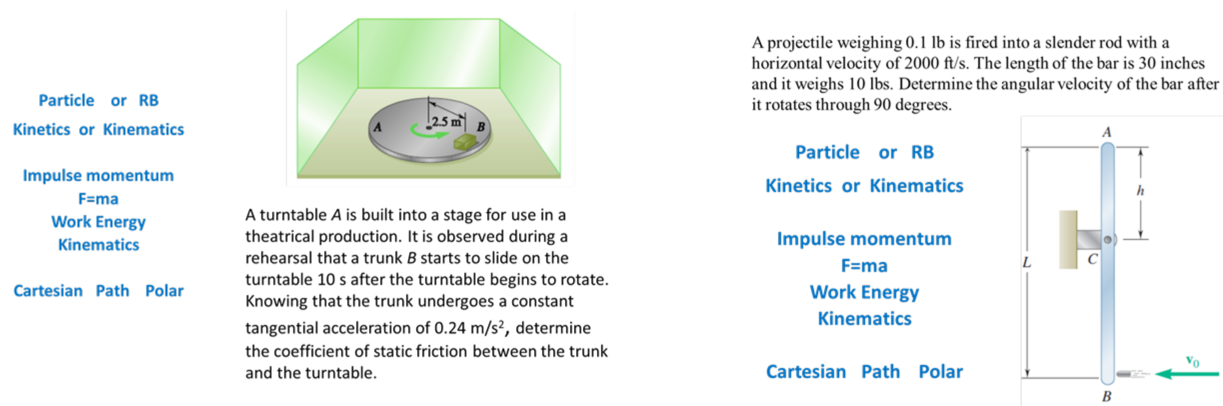
As part of a California State University graduation rate initiative, in the past we were able to offer the special section of the course three different times. Because of the lower number of students enrolled in these sections, it takes additional resources and we are considering if we should offer it again. All offerings were presented in a flipped format, with numerous example problems and lecture material offered in short videos for students to watch before class. The first offering was in Spring of 2019 – the winter quarter provides our largest number of students, typically 13-15 sections of approximately 32 students each. This first offering was hybrid, with two in-person meetings (50 minutes) and one online asynchronous module. Twenty-three students enrolled: two students had taken the class three times before, five students had taken it twice before and the remaining 16 had taken it once before. Twenty of the students had taken the class most recently in Winter 2019.

In the Winter quarter of 2020, twenty students enrolled in the course, which was taught face-to-face in two 80-minute sessions. Because of the pandemic, the common final exam in Winter 2020 was given virtually. After this exam, a large number of students in all sections violated academic integrity obligations on their examination and subsequently failed the course. It is estimated that a large number of these students were in the Spring 2020 special offering of the class, which had 35 students; therefore, it is difficult to determine the level of preparation for these enrolled students. The 2020 Spring quarter offering of the class was of course taught online. Because of staffing issues, we have not been able to offer the section since.

Course Format

As mentioned previously, the class was offered in a flipped format, with online video short lectures and example problems. We utilized undergraduate Learning Assistants (LAs) in each course cohort. The Learning Assistant model consists of three basic principles: the LAs receive instruction in pedagogical strategies, they work closely with the instructors to understand and help plan course activities, and they help the instructor facilitate active learning during class meetings (Cao et al, 2018). In the first attempt, Spring 2019, we did not do a particularly good job of implementing the LA model and did have the LAs take a course in pedagogical strategies. They did take the course from the professor, so were familiar with his teaching strategies. In the following quarters they took part in a pedagogical course offered by the physics department at our university. During Spring 2020, the LAs visited different breakout rooms as students worked through concept questions and problem solving.

Although a review of the material was provided in a similar linear fashion as normal, about half of each class was spent doing “What Approach” conceptual problems. We have found that most students who don’t not succeed in the course can generally do the algorithmic problem solving, but particularly struggle identifying the most efficient type of approach to use (e.g., they apply work-energy instead of impulse momentum, or try to apply Newton’s second law to a kinematics problem). One example of this is shown in Figure 1. These problems were typically assigned in a think-pair-share fashion, where students looked at 2-3 of these problems on their own to formulate their strategy. Two examples of this are shown in Figure 1.



(a) (b)

Figure 1. Examples of "What Approach" problems

Note that these types of problems could be assigned at any point in the course, including Day 1. In some cases, they might even have to identify multiple principles, such as in Figure 1(b). They have seen the material before, and need as much interleaved practice as possible (Rohrer, et al, 2015). Spacing effects, or providing multiple, spaced out opportunities for retrieval practice and application, have been shown to improve student learning (Bude, 2011).

During the first cohort, these “What Approach” problems were simply assigned and discussed during the first part of the class time, then we would go into specific topics more in depth. These topics still followed a typical linear sequence: particle kinematics, particle kinetics, rigid body kinematics, then rigid body kinetics. More time was spent on rigid body dynamics, as suggested by Fang’s (2014) study on what students consider difficult in dynamics classes.

