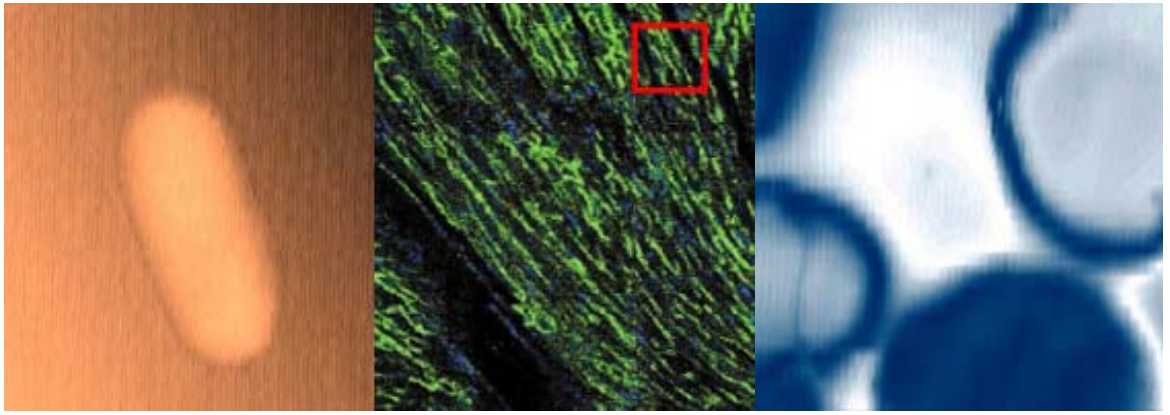

Teaching Measurement Principles in Context: an Instrumentation Laboratory for Biological Engineers

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Department of Biological Engineering, MIT

CDIO 3rd International Conference
June 11, 2007

The Course: 20.309

- Laboratory Fundamentals in Biological Engineering II: Biological Instrumentation and Measurement
- advanced undergraduate laboratory
- modular
  - electronics – DNA melting curves analysis
  - mechanics – AFM
  - optics – fluorescence microscopy, optical trapping
- modules based on measurement systems

20.309 Intellectual core

- Signals and systems
  - time/frequency (elec.) & spatial domain (imaging)
  - correlation and convolution (elec.), image processing (optics)
- Fourier techniques
  - time/frequency (elec./mech.) & spatial domains (optics)
- Fundamental limits of detection
  - position/force detection (mechanics) & resolution (optics)

