Application of Team-Based Learning to a First Semester IPLS Course

Physics 131: *Forces, Energy and Entropy*

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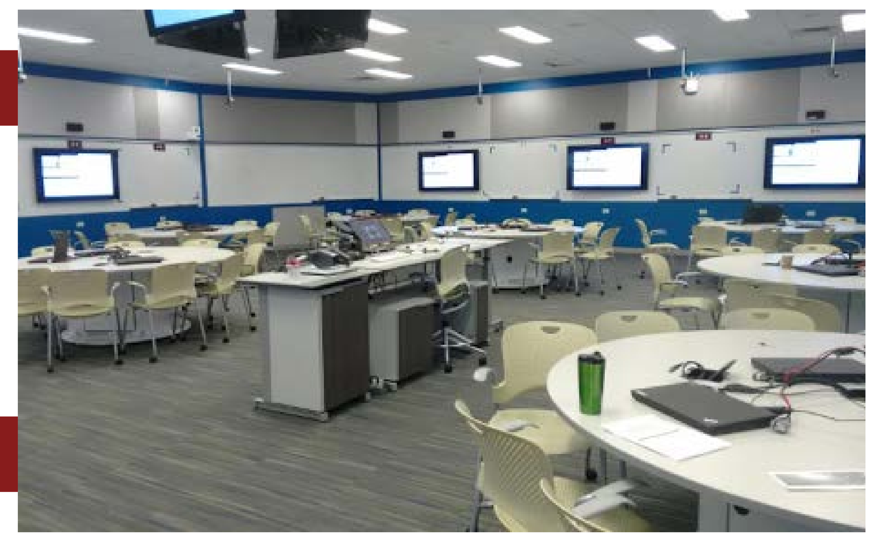
Open Education Initiative

1. Motivation:

What is TBL?[1]

- Students are strategically placed into diverse groups
- They are expected to prepare for course material outside of class
- Focus on application of material during class



Why use it in IPLS-I?

- Few actual facts to be memorized
- Mostly in application of ideas and developing good problem solving skills
- The TBL environment allows us to work with students on challenging problems to develop problem-solving skills

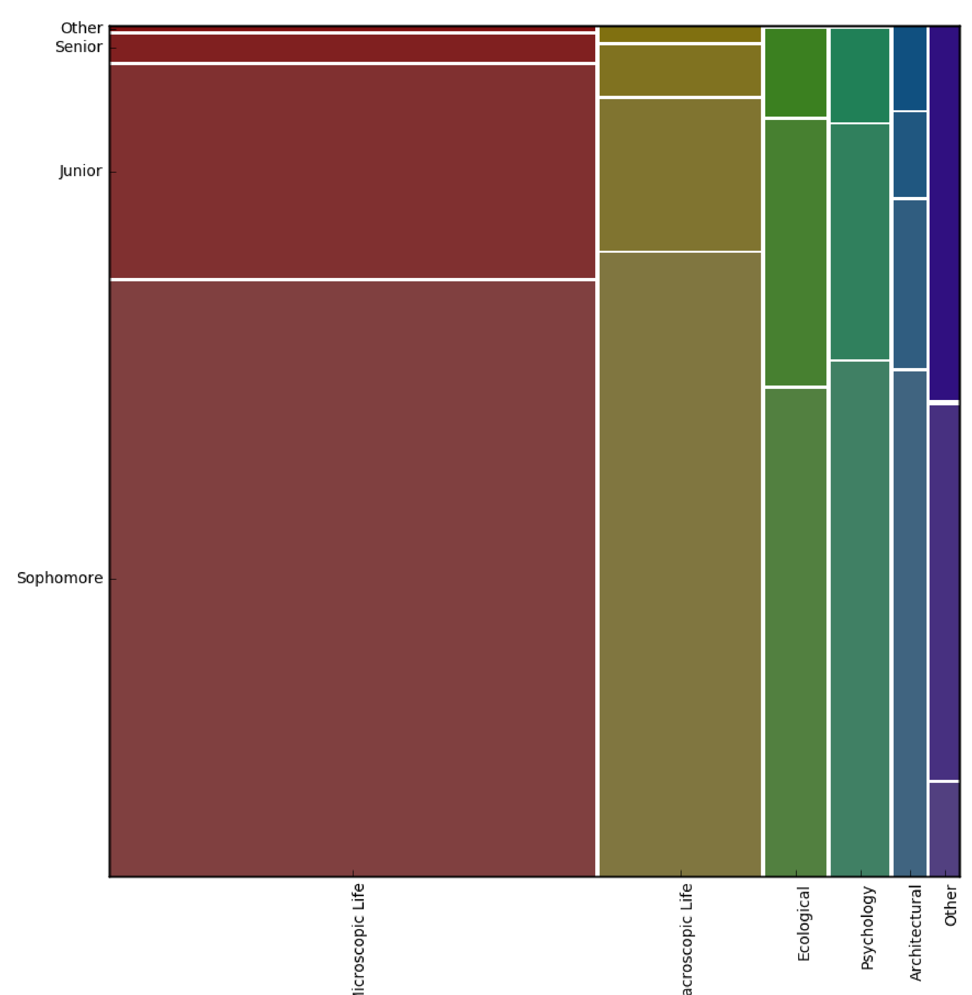
2. Overview of Physics 131, An Algebra-Based IPLS-1 course:

