

The Interaction Between Research and Education in Aerospace Engineering



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Mechanical and Aerospace Engineering

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Turabo University, May 31, 2007



[Hattie, J. and Marsh, H.W. \(1996\).](#) "The relationship between teaching and research: A Meta-analysis," Review of Educational Research, 66(4) pp 507-542

- *"The strongest policy claim that derives from this Meta analysis is that universities need to set as a mission goal the improvement of the nexus between research and teaching. The goal should not be publish or perish, or teach or impeach, but we beseech you to publish and teach effectively.*
- *The aim is to increase the circumstances in which teaching and research have occasion to meet, and to provide rewards not only for better teaching or for better research but for demonstrations of the integration between teaching and research."*



A UK Perspective

- UK Robbins Report argued that University staff should both teach and carry out research on the grounds that ***"the element of partnership between teacher and taught in a common pursuit of knowledge and understanding, present to some extent in all education, should become the dominant element as the pupil matures.... It is of the utmost importance that the ablest, who are capable of going forward to original work, should be infected at their first entry to higher education with a sense of the potential of their studies."*** (para 555).

A US Perspective

- The American scholar Burton Clark argued that ***"research activity can and does serve as an important mode of teaching and a valuable means of learning...(He further argues that) " student involvement in research is an efficacious way to educate throughout the education system the great mass of students, as well as the elite performers, for the inquiring society into which we are rapidly moving"*** (p242, emphasis added)
- **References:**
 - Committee on Higher Education Higher Education: (The Robbins Report), (1963) London, Her Majesty's Stationary Office. HMSO.
 - Clark B. R. (1997) "The modern integration of research activities with teaching and learning", Journal of Higher Education, 68, (30, 242- 255).



"... The research universities have often failed, and continue to fail, their undergraduate populations, thousands of students graduate without seeing the world - famous professors or tasting genuine research."

- *"Scholarship should be required of all academics who teach. " HEFCE should make it clear that its funds for teaching include an element intended to enable staff to engage in scholarship."*

References:

- Re-Inventing Undergraduate Education: Boyer Commission on Educating Undergraduates in the Research University (1998), Carnegie Foundation for the Advancement of Teaching
- HEFCE, (2000) 00/37, Review of Research, Bristol, Higher Education Funding Council for England - para 175, 26.



NSF Proposal Review Criteria

- **What is the intellectual merit of the proposed activity?**
- **What are the broader impacts of the proposed activity?**
- **NSF staff will give careful consideration to the following in making funding decisions:**
- Integration of Research and Education
 - One of the principal strategies in support of NSF's goals is to foster integration of research and education through the programs, projects and activities it supports at academic and research institutions. These institutions provide abundant opportunities where individuals may concurrently assume responsibilities as researchers, educators, and students, and where all can engage in joint efforts that infuse education with the excitement of discovery and enrich research through the diversity of learning perspectives.
- Integrating Diversity into NSF Programs, Projects, and Activities
 - Broadening opportunities and enabling the participation of all citizens, women and men, underrepresented minorities, and persons with disabilities, are essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.

Reference: NSF 07-140 June 2007 Grant Proposal Guide





Linking Teaching and Research in the Disciplines

Learning and Teaching Support Network
Generic Centre,
Oxford Brookes University
([http://www.brookes.ac.uk/genericlink/!](http://www.brookes.ac.uk/genericlink/))



Princeton Example

- All students are required to do at least one semester of **Independent Work** which may also partially satisfy a Design requirement. Independent projects enable one to utilize, and to transcend, classroom learning by applying creativity, coupled with the scientific background acquired from classes, toward a challenging project.
- Year-long senior independent projects may constitute a **Senior Thesis**, and students are strongly encouraged to consider this option. The result of such self-motivated activity has frequently led to publications and design patents.



- Students have the opportunity to to work on a topic which a Faculty advisor is pursuing and this close collaboration will frequently also involve interaction with graduate students studying the same problem. An aspect of the program is to facilitate bringing together as many scientific and nonscientific elements as necessary to pursue a topic; consequently, faculty advisors are not limited to just those within the MAE department. Advisors can be from any relevant engineering or science department and can also co-advise on the problem. **This opportunity is often cited by students as the highlight of their four year experience at Princeton. In the words of Joseph Campbell "You can follow your own bliss."**