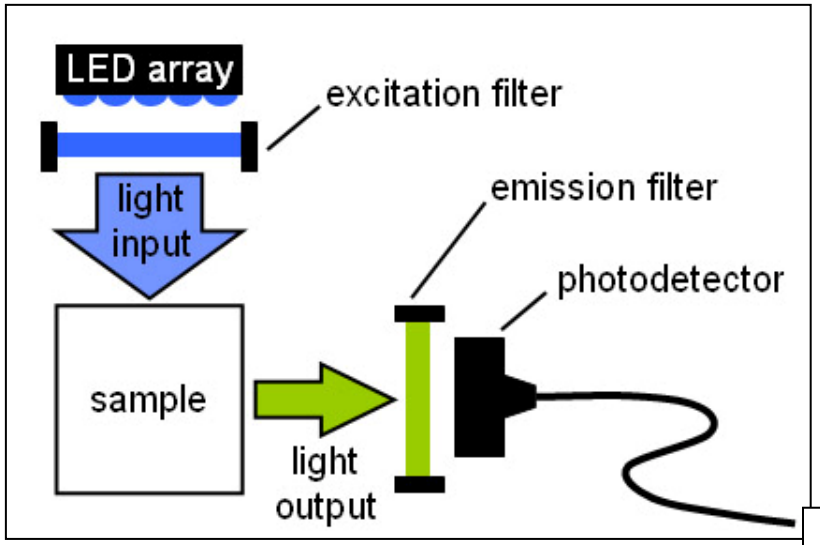
20.309 Course philosophy

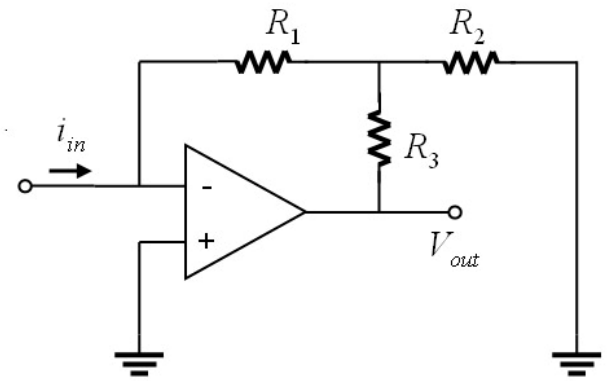
- teach general measurement principles in the context of ***building*** and ***using*** instrumentation
- culture of tinkering, hands-on building & design, teamwork
- continual infusion of topics from current faculty research efforts

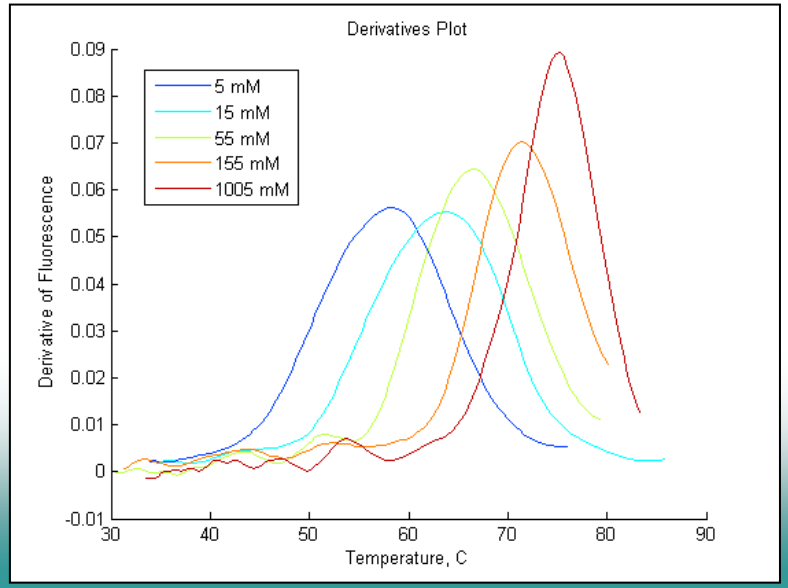
MIT Biological Engineering (BE)

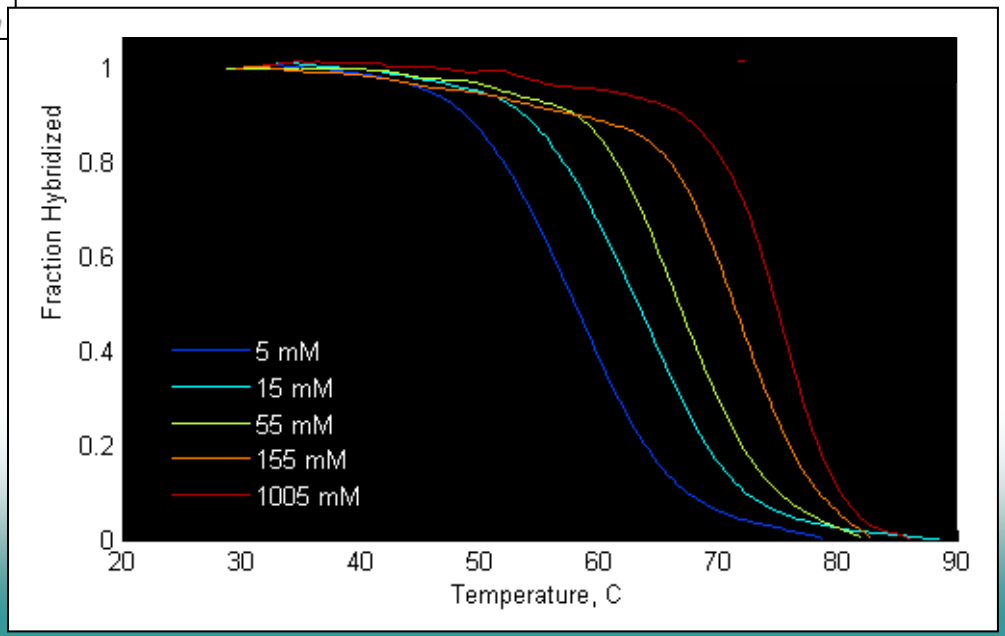
- fusion of molecular life sciences and engineering
- "meta-goals" of 20.309 lab
  - develop quantitative thinking
  - provide experience (comfort?) with multi-domain, interdisciplinary problems
  - learn by doing

