Unstructured Problems in an Advanced Undergraduate Electronics Course: Physical Measurements & Instrumentation

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This work is supported by the U.S. National Science Foundation under grant DUE-0736897.

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Outline

- Project Overview & Motivation
- Capstone Projects & Example
- Unstructured Problem Solving
- Future Plans
- Summary
- Suggestions/Opinions?

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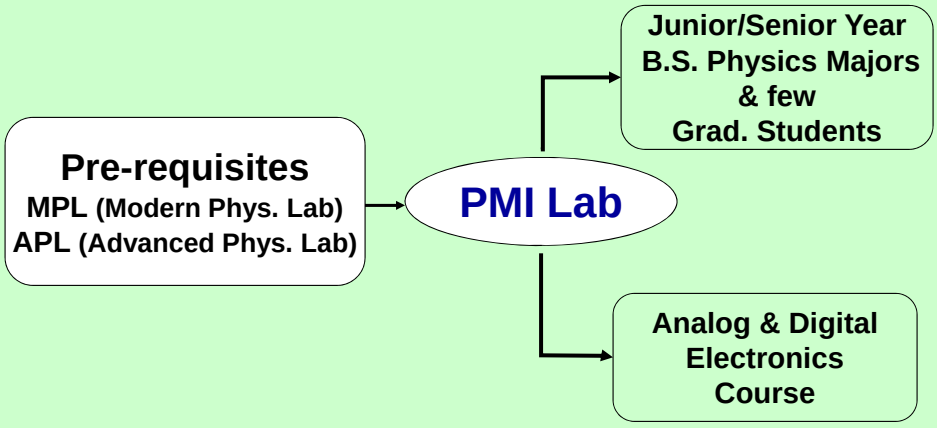
Project Overview

PMI (Physical Measurements & Instrumentation)



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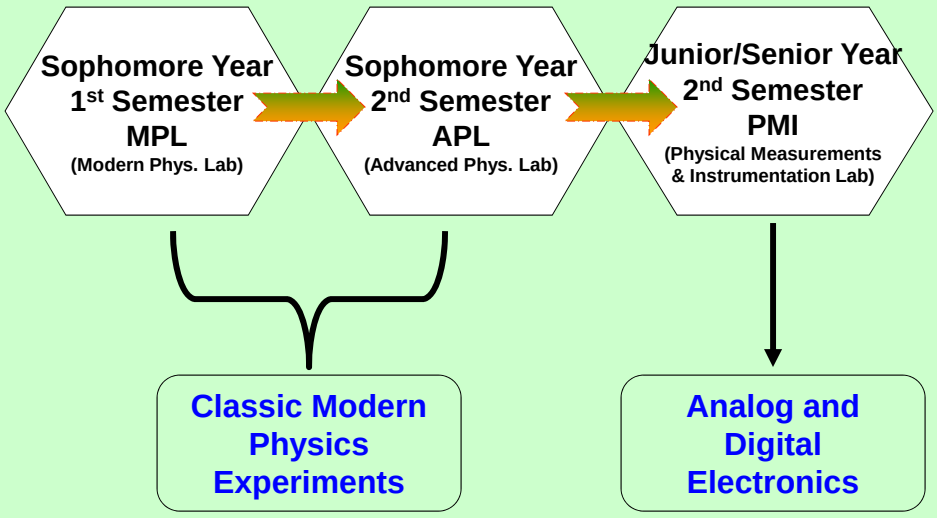
Project Overview



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Motivation

There were concerns because …

- Lack of continuity and connection between these three courses (MPL, ADL & PMI).
- No direct application of the Electronics and Instrumentation knowledge (Learned in PMI) in a laboratory environment.

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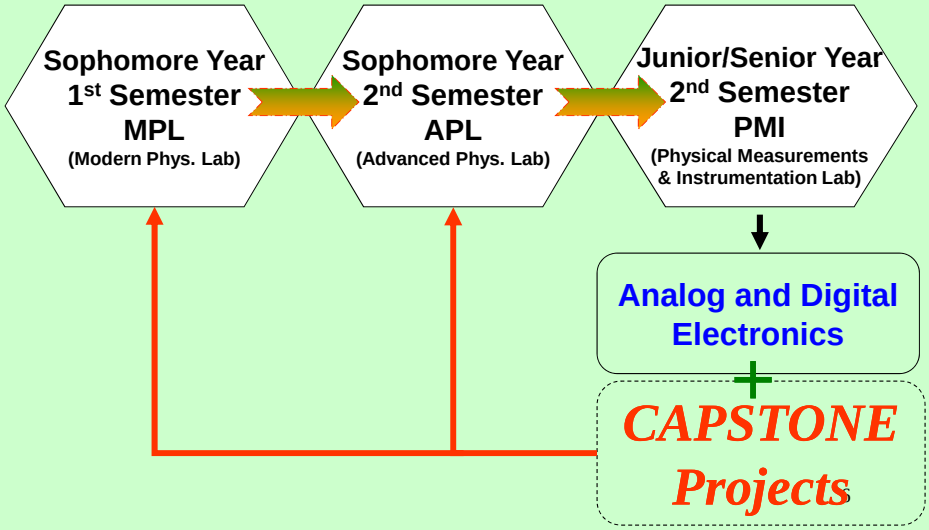
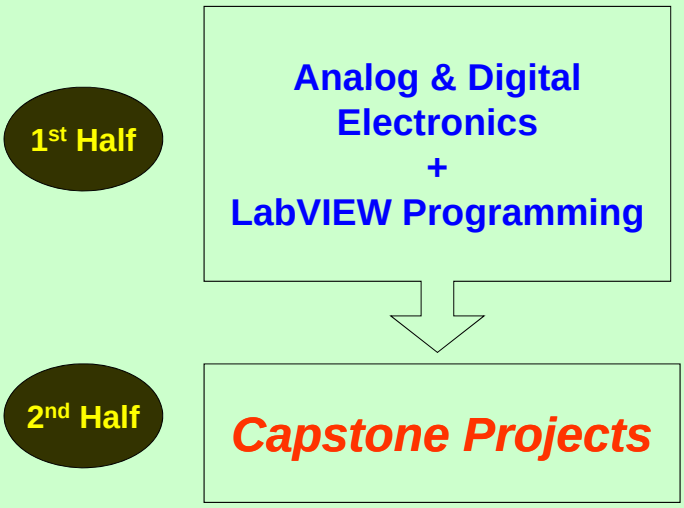
To Address Concerns…

