Case Studies for Small-Group Student Collaboration in Large-Enrollment Introductory Physics Classes

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Goals

- Improve students conceptual learning in large-enrollment introductory physics courses for science and engineering programs using Case Studies format for small-group collaborative activities
- Develop Case Studies that explore the fundamental physics principles through realistic physics scenarios
- Increase students’ engagement

Motivation

- The benefits of peer collaborations in large courses are well-documented [1,2], but typical Peer Instruction often rely on using oversimplified questions presented in a multiple-choice format.
- The main disadvantages of multiple choice format are not giving the students an opportunity to formulate their own ideas and the questions not being open-ended.
- We aimed at creating more open-ended study materials that would also present more realistic physics scenarios thus reducing the reliance on multiple choice questions.

Fostering Students Collaborations

- This project was envisioned before the COVID-19 pandemic and was intended for use during regular on-campus courses.
- However, the switch to remote teaching during the pandemic, and the resulting students' isolation created even more pressing need for student collaboration and community-building.

Background

- This proposal is based on some earlier work [3, 4].
- It involved introducing stand-alone collaborative group activities based on cognitive conflict that replaced the Peer Instruction activities for a limited number of topics [3].
- The analysis of Fall 2007 class intervention demonstrated the high effectiveness of small-group discussions, but at that time, the ability to collect responses to non-multiple choice inquires was limited, as well as the ability to collaborate was also restricted to the nearest neighbors in the classroom.

Case Studies Development

- The instructional materials in the form of Case Studies were prepared with the assistance of an upper year student and a recent graduate from Medical Physics program.
- **Case Studies assignments (worksheets), discussion items, plausible solutions and answers set, as well as grading rubrics** were developed.
- Each of the Case Studies targets common student misconceptions.
- Each Case Study presents a realistic, plausible scenario, and as such, often introduces more than one concept.

Case Studies for Mechanics Content

- Free Fall: Dropping a sandbag from a vertically moving balloon
- Projectile motion: Throwing a sandbag from a vertically moving balloon
- Air resistance: A record-setting jump from a stratosphere
- Conservation of energy, normal force, dynamics of circular motion
- Conservation of a linear momentum: an investigation of a collision

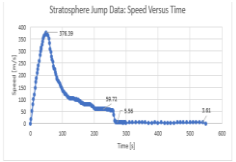
Example of Case Studies

Sky Diving : Record-setting Jump from A Stratosphere

For example, a case study on air resistance and terminal velocity is based on the data log from a record 2011 jump from the stratosphere.

Your group is going to analyze a real event. On October 14, 2012, the Austrian skydiver and Red Bull athlete Felix Baumgartner fascinated millions watching live from around the world when he completed a record-breaking parachute jump from the edge of space. Baumgartner ascended to an altitude of 39,045 meters in a helium balloon where he jumped to Earth from the stratosphere. At the time of his adventure, he broke the world records for the highest "freefall" and the highest manned balloon flight, as well as becoming the first person to break the sound barrier while sky diving. This feat came exactly 65 years after Chuck Yeager first broke the sound barrier while flying in a rocket-powered airplane. The 43-year-old expert reached a maximum of speed of 1,357.6 km/h (Mach 1.25) through the near vacuum of the stratosphere before being slowed by the atmosphere later during his 4:19 minute long fall.

Image from: https://www.usatoday.com/story/money/business/2012/10/15/red-bull-skydiver/1635235/



Sample Questions

- When and at which altitude did his motion stop being a near unobstructed free fall (evidence of air resistance becomes apparent)?
- When and at which altitude did he break the sound barrier? Did this occur after he opened his parachute or before?
- When did he reach terminal velocity with his parachute still closed?
- For how long and at which altitudes was he in a true free fall?

Sample Questions (Continued)

- When he broke the sound barrier, was he still in a free fall or already experiencing the air resistance that cannot be neglected?
- What was his vertical speed when he landed?.
- Calculate his terminal velocity before he opened his parachute.
- Calculate his terminal velocity after he opened his parachute.

Implementation

- Two Case Studies were piloted during 2021/2022 academic year as small-group assignments.
- Completed outside of the class hours and submitted by the small groups via D2L.
- The full set of materials will be used during the 2022/2023 academic year.

Research Questions

- Does providing the students with opportunities to collaborate on analyzing realistic physics scenarios and formulating their own ideas increase students' engagement and fosters active learning?
- Will using these open-ended scenarios/activities as a basis for students' discussions/collaboration further improve students' conceptual understanding beyond what is achievable while relying only on multiple choice questions and standard end-of-chapter problems?
- This is a work in progress. The full impact of students collaborations on Case Studies will be analyzed after a complete implementation during the next academic year.

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Thank you!

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