Module 1: DNA hybridization analysis

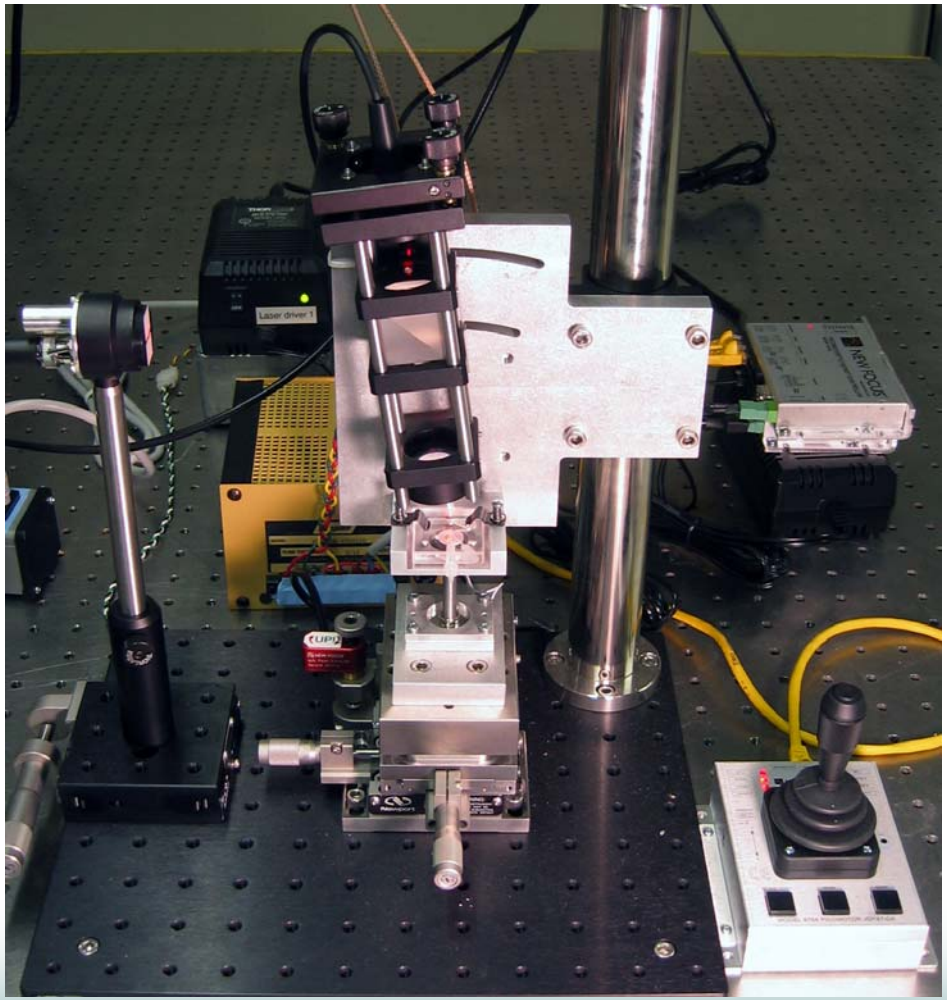




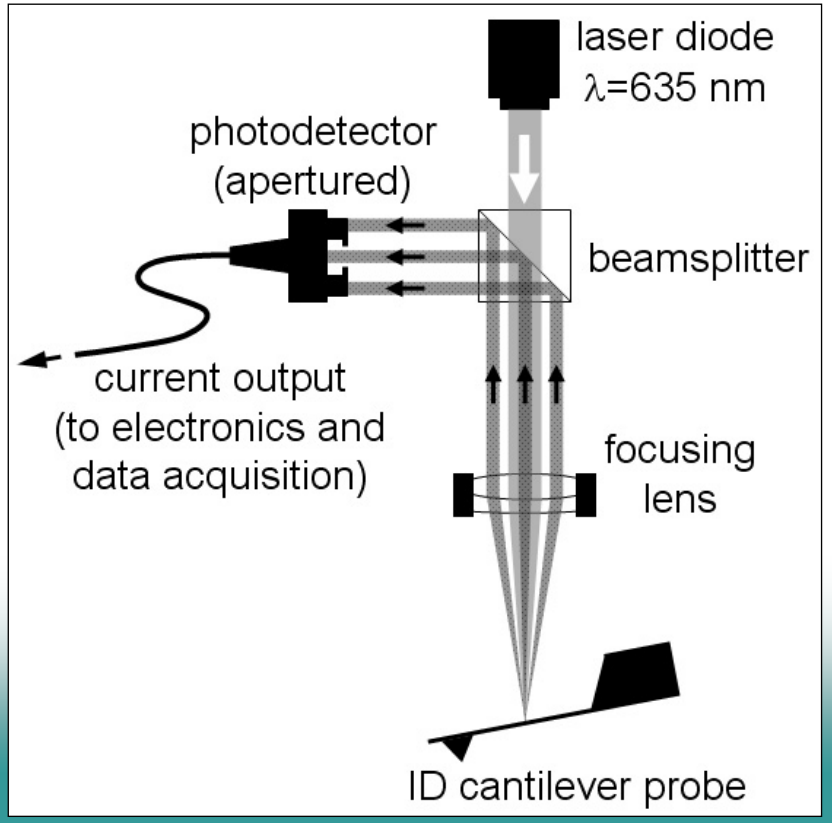




Module 2: Atomic force microscopy



