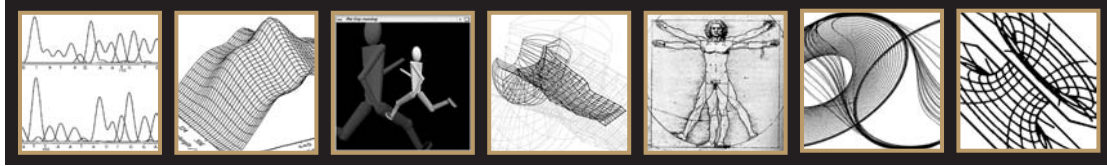
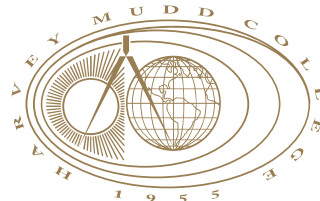


# Presentation Days 2003



A Celebration of Student Projects

**May 5, 6 & 7**



**Harvey Mudd College  
Claremont, California**

## Presentation Days 2003 A Celebration of Student Projects

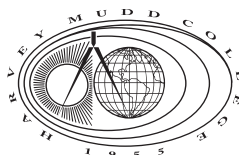
Research is an integral part of the education of all students at Harvey Mudd College. The ability to conduct original investigations, to plan an approach to a problem, and to see it through are essential to success in any scholarly endeavor. We set time aside during the spring semester to celebrate the work of our students as they present their original projects in design or research. Whether this work is done in the context of the Clinic Program, as an individual research project with a faculty advisor, or as part of a class project, the emphasis is on the students' own achievements. Some of this work has already been published; much more of it will be published in the future.

This year 248 students are participating in Presentation Days, including more than 100 research talks from students in each of the majors. Students in the Department of Humanities and Social Sciences are examining the history of books in western culture and displaying their black and white photographs; while students from Interdisciplinary Studies are exploring cultures through a role-playing game they developed. The results of the Introduction to Engineering Design projects, involving 21 teams of freshman and sophomore students, will also be presented.

The keynote speaker for Presentation Days 2003 is Michael H. Dickinson from the California Institute of Technology. Dr. Dickinson will speak on "How Flies Fly," Monday, May 5, at 4:00 P.M. in Galileo Hall.

For more information, please contact the Office of the Dean of Faculty, Harvey Mudd College, at (909) 621-8122.

The Presentation Days Committee consists of Sally Rich Arroyo, Andrew Bernoff, Chih-Yung Chen, Marianne de Laet, Eric Ditwiler, Adam Johnson, Christopher Stone, and Ruye Wang, and is chaired by Catherine McFadden.



## Presentation Days 2003 Schedule

### Monday, May 5

■ 9:00 A.M. Research Presentations Begin

- All Day     **Art 50: Beginning Black and White Photography**—Galileo Foyer
- All Day     **Philosophy 197: Directed Reading in Existentialism**—Galileo Foyer
- On-Going    **American Studies 115: Print and American Culture**—Sprague Library

	<b>Chemistry</b> <i>Galileo-Pryne</i>	<b>Engineering</b> <i>Galileo-Edwards</i>	<b>Humanities and Social Sciences</b> <i>Galileo-McAlister</i>	<b>Mathematics</b> <i>Beckman B126</i>	<b>Physics</b> <i>Galileo-Edwards</i>
9:00 A.M.				D. Beutel	J. Norwood
9:15 A.M.	J. Middendorf				J. Pearson
9:30 A.M.	C. Zarzana			B. Bryant	N. Yoshimizu
9:45 A.M.	C. Edwards				B. Brown
10:00 A.M.	Chemistry and Biology Departments Reception—Galileo Foyer				
10:15 A.M.					
10:30 A.M.	S. Pheasant			P. Lamb	J. Hogan
10:45 A.M.	N. Philips				K. Barbary
11:00 A.M.	M. Patten			D. Gianotti	
11:15 A.M.		J. Hsu, C. Stratton	Media Studies 182:		
11:30 A.M.		E. Koos, A. Utvich	Introduction to Video Production		
11:45 A.M.		M. Erler, G. Breed	↓		
12:00 noon	Lunch Break				