Recent Topics in Independent Work

- **Aero/Astro Engineering:**
 - Development of a Unified Design, Prototyping and Testing Strategy for Small-Scale Jet Turbines, B. Andreas '06 & S. Sucharski '06 (Advisor Nosenchuck)
 - Design of a Multi-Role Unmanned Aerial Vehicle, E. Chen '06, M. Nitzov '06, M. Spano '06, & N. Yungster '06 (Advisor Martinelli)
 - Design of a Homeland Defense Interceptor Fighter Jet AIAA Undergraduate Design Competition, N. Domingue '06, P. Kang '06, A. Prescott '06, & T. Smith '06 (Advisor Martinelli)
 - Design of a Lightweight Collapsible Relief Airplane, B. Jaffe '06 (Advisor Curtiss)
 - Design of a Microwave-Initiated, Gas-Fed Pulsed Plasma Thruster, J. Li '06 (Advisor Choueiri) □ □
- **Materials and Biomaterials**
 - Active Bending in Marine Propeller Blades, T. Edwards '06 (Advisor Arnold)
 - Mimicking Nacre with Laminar, Tabular Ceramics, S. Murthy '06 (Advisor Aksay)
- **Computational Fluid Dynamics and Fluid Mechanics**
 - Experimental Simulation of the Interaction of a Vortex Pair with a Solid Boundary, M. Lowther '06 (Advisor Smits)
 - Application of Computational Simulation Techniques to Model the Effect of Microcatheter Introduction in an Anatomically Accurate Cerebral Aneurysm: A Medical Intervention Planning, M. Soroka '06 (Advisor Oxford)
 - Mechanical and Optical Modeling of the Human Lens, D. VanDeSompel '06 (Advisor Smits & Kunkel)
- **Energy and Environment (Combustion)**
 - Design of a Novel Transesterification Reactor for the Large-Scale Production of Biodiesel, I S. Douville '06 & N. Lowery '06 (Advisor Arnold)
 - Design and Analysis of a Novel, Two-Stage Micro-Scale Combustor, P. Galie '06 (Advisor Ju)
 - Solar Oven Design for Resource-Constrained Cooking, M. Henchen '06 & B. Rogers '06 (Advisor Soboyejo)
- **Humans and Machines, Components and Controls**
 - Labyrinth: Modern Control of a Ball on a Plate, M. Becker '06 (Advisor Littman)
 - Helicopter Stabilization Through Feedback Control, C. Benson '06 & V. Tinajero '06 (Advisor Littman)
 - Design and Analysis of Common Roller Coaster Elements, D. Hough '06 (Advisor Littman)
 - Swimming a Stokesian Fish, C. Murdock '06 (Advisor Rowley)
 - Applying Insect Flight Mechanisms to Micro UAVs, C. Hampson '06 & A. Squires '06 (Advisor Littman)



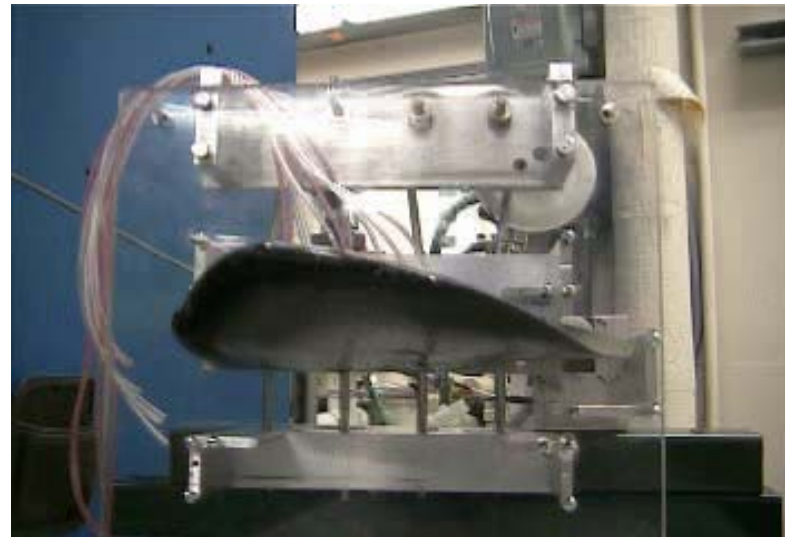
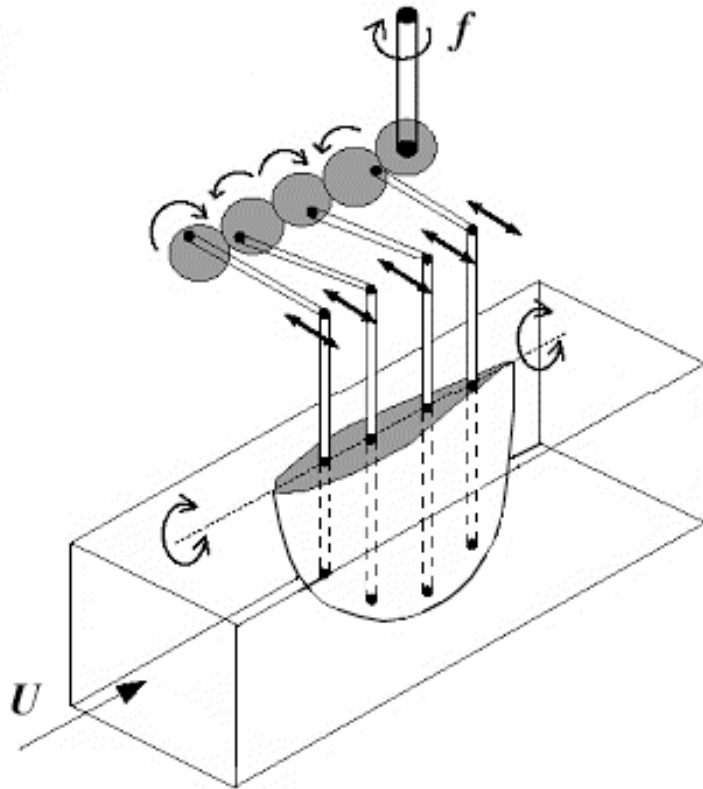
Princeton MAE Department