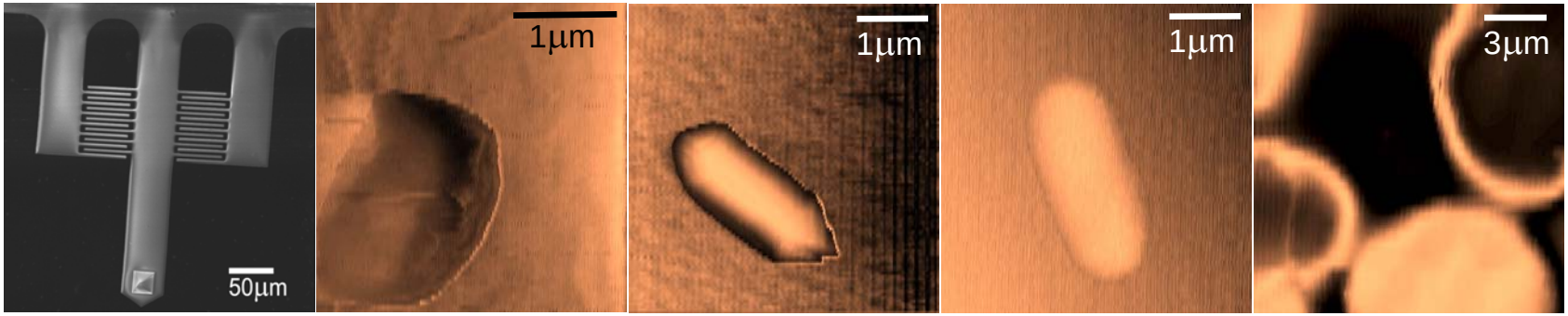
- inexpensive: < $15k
- mostly off-the-shelf parts
- replicable & scalable (we have 7)