■ 1:00 P.M. Research Presentations Begin

	<b>Biology</b> <i>Galileo-Pryne</i>	<b>Computer Science</b> <i>Galileo-McAlister</i>	<b>Humanities and Social Sciences</b> <i>Galileo-Edwards</i>	<b>Mathematics</b> <i>Beckman B126</i>	<b>Physics</b> <i>Galileo-Edwards</i>
1:00 P.M.		K. Evans		C. Pries	D. Liao
1:15 P.M.	P. Brock	E. Kim			A. McCaffrey
1:30 P.M.	D. Asbury	M. Chase, G. Kuan		R. Richardson	M. Lee, R. Lovec
1:45 P.M.	E. Clancy				C. Raub
2:00 P.M.	Break			M. Smukler	
2:15 P.M.	J. Werbin	B. Bentow, J. Malone	Humanities 2: The Book in		
2:30 P.M.	A. Crofut	D. Gleich	Western Culture	K. Sushkoff	
2:45 P.M.	R. Harnett	G. Romer	↓		
3:00 P.M.	A. Bobbs		K. Evans	J. Cloutier	
3:15 P.M.					
3:30 P.M.	Humanities and Social Sciences Department Reception—Galileo Foyer				
3:45 P.M.					
4:00 P.M.	<b>Presentation Days Address—Galileo-McAlister</b> <b>"How Flies Fly"—Michael H. Dickinson, Professor of Bioengineering and Biology, Caltech</b>				

**Tuesday, May 6** Projects day 10:30 A.M.–5:00 P.M. Please See Projects Day Program for further details.

## Presentation Days 2003 Schedule

### Wednesday, May 7

■ 9:00 A.M. Research Presentations Begin

All A.M.    **Chemistry Poster Session—Galileo Foyer**

On-Going    **American Studies 115: Print and American Culture—Sprague Library**

	<b>Chemistry</b> <i>Beckman B134</i>	<b>Computer Science</b> <i>Galileo-McAlister</i>	<b>Engineering</b> <i>Galileo-Pryne</i>	<b>Mathematics</b> <i>Beckman Hall B126</i>	<b>Physics</b> <i>Galileo-Edwards</i>
9:00 A.M.			E158: Introduction to	M. Chase	
9:15 A.M.			CMOS VLSI Design		
9:30 A.M.	Chemistry 112:			J. Rouse	E. Deyo
9:45 A.M.	Inquest/Prosecution				D. Clarke
10:00 A.M.		Mathematics and Physics Departments Reception—Galileo Foyer			
10:15 A.M.					
10:30 A.M.	Chemistry 112:	B. FrantzDale		MCM Presentation	A. Arney
10:45 A.M.	Inquest/Defense	G. Romer,			D. Barnard
11:00 A.M.		R. Fujiyama, W. Berriel,		ICM Presentation	N. Carlson
11:15 A.M.		A. Gadani			N. Stern
11:30 A.M.	Lunch Break				

■ 1:15 P.M. Research Presentations Begin

All P.M.    **CS155: Computer Graphics Projects—Galileo Foyer**

	<b>Physics</b> <i>Beckman B134</i>	<b>Chemistry</b> <i>Galileo-Pryne</i>	<b>Interdisciplinary</b> <i>Galileo-Pryne</i>	<b>Engineering</b> <i>Galileo-Pryne</i>	<b>Engineering</b> <i>Galileo-Edwards</i> <i>Galileo-McAlister</i>	<b>Mathematics</b> <i>Beckman B126</i>
1:15 P.M.	Physics 170:	E. Cukier			E4 Design	A. Barton
1:30 P.M.	Computational	K. Nelson			Presentations	
1:45 P.M.	Physics	L. Baker				S. Haas
2:00 P.M.		S. Awasthi				
2:15 P.M.			ID198: Explorations in RPGs			A. Iannaccone
2:30 P.M.						
2:45 P.M.		Engineering and Computer Science Departments Reception—Galileo Foyer				
3:00 P.M.						
3:15 P.M.				Engineering 191:		N. Eldredge
3:30 P.M.				Advanced Problems		
3:45 P.M.				in Engineering		M. Macauley
4:00 P.M.						
4:15 P.M.						D. Uminsky
4:30 P.M.						

