A Research Experience Based Measurement Laboratory Course

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AAPT Summer Meeting 2018
DL11 (Upper Division Undergraduate)
10:10am-10:20am Meeting Room 10/11

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Objective

- Provide undergraduate students with an alternative to experience of working in a research lab group (encouraged but not possible for all).
- Enhance practical skills with instrumentation, sensors, design, system characterization.
- Student enthusiasm and strong active engagement.
- Not too expensive (limited budget).
- Scalable (ideally).

Course Design

Foundational work (half of semester)

- Instrumentation, sensors, electronics, measurement techniques, system performance.
- Lecture (2h), homework, and lab(4h) strongly coupled.
- Lab: Rough guidelines of tasks, deviation and exploration not penalized.

Student project (half of semester)

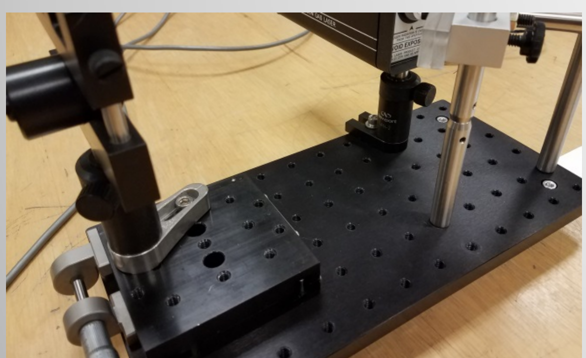
- Students work on a project of their own design, trying to reach self-set **milestones**.
- Students test and **characterize system** in stages.
- Lecture switches into "on demand topic" discussions.
- **Present** to class (last week).

Semi-structured Lab Activities

- Electronic amplifiers (voltage, current, addition, subtraction, filter, integrator);
- Distance measurement (plate capacitor), curve fitting, noise/uncertainty.
- 1st order system (thermoresistor): Responsivity, dynamic system response).
- 2nd order systems (cantilever): Responsivity, dynamic system response).
- Feedback loops.
- Ultrasonic sensing.

Frequently Used Equipment

Digital/Analog I/O (NI/Digilent: $279) + software (free)
= oscilloscope, function generator, voltmeter, logger, spectrum analyzer, network analyzer …



Translation/rotation stages, small optics mounting platforms, posts, etc.

3d printer on to-buy-list
(a student owned one and let all in class use it)

Whatever we could find, borrow, scavenge ….

Student Projects

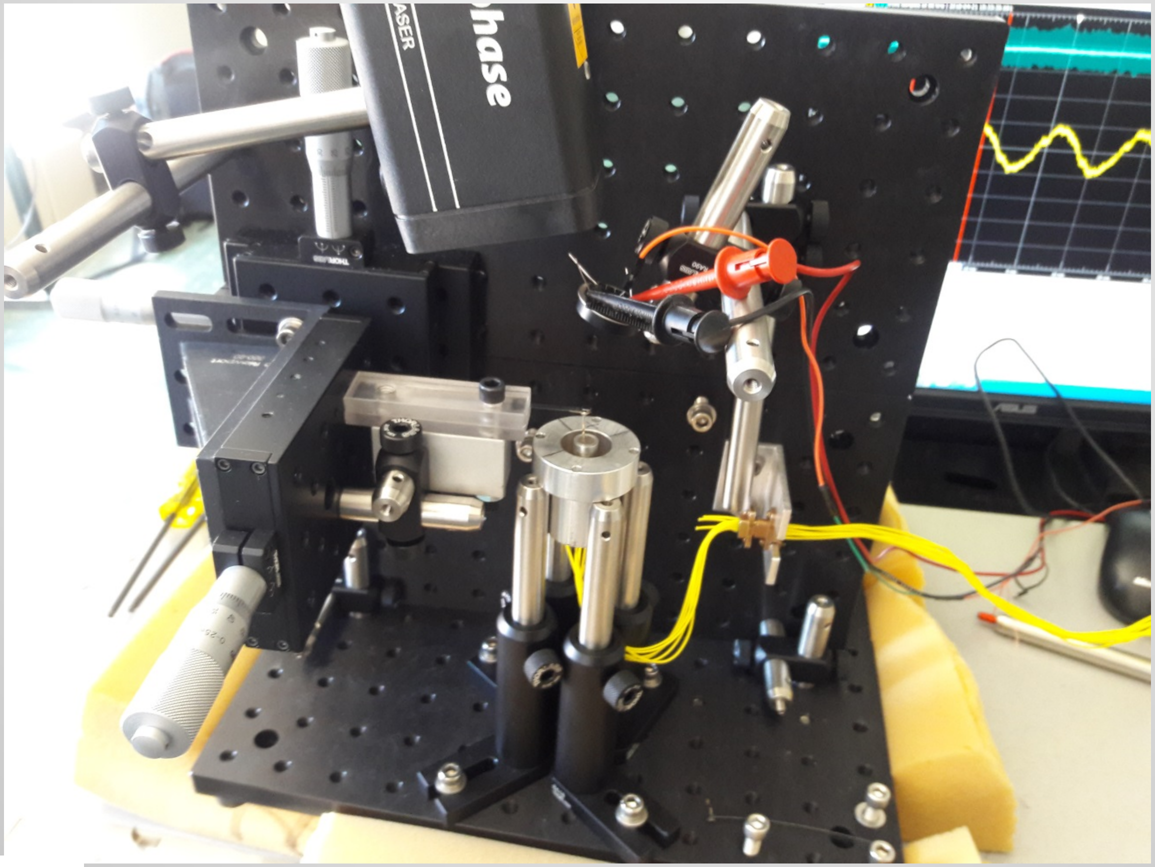
- **Initial proposals 2-3 weeks before project start** (motivation, description, planned course of action, parts requirements, **project milestones**).
- Instructors **review and feedback**.
- Order small parts as needed/within budget.
- A few **doable backup projects** were developed before course started.