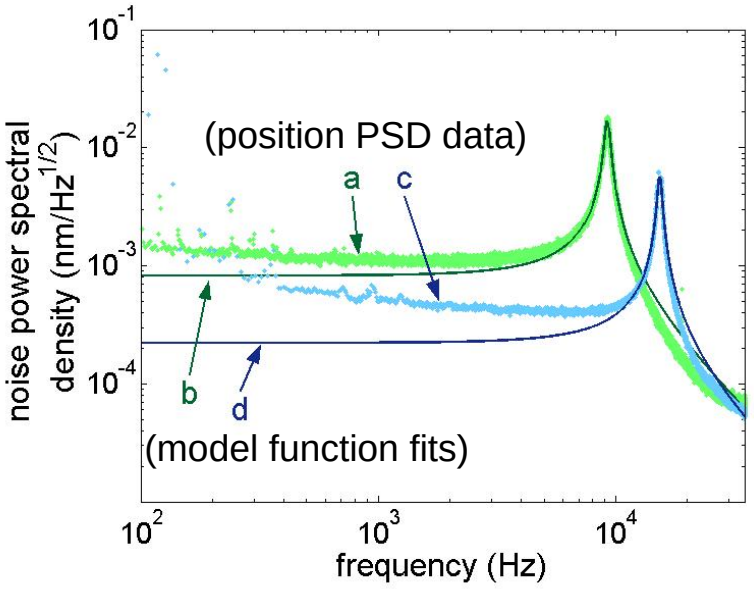
http://web.mit.edu/be/teachAFM/

AFM experiments

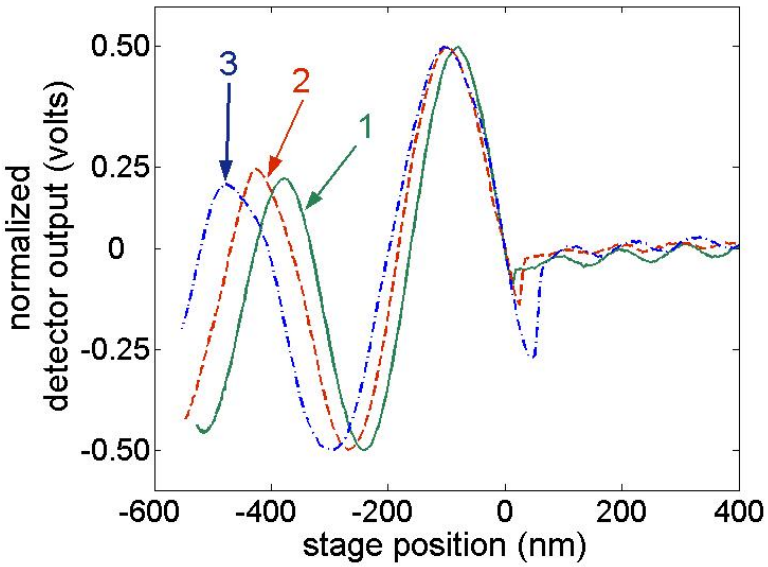
Imaging