**Monday, May 5 2003****9:00 A.M.–12:00 P.M.****■ Research Presentations**9:00 A.M. **Physics Presentations** please see page 59:30 A.M. **Chemistry Presentations** please see page 611:00 A.M. **Engineering 191 Presentations** please see page 811:00 A.M. **Humanities and Social Sciences Presentations** please see page 8**Humanities and Social Sciences—Galileo Foyer**

All Day **Art 50: *Beginning Black & White Photography*—Exhibition of Best Work**  
 Jeremy L. Watson, Kristal T. Pollack, Florence L. Shaffer, Claire Edwards, Monica Jo Patten, Peter Chung, Andrea Crofut, Nils E. Napp, Jenny Xu, Rose Hakim, Eric T. Harley, Keith Miyake, Michelle Sakai, Aileen Nuguid, Will Chang and Sharon Jeun

Each student will exhibit six to eight of his/her best photographic images from the semester. Images will be displayed aesthetically. Each student will provide a brief discussion of artistic objectives, including some discussion of the images themselves.

Faculty Advisor: *Tad A. Beckman, Humanities and Social Sciences*

All Day **Philosophy 197: *Directed Reading in Existentialism***  
 Natalie Schommer: *A Photographic Portfolio*

This portfolio is a collection of black and white photographic images created throughout the semester as a response to readings in the works of Sartre, de Beauvoir and Camus. Some explanatory materials will be provided.

Faculty Advisor: *Tad A. Beckman, Humanities and Social Sciences*

**Humanities and Social Sciences—Sprague Library Circulation Area**

On-Going **American Studies 115: *Print and American Culture*—Exhibition**  
 Tera Bell, Alyssa Caridis, Erin Clancy, Andrew Cole, Jessica Fisher, Mary Peter, Rafael Vasquez

Students in **American Studies 115: *Print and American Culture*** spent part of the semester researching American print artifacts from Special Collections of the Libraries of The Claremont Colleges. The fruits of their research are on display in the Sprague Library circulation area.

Course Instructor: *Jeffrey D. Groves, Humanities and Social Sciences*

**Mathematics—Beckman B126**9:00 A.M. **Dan Beutel: *Flow in Rectangular Microchannels***

In the biotech industry, there is great interest in designing micron-scale mixers. One strategy is to design a channel that mixes a fluid being pumped through it. I will present the results of numerical simulations of fluid flow in a rectangular microchannel, concentrating on how a solute is mixed by the channel flow. I investigated two geometries: first, the mixing of two streams meeting in a Y-junction; and second, the mixing induced by flow over a wavy bottom. I will discuss strategies for optimizing the mixing rate in a microchannel.

Faculty Advisor: *Andrew J. Bernoff, Mathematics*

## Mathematics Presentations Continued

9:30 A.M. **Benjamin P. Bryant: *Modeling Moving Droplets***

We present one-, and two-dimensional models of moving droplets driven by combinations of gravity and wind shear, such as would be found on the surface of a vehicle traveling through rain. Governing equations based on the lubrication approximation are presented, and characterizations of droplet behavior based on numerical solutions are described. Lastly, applications to the efficiency of aircraft wings in rain will be discussed.

Faculty Advisors: *Andrew J. Bernoff and Anette "Peko" Hosoi, Mathematics*

10:00 A.M. **Chemistry and Biology Departments Reception—Galileo Foyer**10:30 A.M. **Peter J. Lamb: *Ridge Coarsening in Evaporatively Driven Climbing Films***

A thin-film mixture of alcohol and water climbing an inclined plate exhibits several interesting instabilities. Where the base of the thin-film rejoins the larger reservoir, small ridges form which slowly drift to the side and merge with others, coarsening into larger ridges. These instabilities are driven primarily by the more rapid evaporation of alcohol than water, forming surface tension gradients and causing what is known as Marangoni convection. In the thin-film limit, the Navier-Stokes equations simplify to a fourth-order partial differential equation for the film thickness. This equation forms the basis for our analytical and numerical modeling of the instability.