Course Goals

- Physics is a list of principles NOT a list of equations
- Principles can be expressed in multiple ways
- Appreciate physics-style problem solving method
- Generalization
- Connect physics to everyday experience and other courses

Categories of Majors

- Microscopic Life – Biology, Microbiology, and Biochemistry
- Macroscopic Life – Kinesiology, Animal Science, etc.
- Ecological – Environmental Science, Public Health



3. Guiding Principles of Course Design:

Backward Design[2]

"What students should be able to *do*"

- Goals:
  - What are the big questions?
  - What should students know in five years?
- Objectives:
  - Measurable behaviors demonstrating progress towards goals
  - Design exams to measure objectives
  - Work to get your students there!

Why use it?

- Buy-in is improved if: Homework → Class → Exam chain is obvious to the students.[3][4]

The majority of 131 students are life-science majors

Problem solving focuses on skills and question content relevant to this population[5]

- Quantitative models of biological systems
- Unified picture of energy microscopic → macroscopic
- See how this physics gives them insight into how biological structures behave

4. Course Structure:

Five Units

I. Mathematical Tools and Foundational Concepts	• Nature of measurement • Graphs • Simulations
II. Forces	• Newton's Laws
III. Forces and…	• Impulse (F & t) • Static torque (F & position) • Work (F & d)
IV. Energy	• Macros: springs, gravity • Micro: temperature, chemical • Transfer: Work, heat
V. Entropy	• Statistical interpretation • Combined systems

Within Each Unit

Preparation – Students are responsible for learning basic content

Content delivery through videos/reading in a custom textbook	Formative homework to develop understanding

↓

First day of unit – Assessment on preparation

Students take a 10-question multiple choice quiz individually	Complete the ***same*** quiz as a team (50/50 split)

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In-class activities – Start from prep

Active learning methods focusing on application	No ***required*** end-of-unit homework

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Exam

In-class connection ***must*** be apparent ***to students***	Learning experience – afterwards students complete as team (75/25)

5. Teams:

Formation

CATME[6]

- Create heterogeneous teams based upon survey results
- Inherently tries to minimize soloing of women and other underrepresented minorities (URM)
- No changing of teams

Size

Five students per team

- Michaelsen et al. suggests teams of 5 – 7 students[1]
- The UMass TBL room is setup for three teams of 3 people at a table of 9
- We run two teams of 5 at a table of 10

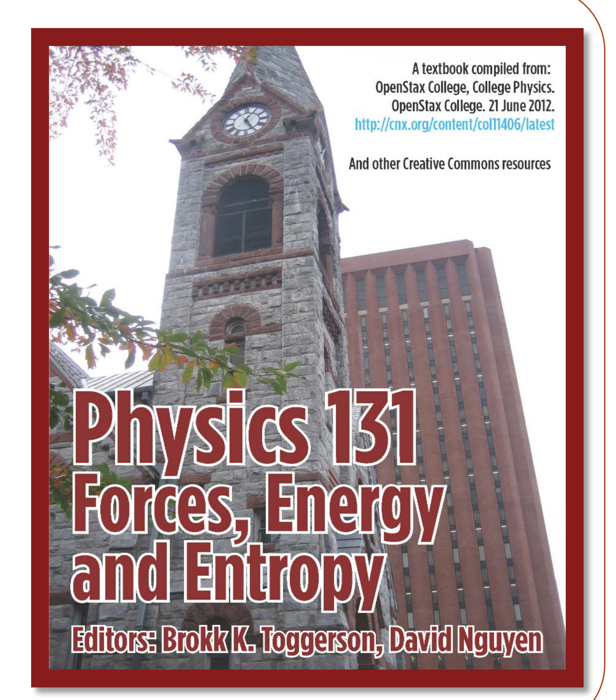
No team roles

Contrast to other studio formats

- Following Michaelsen et al[1]
- Students work out their own patterns over time

6. Preparation, Custom Textbook and Open Educational Resources:

- With support from the Open-Education Initiative at the W.E.B. du Bois library at UMass-Amherst, an undergraduate student and I compiled a custom textbook to facilitate preparation
- https://scholarworks.umass.edu/physics_ed_materials/1/
- Book is free-to-students
- Completed in ***one summer***
- Started from the OpenStax *College Physics* textbook
- Added custom material
  - Text
  - Videos with transcripts
- Instructor's Notes help 131 students focus on key points for preparation
- Response has been positive