Thermomechanical noise

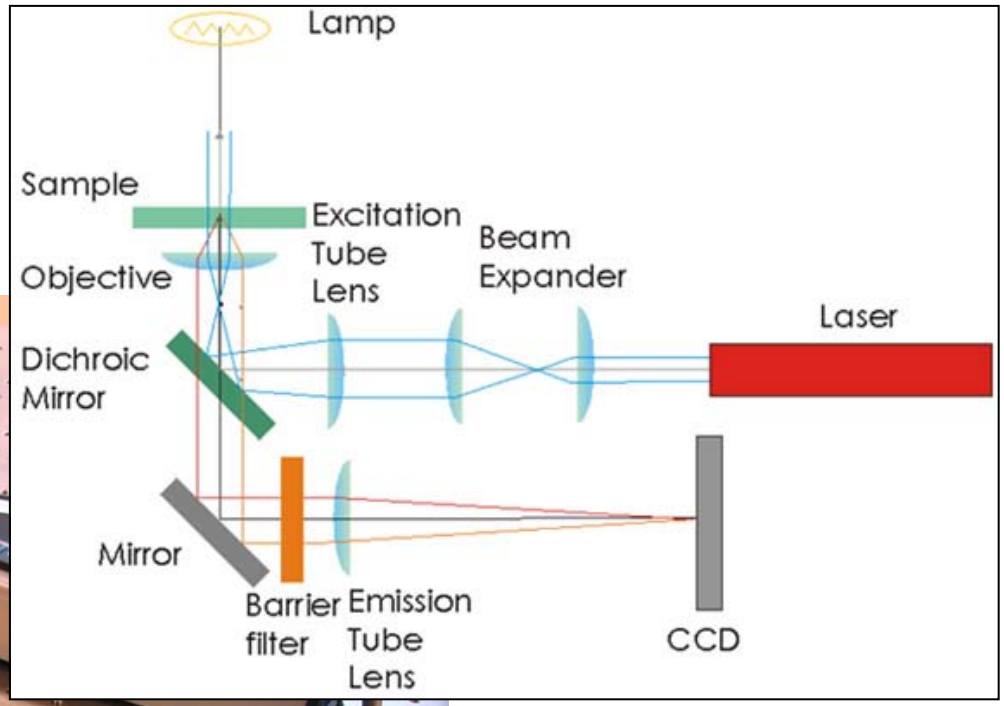


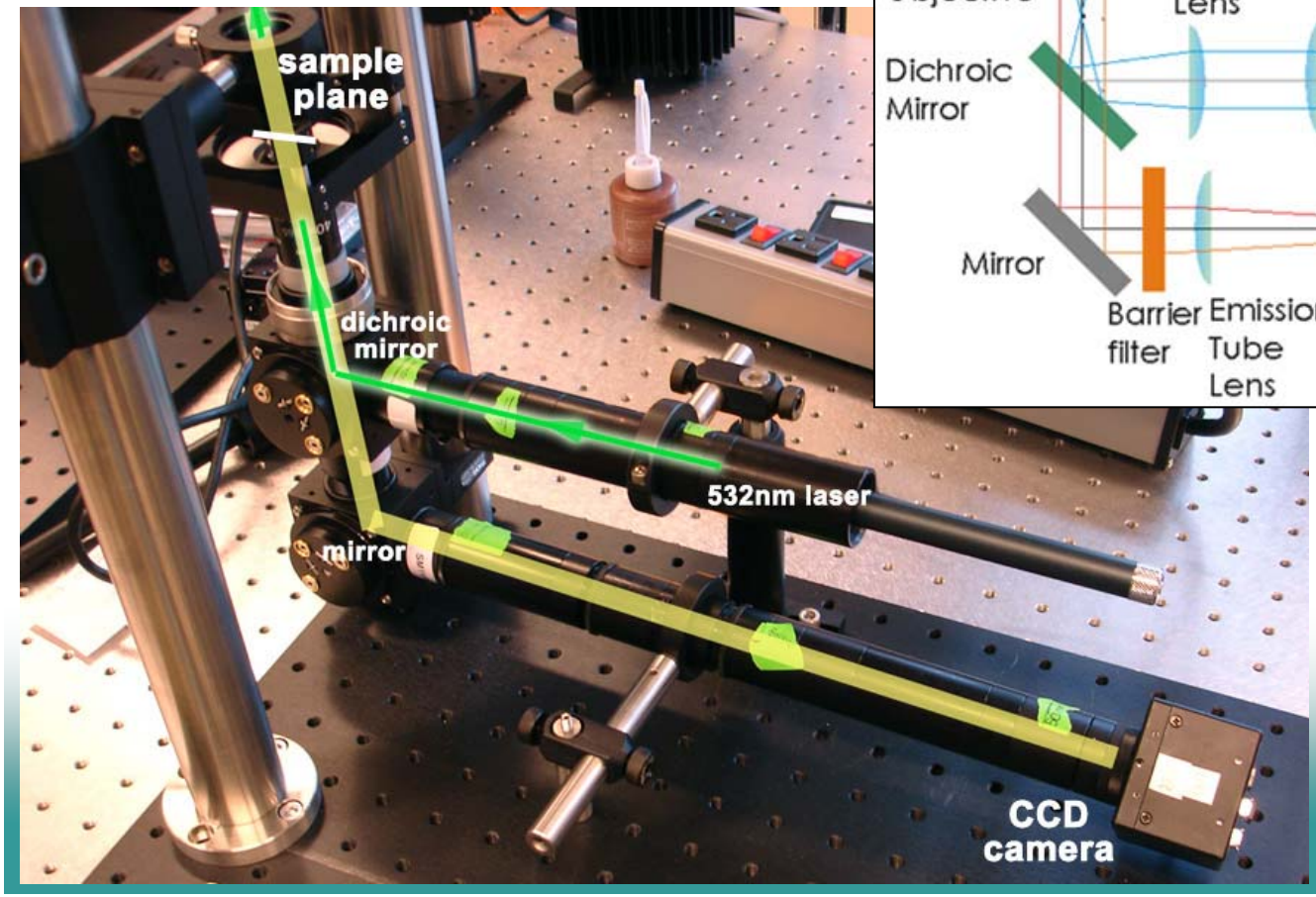
Elastic modulus measurements



