



## Parachute Courses: Reducing DFW Rates in Introductory Calculus-based Physics

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## General Physics 1 is a Killer Course

with or without calculus DFW rates of 20-60%

#### Why?

- Course covers an enormous amount of material often better than a chapter a week
- Assumes a good understanding of math prerequisites

   Algebra, Trigonometry and often Calculus
- Many concepts are counter-intuitive
- Students learning new thinking and math skills as well as new content
- Often hard to visualize what is going on
- Course structure based on premise that students had physics in high school



- \* If we want more students to earn STEM degrees, we need introductory physics to be more of a pump, than a filter.
- \* How do we keep more students in the STEM pipeline with an introductory physics sequence that assumes students have a good background from prior math and physics classes?



\* How do we improve student learning outcomes and passing rates?

#### Defining the problem further:

#### Two key needs

- \*Without changing the course, how do we bring students who fail General Physics 1 to where they need to be, so they can be successful when they retake it.
- \*How do we keep students from failing the first time so they don't risk losing scholarships/financial aid (reduced credits, lower GPA).



#### Background

- Southwestern urban university less <10% of students living on campus</li>
- Academic rating = 180<sup>th</sup> tied (US News & World Report 2016 Best Colleges) Engineering College ranked 14th nationally (Princeton Review)
- Enrollment = 27,000 students (20,000 undergraduates)
- Student average age = 24 large fraction of 1<sup>st</sup> generation college students



#### Background

- Student Population: 40% Hispanic / 5% Native American
- Many students on scholarship; most provided by state lottery scholarship program
- Six year graduation rate is 47%
- Freshman retention rate is 77%



#### General Physics 1

- Course is primarily for engineering majors / some physics majors
- 3 credit 3 hours/week lecture in 275-student lecture hall with excellent demonstration facility attached
- Optional 1 hour/week problem solving (discussion) section taught by lead instructor – taken by 10-40% of students
- Optional (required by some majors) separate 1 credit 3 hour/week lab
- DFW (failure to pass with a C or better) rate of 40-70%



## Solution = A Parachute Course

#### Make it a parachute course:

 A course that students can switch into mid-semester (2<sup>nd</sup> half-semester course), giving them a 2<sup>nd</sup> chance in General Physics 1 and preventing them from failing



 Help students build the skills and knowledge they need to be successful in General Physics 1





- More intense, Four 75 minute meetings per week
- Uses integrated lecture/lab with activity-based learning
- Have it meet before 9 AM => minimal interference with other classes (or after 6 PM)





- Physics 110 meets MTuWTh from 7:30-8:45 AM in a lab or studio classroom
- Students sign form to switch into the Parachute Course; Register processes form manually to remove General Physics 1 from student transcript and add Parachute Course
- No cost to students for switching; Instructor switches students online homework & e-textbook that emphasizes conceptual understanding, visualizations, & problem solving
- Until recently, some students take Parachute Course as physics prep class to prepare for General Physics 1 (more later)

#### Course Format

- Curriculum is adopted from award-winning high school curriculum => ASU Modeling Instruction with extra material on problem solving, vector analysis, & symbolic algebra
- Mostly learning by doing, minimal lecturing
- Each activity ends with student group(s) presenting work to class
   followed by class Q and A discussion
- Course pace slower with less homework than General Physics 1
- Students can pass with a C with good effort, but students told B or better is needed to succeed when retaking General Physics 1

#### **Typical Unit**

- Starts with visualization diagrams and/or graphs from observations and experiments
- Key Ideas & Equations are derived from experiments & observations
- Students summarize each activity on a whiteboard
- End of each activity is a white board Q & A session
   => board meeting groups get up and present activity results



## Typical Unit (cont.)

- Problem worksheets assigned to practice applying concepts
- Students work in groups on worksheets in class and present/discuss results in class before submitting as homework
- Sometimes follow-up experiments are used to modify/deepen the model
- General Physics 1 HW problems assigned in Mastering Physics



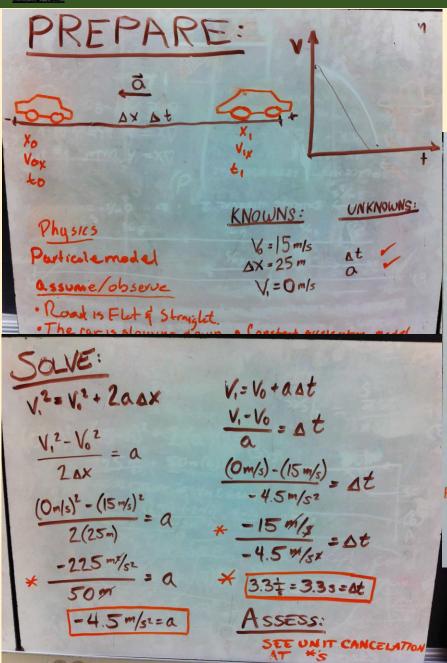
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#### Emphasis on Good PS Practice in class

