“And Then A Collision Occurs”
September 20, 2006

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What To Expect

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

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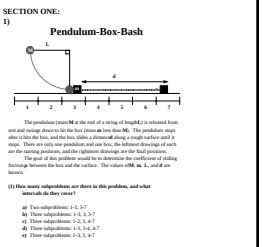
The Problem Decomposition Diagnostic – Thesis Work

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.


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 frictionμ 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

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The Problem Decomposition Diagnostic – Development

Over the course of working on the PDD, it was determined that students could generally decompose problems, with only a few exceptions:

- Energy Conservation
- Collisions

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The Problem Decomposition Diagnostic - Collisions

The PDD was rewritten to focus on these two problem areas, and interviews conducted with engineering honors students.

- They seemed uncomfortable with energy conservation methods of problem-solving.
- They didn’t seem to think collisions were necessary sub-problems at ALL.

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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.

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The Survey – Construction

Each item consists of:

- A diagram, with 7 intervals marked off to roughly subdivide time and space.
- Possible decompositions into sub-problems, using the intervals.
- Blanks for subjects to briefly describe the meaning of each of their sub-problems.

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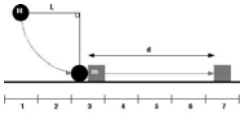
Survey – Pendulum Box Bash



- 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.)

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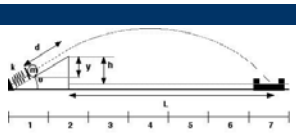
Survey – Spring Launcher



- "Red Herring" item, it was included so that students wouldn't catch on that everything was about collisions.

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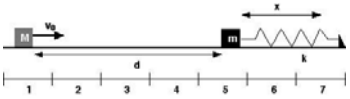
Survey – Block Catcher



- A) 1-4, 5-7
- B) 1-5, 5-7
- C) 1-5, 5-7, 7
- D) 1-4, 5, 6-7
- E) 1-5, 5, 5-7

(Frictionless surface, objects stick together.)

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Survey 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.

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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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More interview results

	1	2	3	4	**5**	6	**7**	**8**
Student resorted to physics terms rather than "your own words"	X	X	X	X	X	X		X
Student confused elastic with inelastic					X	X		
Student assumed mechanical energy was conserved in the collision	X				X	X		
Student assumed kinetic energy was conserved in the collision	X	X		X	X	X	X	
Student tried to find a role for friction during the collision	X	X		X	X			
Student did not believe momentum was conserved, but had no clear reasoning.	X							
Student did not believe momentum was conserved unless energy was conserved.							X	X
Student required "ideal" situation for momentum to be conserved (E conservation not mentioned)					X			

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Still more interview results

	1	2	3	4	**5**	6	**7**	**8**
Student invoked sound energy	X							
Student made a distinction between reality and physics	X							
Student confused force with impulse	X							
Student only accepted 100% elastic or 100% inelastic situations			X	X				
Student explicitly confused momentum and energy						X		
Student invoked velocity transfer	X	X						
Interviewer had to bring up the term momentum (x means it first arose in survey solution)	X	X		X	x			

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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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