Module 3: Fluorescence microscopy

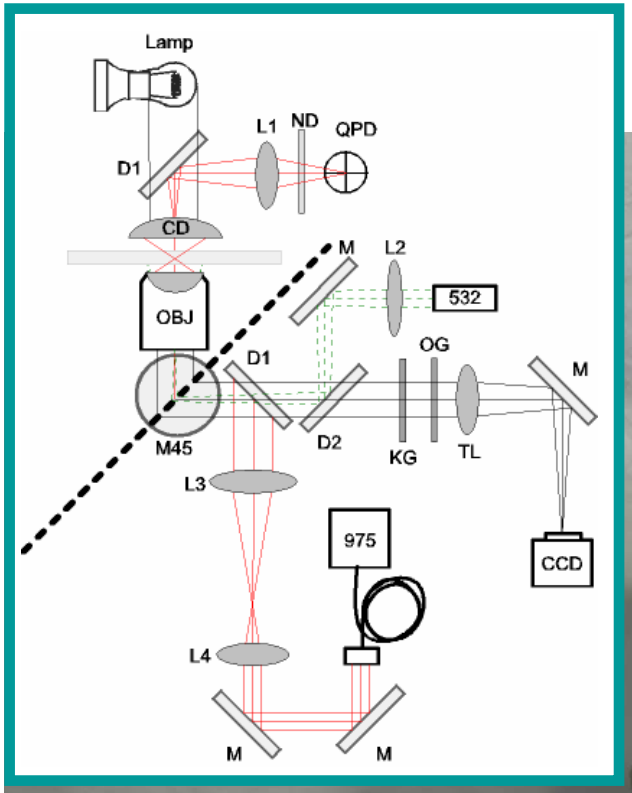
- White-light and fluorescent imaging
- Fourier optics