Faculty Advisor: *Ali Nadim (Claremont Graduate University, Mathematics and Keck Graduate Institute)*

11:00 A.M. **Daniel Gianotti: *Fluid Drop Coalescence in a Hele-Shaw Cell***

A drop of fluid bound between two narrowly-spaced plates behaves according to the Hele-Shaw equation in an approximation of 2D potential flow. Motion of the drop's interface is analytically determined by geometric properties of the boundary curve, physical properties of the fluid, and conditions imposed by the Hele-Shaw cell through a boundary-integral method. When two drops collide, their interfaces unite and their coalescence behavior is determined by the same means as single-drop motion. Discretizing the boundary curve leads to a description of the time evolution of a single drop or multiple coalescing drops based on initial conditions and system inputs.

Faculty Advisor: *Ali Nadim (Claremont Graduate University, Mathematics and Keck Graduate Institute)*

**Physics—Galileo-Edwards**9:00 A.M. **Jim Norwood: *Properties of Certain Main-Belt Asteroids Determined from Lightcurve Observations***

Conclusions obtained from observations of various main-belt asteroids taken this year will be presented. These results are based on photometry based on the changes in each asteroid's brightness over a period of hours, and involve the development of observation and analysis techniques for future large-scale studies of asteroids and similar bodies.

Faculty Advisor: *Gregory A. Lyzenga, Physics*

9:15 A.M. **Jonathan Pearson: *Modeling of Moon Formation from Giant Impact and Subsequent Circum-geo Accretion Disk Using N-body Simulation.***

One of the most popular current models of the formation of Earth's Moon postulates that a large, Mars-sized body struck the early forming Earth, and the Moon formed out of the ejecta of that impact. I use an n-body simulation of the post-impact phase to simulate this process and determine some bounds on the types of collisions necessary to produce the current Earth-Moon system. Some of the major goals of this simulation were to develop efficient  $O(n \log(n))$  force computation and collision detection algorithms. The initial conditions used come from other numerical and experimental work done in the field.

Faculty Advisor: *Gregory A. Lyzenga, Physics*

## Physics Presentations Continued

9:30 A.M. **Norimasa Yoshimizu: *Defects Responsible for Weak Persistent Photoconductivity in d-doped GaAs:Si***

In addition to persistent photoconductivity (PPC) attributed to DX centers, a weak PPC has been observed in  $\delta$ -doped GaAs:Si, which has the highest annealing temperature (230 K) in the GaAs:Si system, and thus is extremely attractive for optical high-density storage. To characterize the responsible defects, the Shubnikov-de Haas oscillations up to a field strength of 30 T were measured at 4 K both before and after illumination. From the Shubnikov-de Haas oscillations, the subband occupation of the electrons under various circumstances is extracted, and used to solve Schrodinger and Poisson's equations simultaneously. The final solution thus provides the information of the width and depth of the potential wells, which is closely related to the location of the defects.

Faculty Advisor: *Chih-Yung Chen, Physics*

9:45 A.M. **Benjamin P. Brown: *Infrared Astronomy and Star Formation***

Low-mass stars form by accreting material from a circumstellar disk. These disks are very luminous in the infrared, so excess IR luminosity is a signature of low-mass star formation. In addition, new stars are typically embedded in dusty clouds. The dust absorbs visible light, but is relatively transparent in IR, so infrared is the band of choice for the study of star formation. For my thesis, I worked on repairing the Pomona/HMC IR camera and began a survey of nearby star-forming regions.

Faculty Advisor: *Ann Esin, Physics*

10:00 A.M. **Chemistry and Biology Departments Reception—Galileo Foyer**10:30 A.M. **Jason Hogan: *The Droplet Source Project***

In the last ten years, laser-driven fusion experiments performed on angstrom-scale deuterium clusters have shown a surprisingly high neutron yield per Joule of incident beam energy. Results indicate that the optimal cluster size that maximizes fusion events should be in the 0.01 to 1 micron diameter range, but an appropriate source of droplets of this size does not exist. In an attempt to meet this need, we use ultrasonic atomization to generate micron scale droplet aerosols of high average density, and we have developed and refined a reliable droplet sizing technique. In the process, our results have allowed us to test the theory of fluid dynamics in a novel regime.