7. Lab:

No separate lab time

- Class meets for 75min 3-times per week
- Can do lab at any time
- Can split a lab over several days
- Can interleave lab and other activities
- Can use lab for any part of the learning cycle[7]

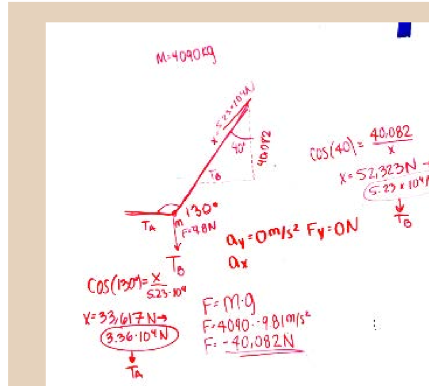
Labs

- Testing understanding of motion graph ←→ story using ioLab carts
- Writing simulations in Excel to understand the flight of objects
- Mathematical modeling and limitations of empirical force laws
- Adapted a University of Southern California biomechanics 408 lab using a force plate to investigate impulse[8]
- Monty Hall problem
- Flipping coins to understand free expansion

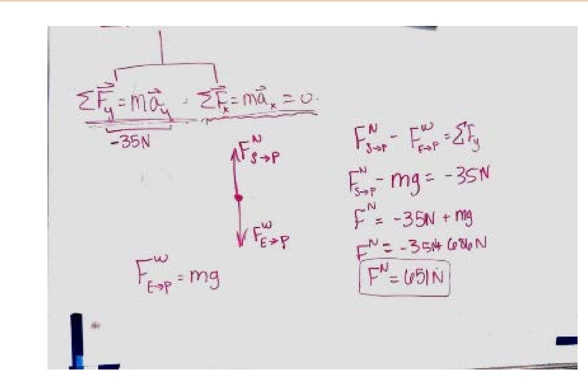
8. Other In-Class Activities:

At-the-board problem solving

- Model problem solving followed by students working
  - TBL allows instructors to give *immediate* feedback on technique ***when the students need it***
- At the board is ***key***
  - Allows instructors to see who is stuck
  - Students work differently at the board
  - Instructors can engage more effectively with teams
  - Takes training of students

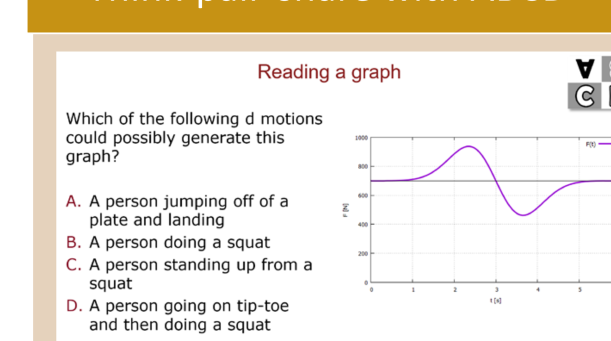


First Newton's Law Problem



Fourth problem, one week later

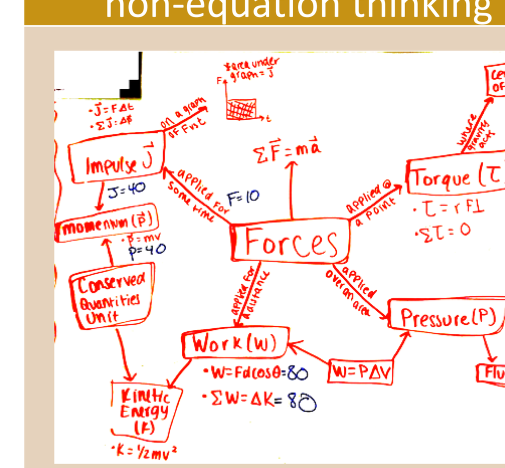
Think-pair-share with ABCD[9]



- Used to enhance conceptual understanding
- Allows students to test their knowledge without team
- Use a folding piece of paper instead of a clicker as in [10]

Other activities to promote non-equation thinking

- Making concept maps: focus on the connections between ideas
- Writing definitions for physics terms: focus on clear understanding of the ideas and ability to articulate



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