Particle tracking and cellular microrheology

Module 4



Undergraduate Optical Trap

- Position detection
- Fluorescence
- Stage motion
- Low cost

QPD

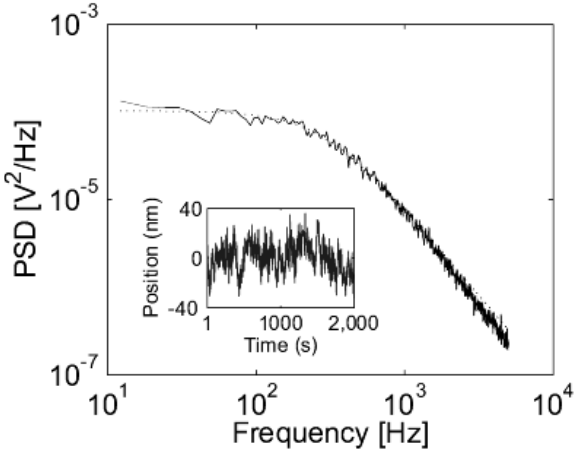
532nm Laser

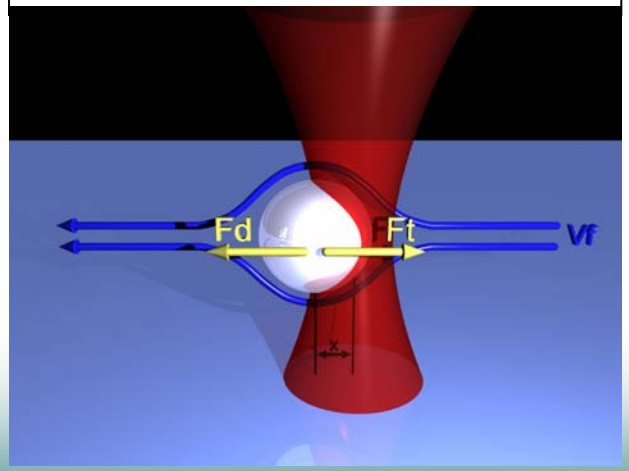
975nm Laser

CCD

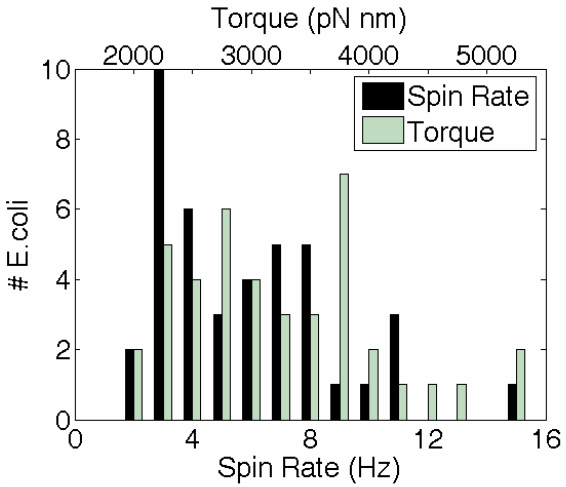
Optical trap capabilities

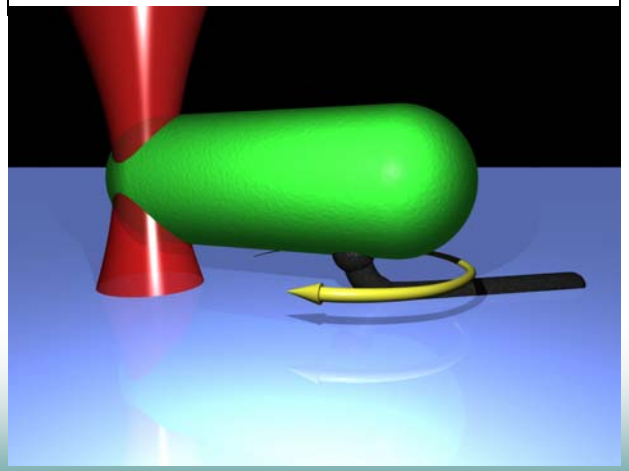
Calibration



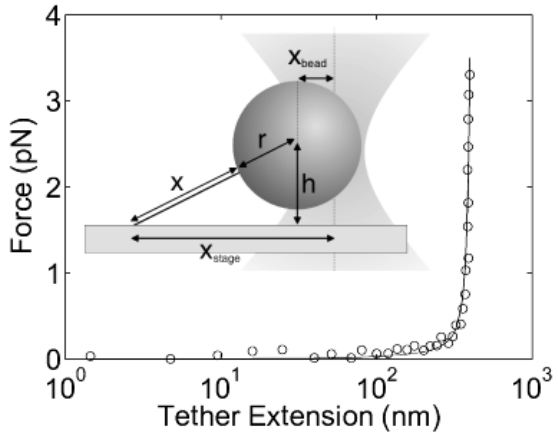


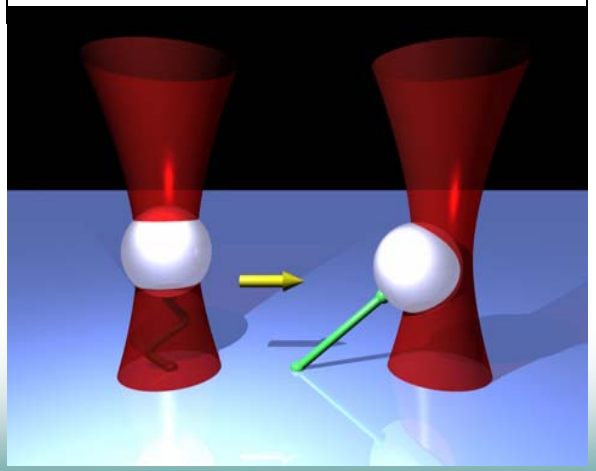
Molecular Motors





Tethered Assays





http://www.openwetware.org/wiki/Optical_Trap

Compatibility with CDIO standards

1. CDIO as Context *
2. CDIO Syllabus Outcomes *
3. Integrated Curriculum *
4. Introduction to Engineering
5. Design-Build Experiences *
6. CDIO Workspaces
7. Integrated Learning Experiences *
8. Active Learning
9. Enhancement of Faculty CDIO Skills *
10. Enhancement of Faculty Teaching Skills
11. CDIO Skills Assessment *
12. CDIO Program Evaluation

Color Legend

- specific to 20.309
- provided by MIT BE curriculum
- no direct equivalence
- * "essential" standards

Online Materials

- Course website: http://www.openwetware.org/wiki/20.309/
- AFM site: http://web.mit.edu/be/teachAFM/
- Optical Trap site: http://www.openwetware.org/wiki/Optical_Trap