“Learn by Doing”

- Sophomore
 - MAE 224 Lab Course culminates in independent work project
- Junior
 - Junior Independent Work offered both semesters
 - Design courses
- Senior
 - Senior independent work (group projects)
 - Senior Thesis (individual, 2 semesters)
- MAE Summer Internships (6 available on a competitive basis every year, 67%/33% split)

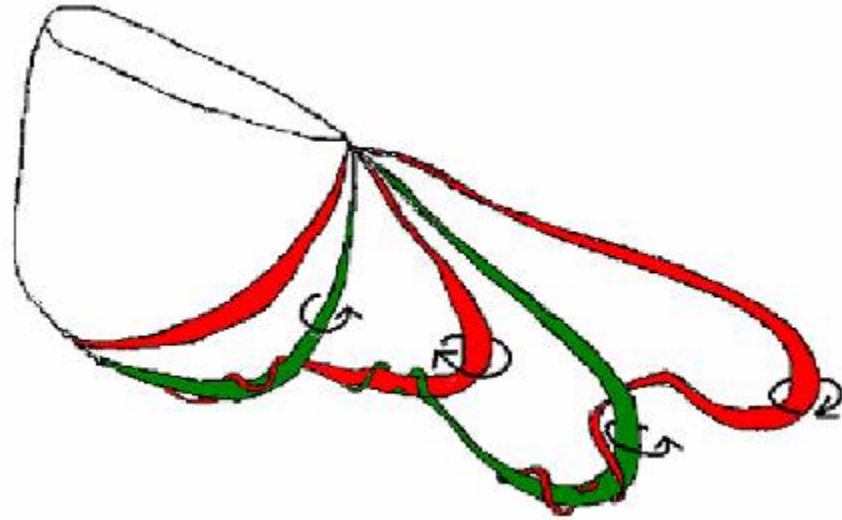
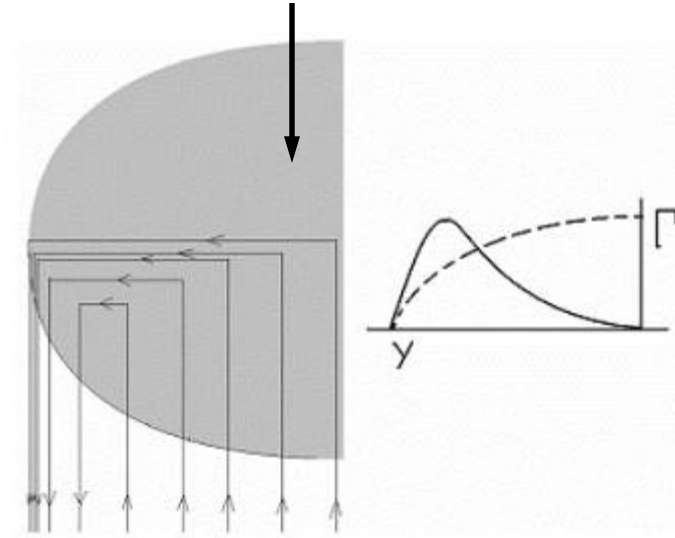
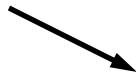
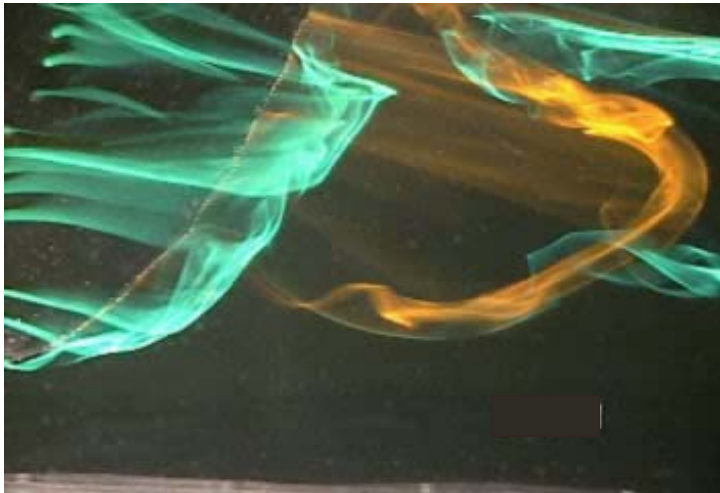