Faculty Advisor: *Thomas D. Donnelly, Physics*

10:45 A.M. **Kyle Barbary: *Measurement of the Spatial Coherence of Second-order Harmonic Light Generated from a Gold Surface***

Second harmonic generation (SHG) can be used to investigate the dynamics of surface states of metals. We present an experiment that uses SHG to determine the dephasing rate of electrons at a gold surface. Using a series of Young's double-slits, the spatial coherence of second harmonic light can be measured. This measurement will be used by our collaborators to constrain a numeric model of gold, and thus determine the electron dephasing rate.

Faculty Advisor: *Thomas D. Donnelly, Physics*

**Chemistry—Galileo-Pryne**9:15 A.M. **Josh Middendorf: *Lyotropic Mesophases Exhibited by Cobalt(II) Stearate and Hexatricontane***

Advisor: *Gerald R. Van Hecke, Chemistry*

9:30 A.M. **Chris Zarzana: *The Use of Microhotplate Arrays for the Preparation of Selective Gas Sensors***

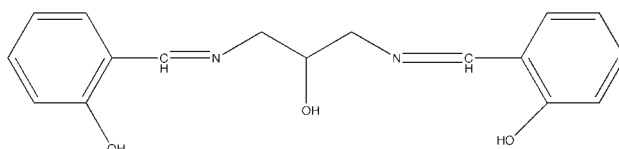
Electronic nose (EN) technology has recently begun to gain interest as an analytical tool. Thin metal oxide films are promising materials for the construction of the sensing portion of these devices. Additionally, the development of micromachined silicon platforms called microhotplates has provided an interesting test bed on which to deposit these films. Chemical vapor deposition is an effective, temperature-controllable process for preparing metal oxide thin films on these devices. We report on the design and construction of an apparatus for the controlled deposition of thin metal oxide films on microhotplate arrays, and the use of these film arrays for gas sensing.

Faculty Advisor: *Charles Taylor (Pomona College, Chemistry)*

## Chemistry Presentations Continued

9:45 A.M. **Claire Edwards: Synthesis of Novel Fe(II)-Ti Complexes**

The synthesis of polymetallic species constitutes the first step toward enzyme active site modeling and molecular computing. Here the target complex is  $\text{TiCl}_2(\text{NMe}_2)(\text{Fe(II)Y})$ , in which Y is a SalprenOH derivative. For each Y (yellow) ligand there is a corresponding W (white) ligand in which the carbon-nitrogen double bond has been reduced. Emphasis was placed on altering the solubility properties of Y (W) by replacing the salicylaldehyde in the ligand synthesis with similar benzaldehydes containing tert-Butyl groups. This was shown to enhance the solubility of the iron- and iron-titanium complexes.



SalprenOH

Faculty Advisor: Adam R. Johnson, Chemistry

10:00 A.M. **Chemistry and Biology Departments Reception—Galileo Foyer**10:30 A.M. **Sean Pheasant: Intramolecular Electron Transfer in Ruthenium Porphyrin Dimers**

Electronic coupling elements between pairs of centers were calculated for three different ruthenium-porphyrindimers: cofacial  $(\text{Ru-porphyrin})_2(\text{pz})_2(\text{CO})_2$ , shishkebab  $(\text{Ru-porphyrin})_2(\text{pz})(\text{py})_2$  and shishkebab  $(\text{Ru-porphyrin})_2(\text{pz})(\text{CO})_2$ . The theoretical methods used were DFT, RHF theory, and the semiempirical method, ZINDO. The Creutz-Taube ion  $[(\text{Ru}(\text{NH}_3)_5)_2(\text{pz})]^{+5}$  was also analyzed as a means of assessing our porphyrin dimer calculations. Our calculations confirmed that the coupling was large in this compound. Couplings comparable to the Creutz-Taube ion were found only for the shishkebab  $(\text{Ru-porphyrin})_2(\text{pz})(\text{py})_2$  dimer.

