

Curriculum Reform of the Mechanical Engineering Program at the City College of New York

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Supported by NSF and in collaboration with ASME



OBJECTIVES

- Incorporation of Emerging Technologies into the Mechanical Engineering Curriculum
- Introduction of New Teaching Strategies Focused on Student Learning
- Recruitment and Retention Efforts to Increase Students Majoring in Mechanical Engineering, Especially Underrepresented Minorities and Women

INCORPORATION OF EMERGING TECHNOLOGIES INTO THE ME CURRICULUM

- MEMS/NEMS
- Advanced Materials
- Computer Aided Engineering
- Intelligent Systems/Electronics
- Biotechnology
- Nanotechnology
- Nontraditional Energy

INCORPORATION OF NEW TEACHING STRATEGIES

- Cooperative Learning
- Project-based Learning
- Research Methods
- Laboratory Experience
- Independent Learning

RECRUITMENT AND RETENTION

- RECRUITMENT
 - The Freshmen / High School Design Contest
 - The ASME, SAE and AIAA Design Contests
 - Reverse Engineering Workshop
- RETENTION
 - Early Exposure to Engineering
 - Early Intervention with Marginal Students
 - Creating a Receptive Environment for Women Students

ELIMINATION AND ADDITION OF COURSES NEW SCIENCE REQUIREMENTS

- New course: *Micro/Nano Materials and Manufacturing*
- Combine: *Thermodynamics II, Energy Systems Design, To one New course: Thermal Systems Design and Analysis*
- Establish new *Energy System Laboratory*
- Restrict 2nd Science Elective to: Human Physiology, Organic Chemistry or Modern Physics

COLLABORATION WITH ASME

- Incorporation of *ASME Professional Practice Curriculum Modules* into the ME curriculum
- Effective Teaching Workshop
- Industry Advisory Board
- Dissemination

INCORPORATION OF EMERGING TECHNOLOGIES

New Micro/Nano Technology Course

ME 46300: *Micro/Nano Technology: Mechanics, Materials, and Manufacturing*

The aim of this course is to introduce students with diverse technical interests to the emerging area of micro and nano phenomena in science and engineering. Micro-Electrical Mechanical Systems (MEMS) and Nanotechnology continue to revolutionize research in the engineering and science communities requiring newcomers to familiarize themselves with these fundamental principles. This course will address synthesis and manufacturing techniques of micro/nano devices, relevant mechanics concepts (such as fracture and contact mechanics, elasticity), material property determination at small scales (e.g. size-scale strength effects), and engineering difficulties with manipulation and control of materials and phenomena on scales less than 1000 times the width of a human hair. The course will be centered upon a series of investigational exercises including microfluidics experiments, electro-mechanical testing of microdevices, transport and deposition of macromolecules (e.g. DNA, proteins), nanolithography, and manipulation of carbon nanotubes. Course material will also briefly discuss the evolution of select micro/nano innovations and their impact and applications in applied sciences, medicine, space development, policy, and the environment.

INCORPORATION OF EMERGING TECHNOLOGIES IN THERMODYNAMICS

Reversible computing (electrical engineering)

Current trends indicate that integrated circuits with transistors roughly an order of magnitude smaller than today's will generate 1 MW/cm² of heat, melting their substrates and consuming energy equivalent to the output of a small, commercial power plant. One workaround is to dramatically change the chip architecture, as Intel is now doing, to increase processing speed through increased parallelism rather than through increased clock rate. A second option is to make chips operate reversibly and therefore eliminate waste heat generation. A research group at the University of Florida recently created the world's first fully adiabatic microprocessor. Presenting this technology illustrates the critical importance of thermodynamic reasoning in a very nontraditional application.

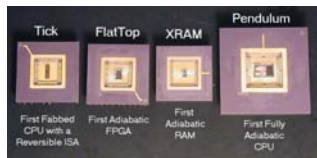


Figure 1. Reversible chips.

Ink jet printers (mechanical and chemical engineering)

Ink jet printing illustrates a reversible work mode in the form of surface tension work on the forming ink bubble. This technology has emerged over the last decade as the most affordable way to achieve high quality printing.