Batoid-Inspired Articulated Fin

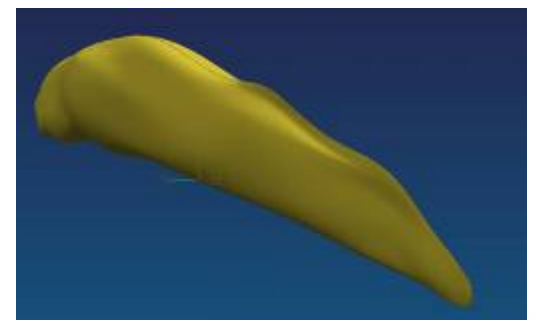
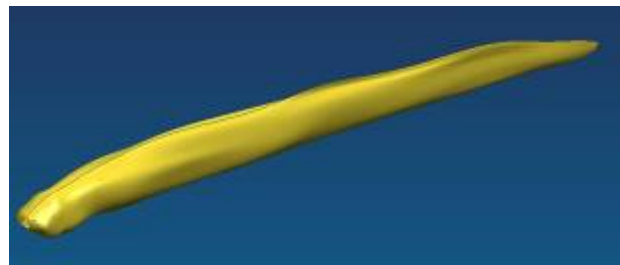
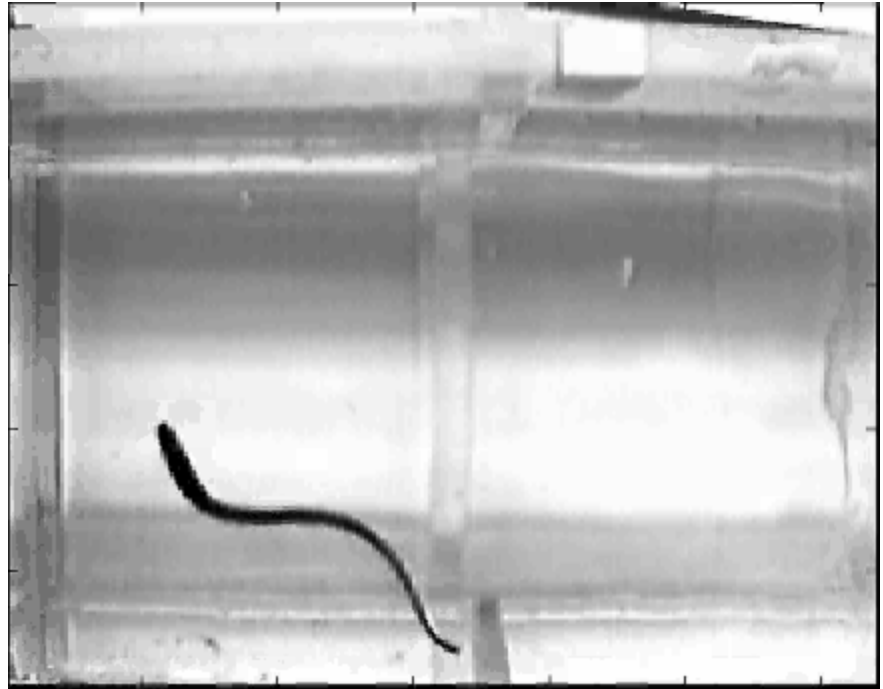