Actual Projects Proposed

- Build an atomic force microscope (***AFM***).
- Build an optical spectrometer and measure fluorescence of a liquid (***Spectrometer***).
- Design a system which detects who in the room is speaking the loudest and from where (and then have a catapult shoot a marshmallow into the mouth of the loudest talker). (***Audio***)

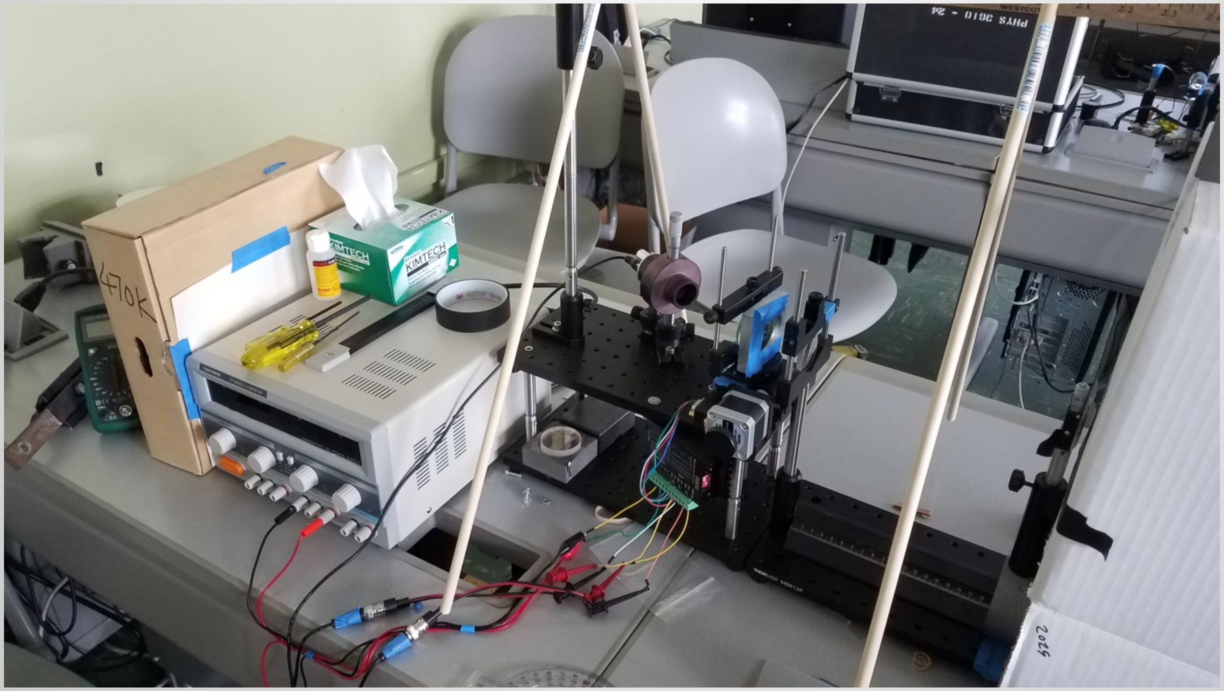
Achieved Milestones - AFM

- Built laser-cantilever system with piezo-tubes for sample movement.
- Controlled and characterized 3d piezo-tube movement.



Achieved Milestones - Spectrometer

- Built a computer controlled spectrometer.
- Characterized resolution using neon lamp.
- Measured a fluorescence spectrum.



Achieved Milestones - Audio

- Built a detector structure with 5 digital microphones.
- Wrote algorithm to calculate origin of sound.
- Characterized system performance (cm accuracy at meter distances).
- Discovered measurable effects due to sound shadowing.
- (Described project in a paper and poster for a communications class.)

Student Reaction to Course

- **High level of motivation** (24/7 access to lab room, students found there late in evening & on weekend working on project. Students volunteered to bring some material/equipment from home to utilize in project.)

- **Strong cooperation** between all students.

- **High level of satisfaction** with course (students expressed that they learned a lot of practical skills in a short period of time).

- Some disappointment that fewer milestones were achieved than anticipated (welcome to reality!).

Challenges: Scalability

- Will we need too much stuff to maintain student project freedom/flexibility?
- Can we maintain lab access “after hours”?
- Can we attract a larger number of students?