After end of course feedback from our first cohort, in subsequent quarters we often worked out one of the “What Approach” problems at the end of class. Other problems were assigned as optional problems in the publisher’s online homework tool so that students could attempt the problems and get immediate feedback.

Outcomes of the Special Section of Dynamics

The Spring 2019 is the only quarter in which we looked at actual grades and scores. The pandemic interrupted the two other cohorts, and students were also allowed to take their course credit/no credit. Different forms of subjective survey data are reported for all three cohorts.

A comparison of DFW (D, F, or withdraw) and FWI (F, withdraw, incomplete) rates between the treatment section and all other sections for the Spring 2019 quarter is given in Table 1. No significant differences in these rates are found. Table 2 shows the comparison of Final Exam scores the treatment section, the non-treatment section by the same professor, and all other sections. Note that all sections take the same exam and have the same graders for consistency. The treatment section average was quite good compared to the other sections, although it was similar to the professor’s non-treatment section.

Table 1. D-F – Withdrawal – Incomplete rates for dynamics students, Spring 2019

ME212 DFWI Spring 2019	# of Students	DFWs	FWIs	DFW %	FWI%
All Sections (different professors)	200	53	28	26.5%	14.0%
Treatment Section	23	7	3	30.4%	13.0%
Non-Treatment Sections (same professor)	177	46	25	26.0%	14.1%

Table 2. Exam scores, Spring 2019 cohort.

ME212 Final Exam Scores	# of Exams	Average Score
Treatment Section	22	65.7%
Non-treatment sections	23	64.5%
All other Sections (n=6)	145	58.5%

Use of Learning Assistants

During a Spring 2020 mid-quarter survey, students answered a Likert question concerning the LAs. Results are shown in Figure 2.

The Learning Assistants have been effective during class:

Strongly agree	10 respondents	**40 %**
Agree	10 respondents	40 %
Neither agree nor disagree	4 respondents	16 %
Disagree	1 respondents	4 %
Strongly disagree		0 %

Figure 2. Student responses to if LAs were effective.

Comments included "They are very helpful in the break out rooms" and "They have been really helpful this quarter and super approachable." Both Spring 2019 and Spring 2020 students were asked about the effectiveness of the "What Approach" problems.

How helpful were the "What approach?" problems we did in class?

Response	Average	Total
Very helpful	77%	10
Slightly helpful	23%	3
Total responses to question	100%	13/13

Figure 3. Spring 2019 responses to helpfulness of the "What Approach" problems.

Doing the "What approach" problem helps me think about what principle(s) to apply in a dynamics problem.

Strongly agree	14 respondents	56 %
Agree	9 respondents	36 %
Neither agree nor disagree	1 respondents	4 %
Disagree	1 respondents	4 %
Strongly disagree		0 %

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Figure 4. Spring 2020 responses usefulness of the "What Approach" problems

Students in Spring of 2019 were also asked if the special section should be offered again in the future. Results are shown in Figure 5.

This special review format type of section should be repeated next year.

Response	Average	Total
Strongly agree	77%	10
Agree	15%	2
Neither agree nor disagree	8%	1
Total responses to question	100%	13/13

Figure 5. Student responses to if this type of sections should be offered in the future.

In Spring 2019, we asked the students "What did you do differently this quarter than the last time you took dynamics?" Responses included:

> *Studied, did practice problems, attempted all of the homework. Actually learned a lot more this quarter.*
>
> *I focused more on approach, and I didn't use online answers when doing homework and problems.*
>
> *I studied up on more of the conceptual problems and I also tried very hard to identify the problems before doing them. Last quarter we just kept going over examples and I guess I didn't really understand the problems fully,*

Discussion

The DFW numbers from Spring 2019 (see Table 1) were a little disappointing. Of the three students who failed, two were taking the class for the third time and one was taking the class for the fourth time. For the other four students who had taken the class two or more times prior, one earned an A, another a C and two earned D's.

Subjective feedback was for the most part positive. The interweaved practice seemed to be appreciated by the students, and could potentially be expanded in future offerings. Students understand that the majority of their assessment, particularly on the final exam, will be based on problem solving. Perhaps we could attempt to entirely interleave the course, working problems from throughout the course syllabus each lesson. Some might even suggest using mastery techniques, or asynchronous online methods so students could practice at their own pace. Using such approaches might sacrifice the sense of community that was developed in the classroom, and the collaborative problem-solving techniques that were appreciated by the majority of students.

Conclusions

In general, the students seem to appreciate the approach taken in the course and can be successful in the class if they put in the required work. Initially we were concerned that students might be hesitant to enroll in a section where everyone knew they had not been successful the first (or second) time around. We actually found the opposite to have occurred – the students seemed to form community and were willing to help one another out.

References

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