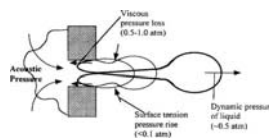


Figure 2. Ink jet printing.

Magnetic levitation, superconductivity and superfluidity (electrical and mechanical engineering)

Magnetic levitation provides students with an example of an emerging technology based on reversible electric conduction and reversible magnetic work. Furthermore, discussing the high thermal conductivity of superfluid liquid helium and its application to cooling superconducting magnets provides an example of one of the few truly reversible mechanical processes in nature.

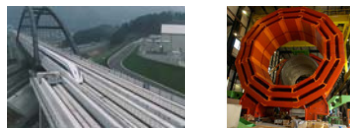


Figure 3. (a) Superconducting magnetic levitation and (b) superfluid-cooled particle accelerator magnets at CERN.

The following emerging technology illustrates the irreversible work concept and exemplifies the general principle that any final system state reached through irreversible work can also be reached through reversible work plus heat transfer.

Seismic isolation (civil engineering)

Seismic isolation is a vibration damping technology used in building design. As isolators absorb earthquake shocks, a spring compresses reversibly and a fluid damps the motion irreversibly. In terms of the beginning and ending states, this is thermodynamically equivalent to reversible compression of the spring plus heat transfer to the fluid. This technology is emerging as buildings are being designed to respond actively to environmental inputs.

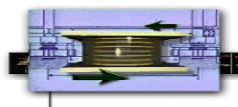


Figure 4. Seismic isolator.

Magnetic cooling is one other emerging technology presented. It facilitates further discussion of reversible magnetic work and provides a platform for introducing the need for environmentally friendly refrigeration without the use of traditional refrigerants.

NEW TEACHING STRATEGIES (FLUID MECHANICS): Fluid Flow Visualization

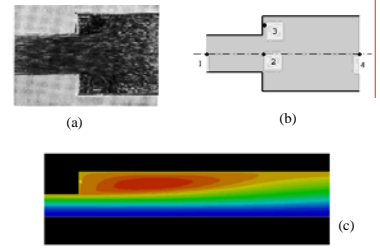


Figure 5. a) Experimental flow visualization of flow through and expansion, from *Visualized Flow*, Japan Society of Mechanical Engineers, Pergamon Press, 1988, b) typical diagram for control volume analysis of flow through an expansion, and c) CFD visualization of flow through an expansion created using FLOWLAB software

NEW TEACHING STRATEGIES: AN EXAMPLE

INCORPORATION OF HOME EXPERIMENTS INTO MECHANICS OF MATERIALS COURSE

Home Experiments: Students perform simple experiments at home using common materials and supplies to learn about concept introduced in class

Experiment 1: Elongation in Axial Loading

Suspend a ruler with two nylon fishing lines as shown in Fig. 6. Apply a load to the ruler at a point between the two lines and measure the elongations of the two lines. Compare your result with theoretical prediction of the elongations.

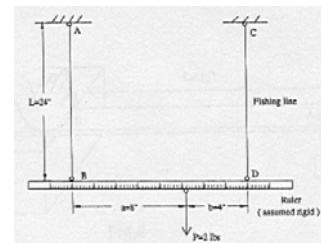


Figure 6.

Experiment 2: Bending Failure of Chalk

Supports a stick of chalk horizontally at both ends on two round pencils as shown in Fig. 7. Load the chalk by suspending a weight at its mid-span. Increase the load until failure occurs. Use theory and data from this test to predict failure due to a load at another location. Compare with your experimental result.

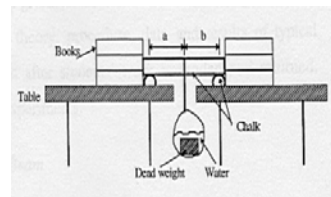


Figure 7.

Experiment 3: Torsion Failure of Chalk

Apply torsion to a stick of chalk by placing it vertically on a table and suspending a load with a string wrapped around the chalk as shown in Fig. 8. Increase the load until failure occurs. Compare with theoretical prediction of failure load.

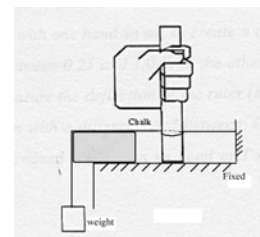


Figure 8.