- Capstone Projects were introduced in PMI



PMI Course



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PMI Capstone Projects

In the Capstone Projects Students…

- Revisit 1 or 2 experiments from MPL or APL
- Design instrumentation that automates the control, data collection and analysis in the experiments using LabVIEW and NI ELVIS.

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PMI Capstone Projects

- The capstone projects include: -
  - Speed of Light (MPL)
  - Frank-Hertz Experiment (MPL)
  - Photoelectric Effect (MPL)
  - Saturated Absorption (APL)
  - X-Ray Spectrometry (APL)

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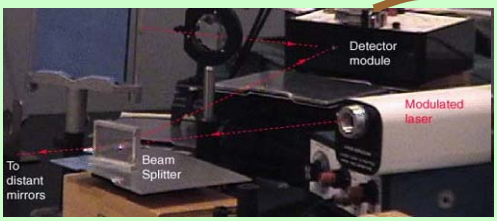
Example Capstone Project

Measuring the Speed of light

In MPL

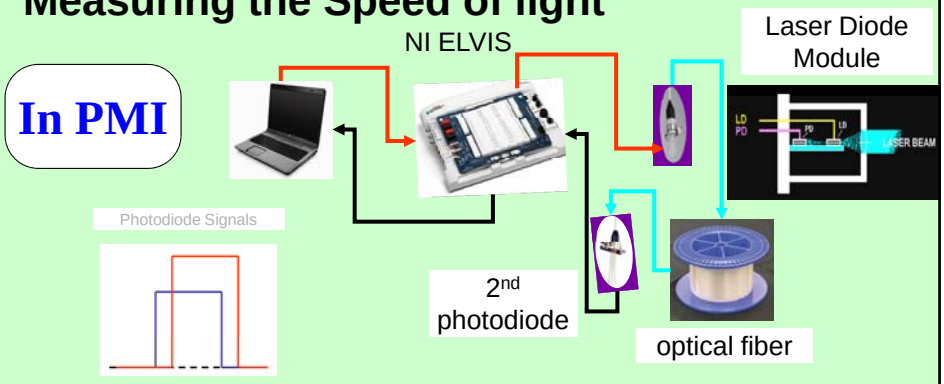


- Light is split into two beams
- The beams are detected & compared on o-scope

$$Speed\ of\ Light = \frac{Distance\ Difference}{Measured\ time\ Difference}$$

Example Capstone Project

Measuring the Speed of light



- LabVIEW is used to find the time difference between the two Photodiode pulses.
- Calculation of the speed of light in the optical fiber & further analysis of obtained results.

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PMI Capstone Projects

- **Through the capstone projects students:-**
  - Get a context to apply their newly learned knowledge of :-
    - Analog & Digital electronics
    - LabVIEW programming
  - Form a better connection between the three courses (MPL, APL & PMI)

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Research Opportunity

Research Goals	Broad Areas of PER
• Explore how students solve unstructured problems.	• Unstructured Problems
• Explore how students work in teams.	• Group/Team Problem solving
• Assess what students learn.	• Project/Design Based learning
	• Advanced Lab

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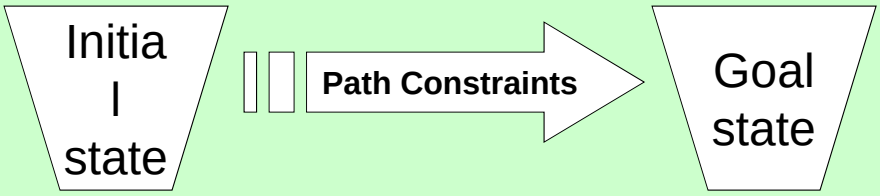
About Problems

- What is a problem?[1]
  - From a traditional, information processing perspective consists of ……



- So the problem is to find a path through the problem space ….

