“And Then A Collision Occurs”
July 25, 2006 – Talk CM12

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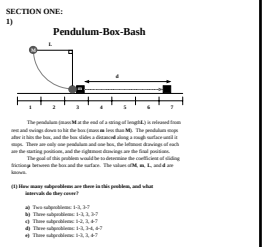
What To Expect

- Background – The Problem Decomposition Diagnostic
- The Survey
- The Interviews
- Looking Ahead

The Problem Decomposition Diagnostic – Thesis Work

The PDD was developed at The Ohio State University from 1998-2000 as part of PhD thesis work.

It was intended to measure student ability to break complex problems into simpler pieces, and ended up focusing on a few problem areas, such as collisions, energy conservation and ballistic paths.


SECTION ONE:
1)

Pendulum-Box-Bash

The pendulum (mass **M**) at the end of a string of length(**L**) is released from rest and swings down to hit the box (mass **m** less than **M**). The pendulum stops after it hits the box, and the box slides a distance**d** along a rough surface until it stops. There are only one pendulum and one box, the leftmost drawings of each are the starting positions, and the rightmost drawings are the final positions.

The goal of this problem would be to determine the coefficient of sliding frictionp between the box and the surface. The values of**M**, **m**, **L**, and **d** are known.

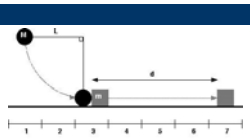
(1) How many subproblems are there in this problem, and what intervals do they cover?

a) Two subproblems: 1-3, 3-7
b) Three subproblems: 1-3, 3, 3-7
c) Three subproblems: 1-2, 3, 4-7
d) Three subproblems: 1-3, 3-4, 4-7
e) Three subproblems: 1-3, 3, 4-7

The Survey - Intro

- Three items were chosen from the PDD to create an online survey in early 2006:
  - Pendulum Box Bash (collision)
  - Spring Launcher (energy, ballistics)
  - Block Catcher II (collision)
- The Block Catcher II item turned out to have a confounding directional issue, and was de-emphasized in the interview stage.
- Spring Launcher was a red herring, to avoid making it obvious this was a collisions survey.

Survey – Pendulum Box Bash



- A) 1-3, 3-7
- B) 1-3, 3, 3-7
- C) 1-2, 3, 4-7
- D) 1-3, 3-4, 4-7
- E) 1-3, 3, 4-7

(Problem description omitted for this slide, too small to read anyway. Surface has friction.)

Survey Results - Subjects

- Students in calculus-based Engineering Physics 2 attempted the survey in exchange for homework extra credit. There were around 140 submissions.
- 72 students completed the survey and provided usable results.
  - Not all students completed all items.
  - Some students submitted two sets of responses.
  - The IRB requires that opting out be allowed without loss of extra credit points, and several students completed the survey but opted out.

Survey Results

- 31 students picked the two-part solution.
  - 15 invoked energy conservation
  - 5 invoked momentum but omitted some other step.
  - 2 invoked velocity conservation explicitly
- 41 students picked a three-part solution.
  - 11 invoked momentum conservation correctly
  - 10 invoked momentum, but called the collision elastic
  - 20 invoked energy conservation in some way (some overlap with the above category)
  - 1 invoked velocity conservation explicitly

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Interviews

- Recruited from survey respondents. 5 subjects with clearly "incorrect" survey responses and 3 with "correct" responses.
- Mostly "A" students responded, although students of all levels invited in roughly equal proportions.
- Audiotaped interviews using a common interview protocol for all subjects.
- Focused on the Pendulum-Box-Bash, used a physical demonstration model of it.

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Interview Results

- Common issues:
  - Remembering momentum in the first place (4/8)
  - Dichotomous elasticity (5/8 implicit, 2/8 explicit)
  - Mixing collision and slide somehow (4/8)
- All three "correct" survey respondents stated that momentum was only conserved in cases where energy was conserved (2/3) or "ideal" situations (1/3). One other student believed momentum was not conserved, but gave no clear reasoning.
- One subject brought up the issue of "The collision doesn't belong to either the pendulum or the box," despite not being part of the interview protocol.

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The Final Slide

- No obvious suggestions (yet) for improving student skill with multi-part problems.
- Some specific topics seem worth addressing, including:
  - Elastic/Inelastic dichotomy
  - Energy conservation vs. momentum conservation
- If you want more info, please email dvandom@phys.ksu.edu

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