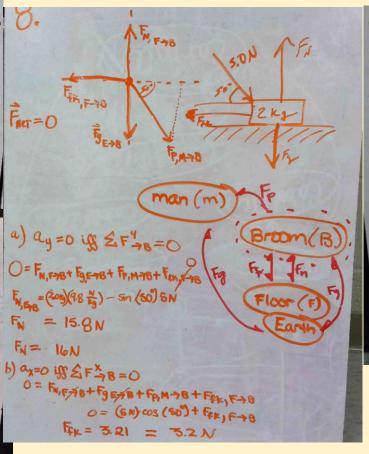
- Students are taught an expert problem solving strategy SPS – Strategic Problem Solving
- Start by visualizing the problem with diagrams and graphs
- Then identify the key concept(s)
- Working problems step-by-step on paper
- Every calculation is preceded by solving for the unknown in symbols => all algebra done in symbols
- Course material is centered on building, understanding, and applying essential force & motion models

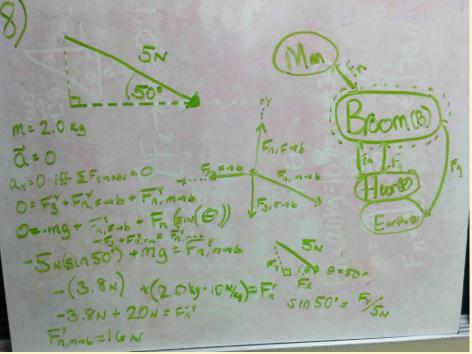
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## Sample Whiteboards







#### Does it work?

Two criteria

1. Helping struggling students in General Physics 1 not fail and maintain their semester credits and their GPA

2. Helping students develop knowledge and skills needed to pass General Physics 1 course when they retake it



#### Criteria 1

- 1. Helping struggling students in General Physics 1 not fail and maintain their semester credits and their GPA
- 79% of students taking the parachute class passed with at least a C.

**TABLE 1.** UNM Physics parachute course results over 11 semesters.

Term	Course Size	DFWs	B or Better
Fall 2009	21	3	12
Spring 2010	25	2	13
Fall 2010	25	7	12
Spring 2011	31	9	11
Fall 2011	40	3	19
Fall 2012 [12]	54	8	12
Spring 2013	26	8	8
Fall 2013	43	6	32
Spring 2014	16	4	7
Fall 2014	29	10	13
Spring 2015*	75	22	34
Totals	385	21%	45%

\* Large student numbers required teaching parachute course as an evening section in physics lecture hall.

#### Criteria 2

- 2. Helping students develop knowledge and skills needed to pass General Physics 1 course when they retake it
  - This was trickier. Coulombe did a longitudinal study of students who retook General Physics 1
    - 105 students took the parachute course before retaking
    - 180 students retook the course without taking parachute course



#### Criteria 2

- 2. Helping students develop knowledge and skills needed to pass General Physics 1 course when they retake it
  - Coulombe did a longitudinal study of students who retook General Physics 1
    - Letter grades converted to 12 point numeric scale
    - Ran linear regression analysis using R (Lavaan equation modeling package) of several factors including student GPA and SAT/ACT.

#### Criteria 2 Results

- 2. Helping students develop knowledge and needed to pass General Physics 1 (<u>GP1</u>) course when they retake it
  - Although students who did not take the parachute course has a slightly lower mean grade when retaking GP1 (C vs. C+, p < 0.447, <u>not</u> statistically significant)
  - Students who passed parachute class with a grade lower than B had lower mean grade when retaking GP1 than students who passed with a B or better (C- vs. C+/B-, p < 0.001, <u>is</u> statistically significant)



### Criteria 2 Results

- 2. Helping students develop knowledge and skills needed to pass General Physics 1 (GP1) course when they retake it
  - Students who passed parachute course with B or better had a higher mean grade when retaking GP1 than students who retook GP1 without taking the parachute course (C+/B- vs. C/C+, p < 0.01, <u>is</u> statistically significant)
  - However, when students' GPA taken into account, this last result is <u>no</u> <u>longer statistically significant</u> (p < 0.716)</li>
  - Student GPA correlated strongly with grade in GP1 in general (Wald z = 12.58 p < 0.001)</li>



#### Criteria 2 Results

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- However, when students' GPA taken into account, this last result is <u>no</u> <u>longer statistically significant</u> (p < 0.716)</li>

This result suggests that of the students switching or dropping GP1, the students with higher GPA (better students?) are taking the parachute course.



#### **Result Summary**

- The current Parachute Course does a good job of improving student retention by helping students maintain their GPA (79% success rate).
- For students in the Parachute Course, achieving a "B" or better helps students succeed when retaking General Physics 1
- Although at first glance, it looks like the Parachute Course helped students achieving a "B" or better in that course performed better in General Physics 1, the difference closes to statistical insignificance when students' general GPA is taken into account.



#### Discussion

- Further study is needed to determine whether the Parachute Course helps students succeed when retaking General Physics 1
  - If not, then a redesign to make the course more effective or other options should be considered
- A similar course at University of Illinois has changed to a full semester prep class that students can switch into from General Physics 1 during the add/drop period (Gary Gladding).
- At this school, a one-semester prep class has been implemented in parallel with the parachute course. The students who previously took the parachute course as a prep course not take this class.

Thought for the day: A good engineer is one who has made the right mistakes and learned from them

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are part of life. If you don't fail, you don't learn. If you don't learn you'll never change.

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