1 - Jonassen (2007)

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What Affects Problem Solving?

- Two main factors influencing problem solving are[1] -
  - Internal factors: problem solvers characteristics
    - Prior experience and knowledge, strategies
  - External factors: the nature of problem
    - Context
    - Complexity
    - Dynamicity
    - Structuredness

1 - Jonassen (2007)

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Structure of a Problem

- Problems range from well-structured to ill-structured over a continuum[1,2]
  - well-structured problems:
    - All needed information is presented
    - Require regular procedural manipulation
    - Have well defined solutions
    - Typical end of textbook chapter problem

1 - Jonassen (2007)
2 - Jonassen (1997)

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Structure of a Problem

- Problems range from well-structured to ill-structured over a continuum[1,2]
  - Ill-structured:
    - One or more problem elements are unknown
    - Require integration of content domains
    - Solutions not predictable or convergent
    - Typical problems encountered in everyday life

1 - Jonassen (2007)
2 - Jonassen (1997)

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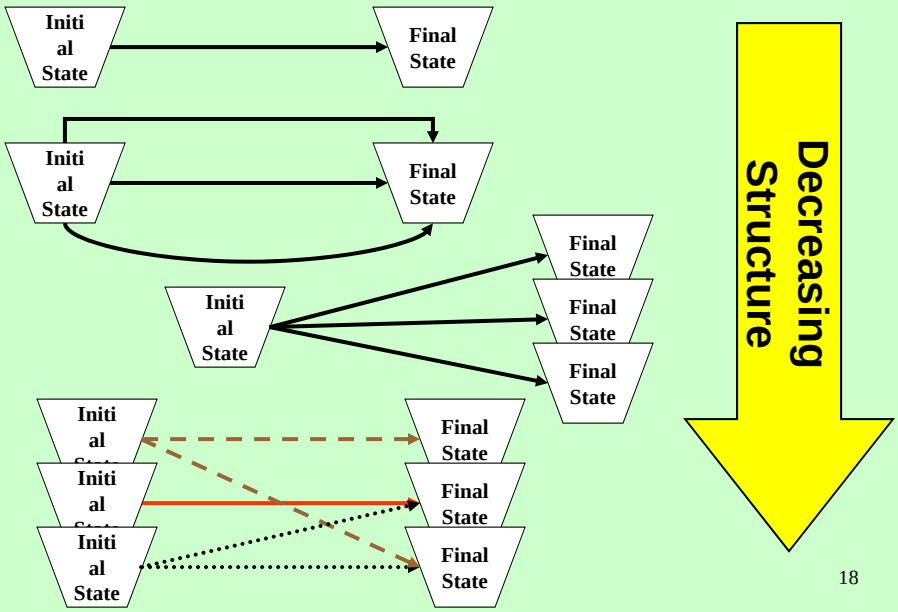
Levels of Structure



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Unstructured Problem Solving

How it applies to our Capstone Projects

'Speed of Light' as example ….

• One or more problem elements are unknown →	• Electronic components, measurement & analysis technique
• Require integration of content domains →	• Electronics, instrumentation, Physics & programming
• Solutions not predictable or convergent →	• Time resolution, electronic equipments used
• Typically encountered in everyday life →	• Experimental measurement, planning, debugging etc.

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Unstructured Problems

- Well-structured and ill-structured problem solving require different skills[1,3]
- In order to solve ill-structured problems. The problem solver needs:-
  - Developed conceptual knowledge:
    - Algorithmic approaches are insufficient
  - Strong metacognitive skills:
    - Analysis, planning, monitoring & justification
  - Epistemological development:
    - General student's belief about knowledge

1 - Jonassen (2007)
3 - Ogilve (2007)

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Future Plans 1/2

- Complete other capstone projects.
  - Speed of Light
  - Saturated Absorption
  - Frank-Hertz Experiment
  - X-Ray Spectrometry
  - Photoelectric Effect
- Literature review
  - Unstructured Problem Solving
  - Problem Based Learning
  - Other Efforts in Improving Advanced Phys Labs

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Future Plans 2/2

- Collect data during Spring 2010 & 2011.
  - Conceptual questions
  - Observe students working on capstone projects
  - Pre- and Post-interviews with students
- Analyze obtained data
  - Resource Analysis[4]
  - Interaction Analysis[5]

4 - Hammer (2000)
5 - Tang and Leifer (1991)

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Summary 1/2

Capstone projects in the PMI course

- provide an opportunity for students…
  - Relearn physics concepts underlying modern physics.
  - Learn to design experiments integrating hardware & software
- are unstructured and offer students an opportunity to ..
  - Develop deeper conceptual understanding
  - Build Strong metacognitive skills
  - Facilitate Epistemological development
  - Get a glimpse of the experimentation process

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Summary 2/2

- Capstone projects offer PER researchers to investigate how students…
  - Integrate knowledge from different domains (modern physics + electronics + programming)
  - solve unstructured problems
  - work collaboratively

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References

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THANK YOU

Questions or Comments

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