Batoid-Inspired Articulated Fin: Wake Model

Clark & Smits, JFM 2006

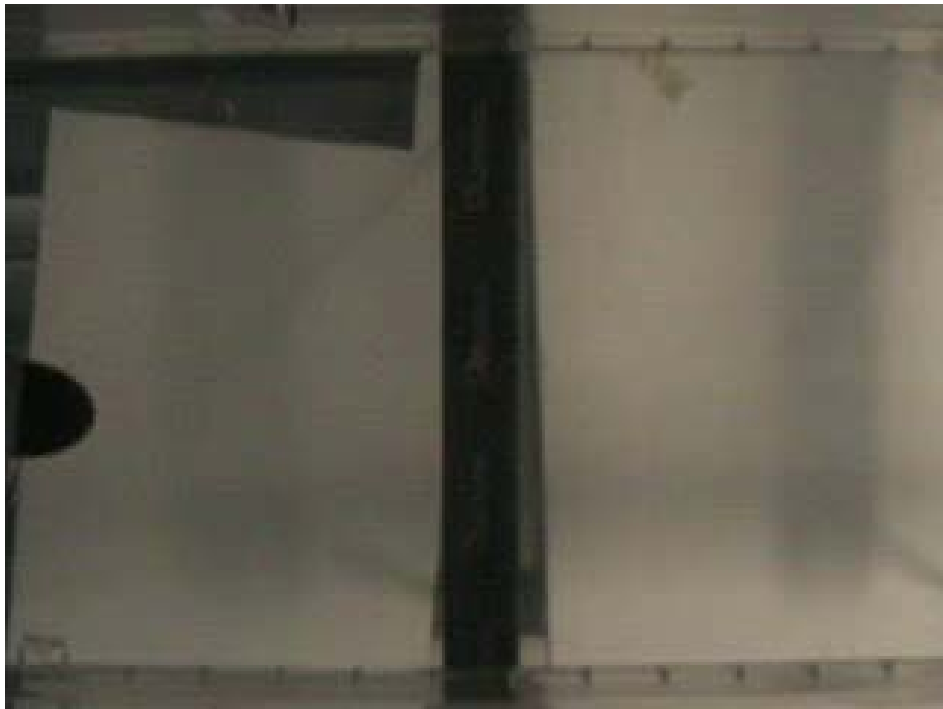


Lamprey Swimming



Robotic Lamprey

Annora Bell
Edward Shelton
Steven Batis
Tarik Jones

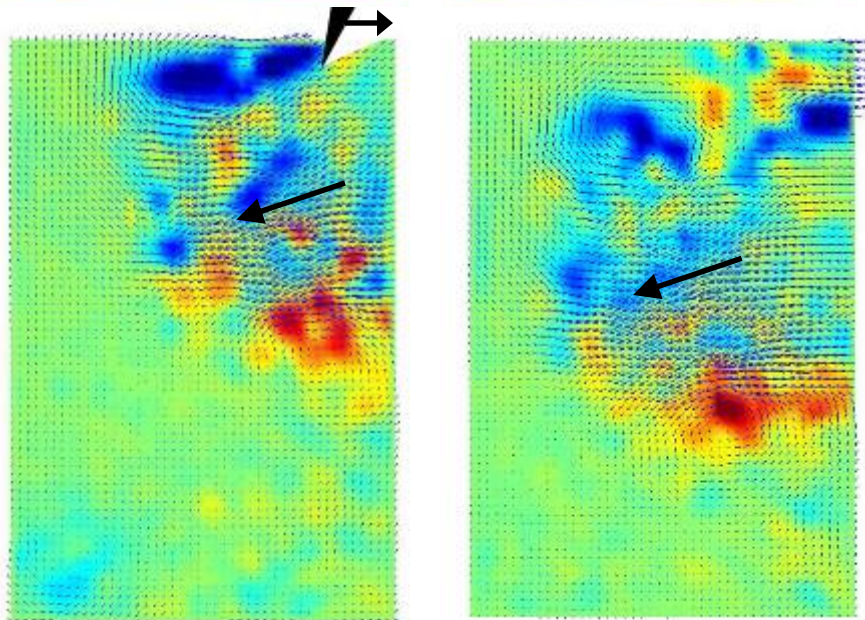
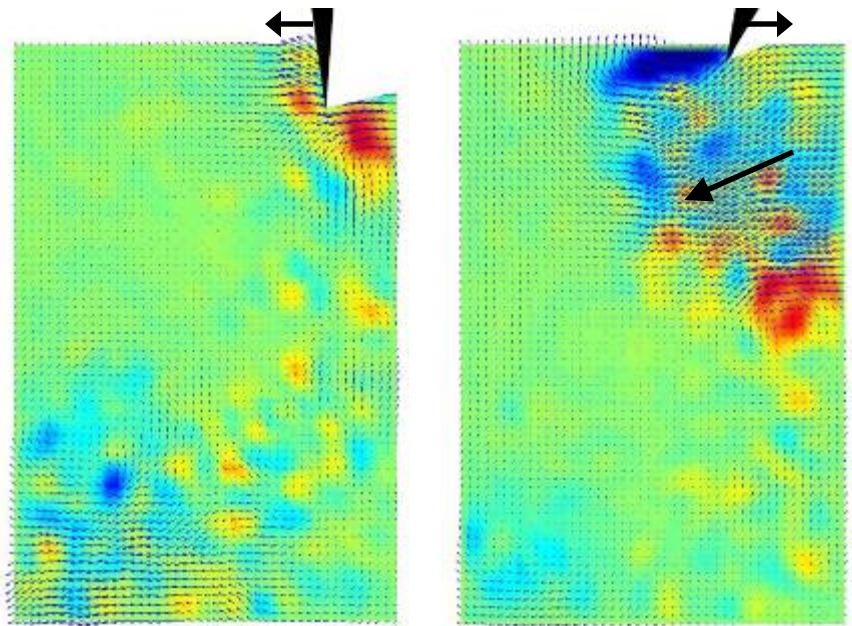


Movie: Steven Batis

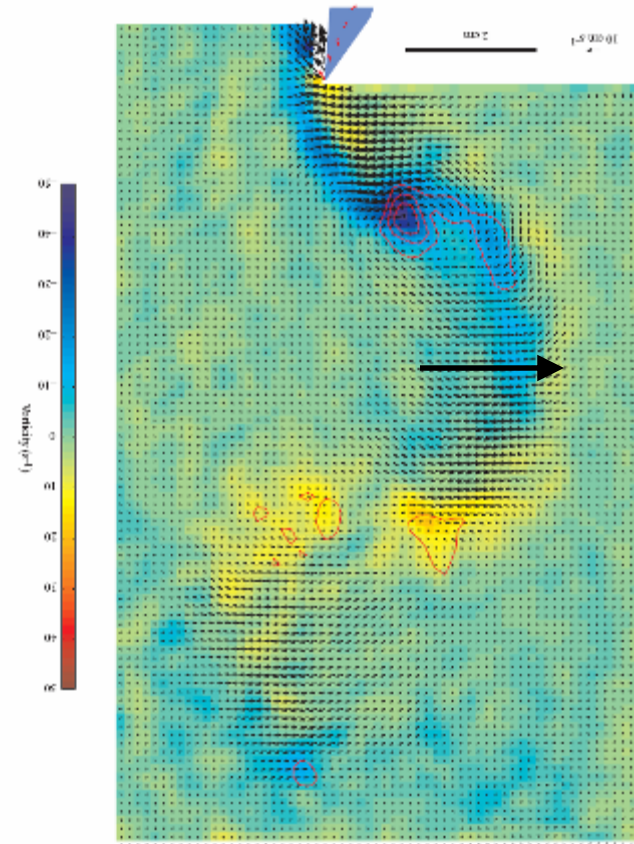


Lamprey PIV: Marcus Hultmark





Lamprey PIV: Marcus Hultmark



Eel PIV: Eric Tytell



MAE 222: Introduction to Fluid Mechanics

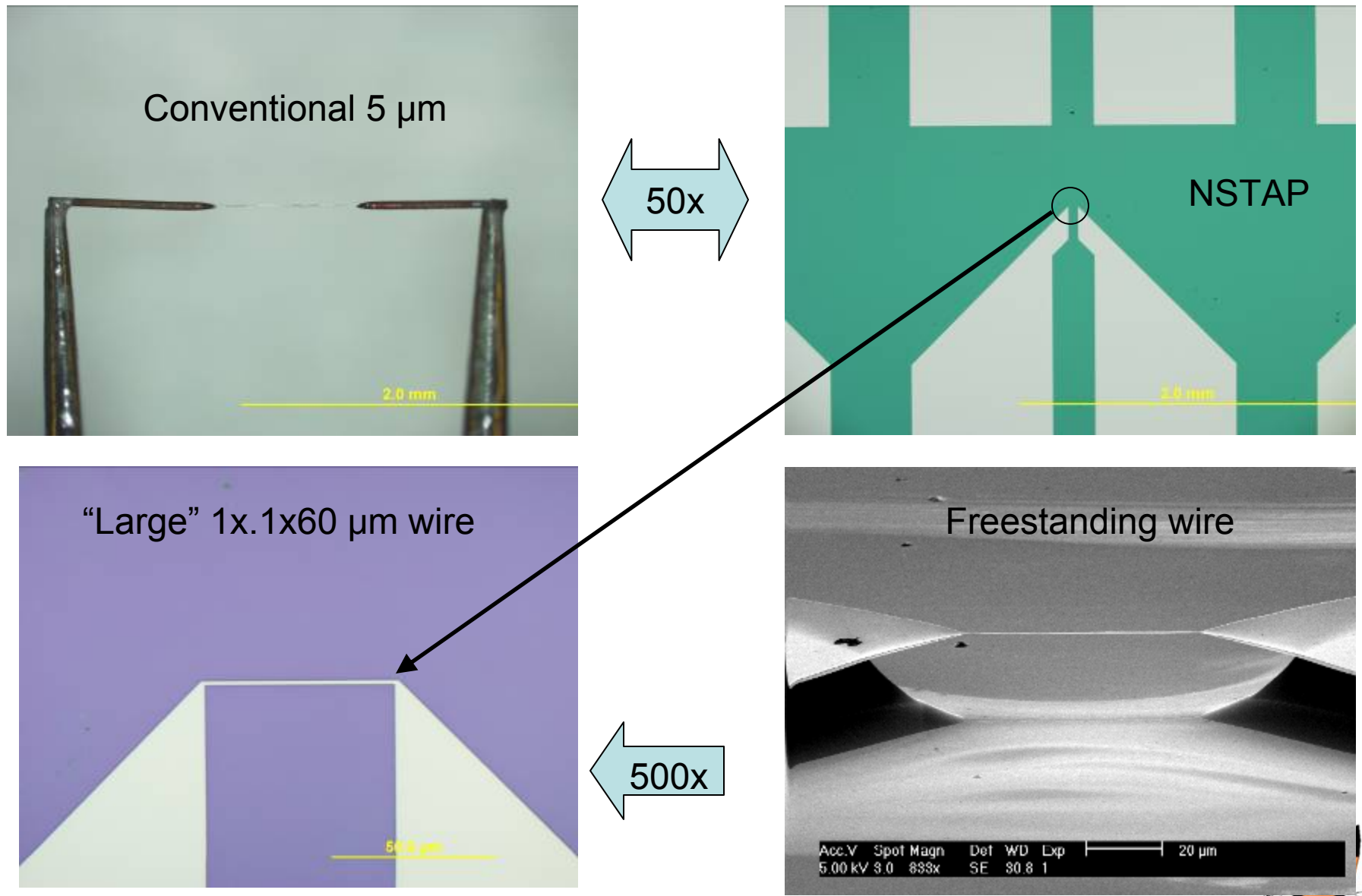
2nd Mid-Term exam, 2005

Question 3 (20 points)

- The drag force (F) produced by an eel swimming on the surface of a lake depends on the frequency of the tail beat (f), the peak-to-peak amplitude of the tail movement (d), its forward velocity (V), the density (ρ) and viscosity (μ) of the fluid, its length (L), and the acceleration due to gravity.
- Express the non-dimensional drag force as a function of the other non-dimensional groups. Try to use groups that are in common use.
- An eel is observed to travel at 1 m/s in water when it beats its tail at 1 Hz. What would the forward velocity and tail beat frequency of a dynamically similar robotic eel that is 3 times larger than a real eel? What would the kinematic viscosity of the test fluid need to be (compared to water) to maintain dynamic similarity?



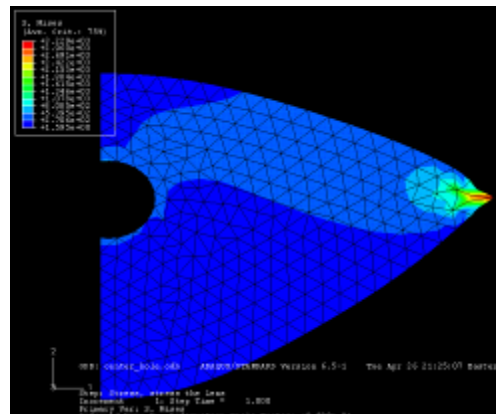
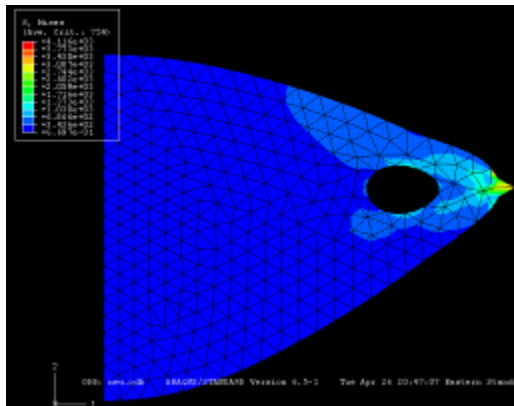
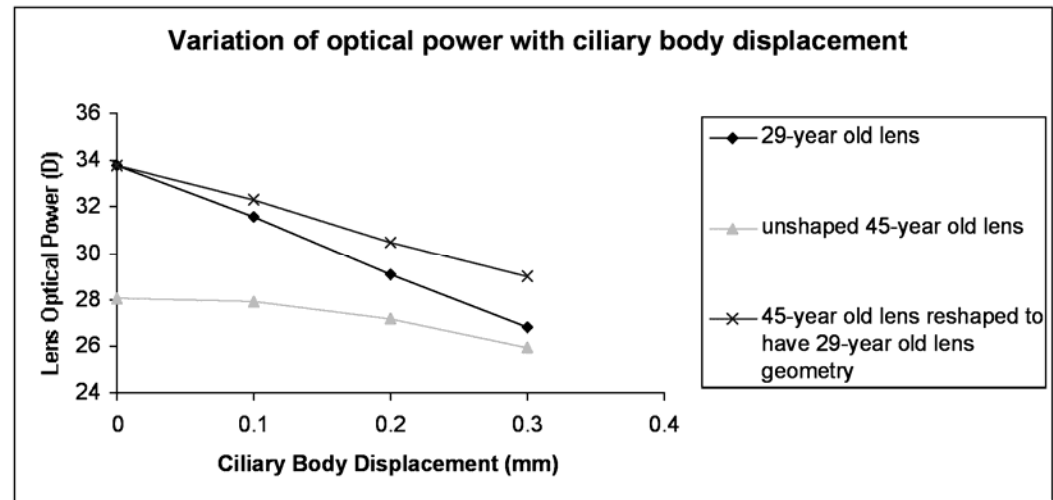
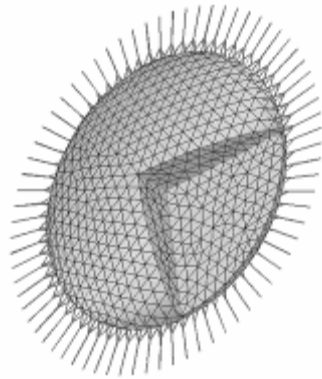
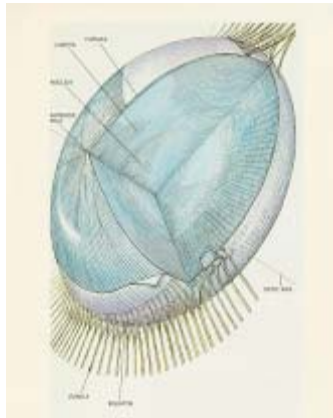
Development of NSTAP: Nanoscale thermal anemometry probe



(Jeff Hill, with Dr. Gary Kunkel and Professor Craig Arnold)



Femtosecond Laser Eye Lens Surgery



- Use femtosecond laser to ablate lens material in the human eye to correct for presbyopia (with Professor Suckewer).
- Perform computations to devise optimum laser ablation strategies



Coupling Research and Education

- Students compete on a world stage
- Students are challenged to go beyond their potential
- Students use world-class facilities
- Teaching is informed by current frontiers of inquiry
- Faculty have access to bright, motivated students (inexperienced but cheap)
- Faculty can explore new areas/interests with little risk
- Faculty help develop a pool of candidates for graduate studies



- *BILL MOYERS: Do you ever have the sense of... being helped by hidden hands?*

JOSEPH CAMPBELL: All the time. It is miraculous. I even have a superstition that has grown on me as a result of invisible hands coming all the time - namely, that if you do follow your bliss you put yourself on a kind of track that has been there all the while, waiting for you, and the life that you ought to be living is the one you are living. When you can see that, you begin to meet people who are in your field of bliss, and they open doors to you. I say, follow your bliss and don't be afraid, and doors will open where you didn't know they were going to be.

* * *

My general formula for my students is "Follow your bliss." Find where it is, and don't be afraid to follow it.

--Joseph Campbell, [The Power of Myth](#), pp. 120, 149



Questions?

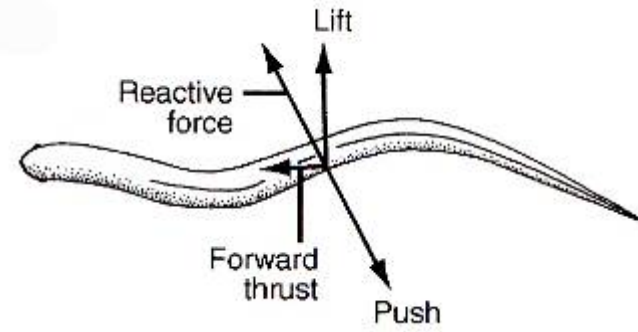
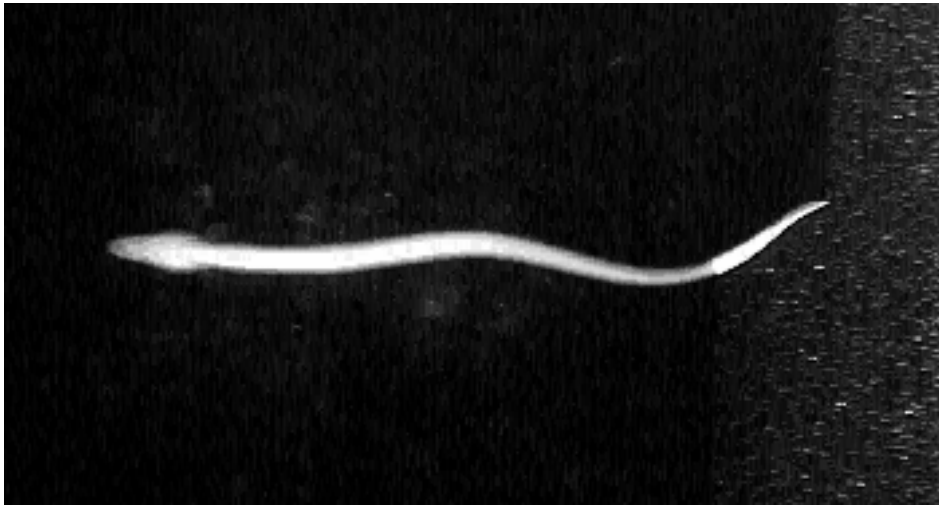


The Central Role of the Discipline

- **Colbeck** (1998) carried out a detailed study of staff from English and Physics. In English the linkage was stronger with respect to the content of the curriculum. In Physics the link lay more in the process of inquiry and the involvement of undergraduate and postgraduate students in staff research projects.



Eels anguilliform locomotion



lamprey