Faculty Advisors: Robert J. Cave and Hal Van Ryswyk, Chemistry

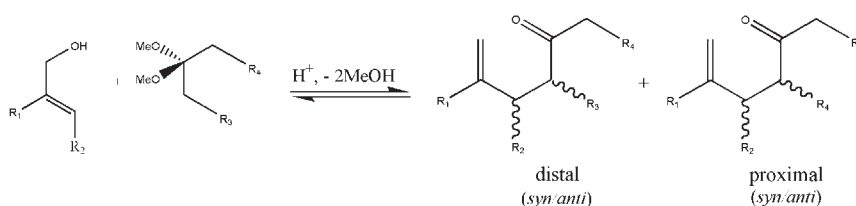
10:45 A.M. **Noah Philips: Domain Ordering in Asymmetric Diblock Copolymers**

The effect of electric fields on the microstructure of a polystyrene-polyvinylpyridine copolymer was investigated. Theoretical calculations and modeling indicate that a reordering from spherical to cylindrical micelles could be achieved through the application of a strong ( $\sim 10$  kV/cm) electric field. An experimental procedure is described for creating the ordering, and the results of the procedure are presented.

Faculty Advisors: Shenda M. Baker, Chemistry and Joseph A. King, Engineering

11:00 A.M. **Monica Jo Patten: Regio- and Stereoselectivity of the Ketal Claisen rearrangement**

The regio- and stereoselectivity for the ketal Claisen rearrangement has been studied by finding the proximal/distal selectivity and *syn/anti* selectivity in the proximal and, when applicable, the distal portion of the product mixture. The substitution patterns of both the alcohol and the ketal have large effects on the regioselectivity, and the alcohol's substitution pattern has significant effects on the stereoselectivity. Products were characterized by IR,  $^1\text{H}$  and  $^{13}\text{C}$  NMR, and mass spectral analysis.



Faculty Advisor: G. William Daub, Chemistry

**Engineering—Galileo-Edwards****Engineering 191: Advanced Problems in Engineering**

11:15 A.M. **Judy Hsu and Chris Stratton:** *Design and Construction of the HMC Wind Tunnel*

During the summer and fall of 2002, students researched, designed and constructed the Harvey Mudd College wind tunnel facility to study the aerodynamics of baseball pitches. The subsonic wind tunnel has an open-circuit configuration with a 1ft. x 1ft. test section. Unique features of the facility include compartments specialized for easy removal of flow-conditioning screens and honeycomb. In addition, the test section instrumentation allows for force and drag measurements on a spinning baseball while transparent, and detachable panels ease flow visualization.

Advisor: *Jennifer Stroud Rossmann, Engineering*

11:30 A.M. **Erin Koos and Alexis Utvich:** *Validation and Instrumentation of the HMC Wind Tunnel*

A range of experiments were performed to validate the performance characteristics of the new HMC wind tunnel. The support structure for the tunnel was characterized and refined, and the flow generated was also investigated. The facility's current instrumentation consists of a Pitot-static pressure probe, from which velocity data is obtained; a sting balance capable of lift and drag force measurements; and a hot-wire anemometer useful in validating the test section flow, as it reliably and accurately measures air speed fluctuations and these fluctuations reflect the level of turbulence present. A custom fog injection rake, designed and built by the undergraduate research team, allows visualization of flow streamlines.

Advisor: *Jennifer Stroud Rossmann, Engineering*

11:45 A.M. **Matthew Erler, Genevieve Breed:** *Comparison of Noise Tolerant Precharge (NTP) to Conventional Feedback Keepers for Dynamic Logic*

Dynamic logic requires some sort of keeper to prevent the output node from floating and to provide acceptable noise immunity. A number of recent papers have advocated using a very weak complementary pMOS network in place of the conventional feedback keeper; such a technique is called Noise Tolerant Precharge (NTP). This paper compares the delay and noise margin of NTP with conventional feedback keepers. Although NTP is more robust in that it can recover from a dynamic noise event, it is also 5–50 percent slower than conventional feedback keepers with the same static noise margin.

Faculty Advisor: *David Harris, Engineering*

**Humanities and Social Sciences—Galileo-McAlister**

11:00 A.M. **Media Studies 182s:** *Introduction to Video Production*

These short videos were created individually and in groups as final projects for the Introduction to Video Production class, using Canon XL1 cameras and Final Cut Pro.

Course Instructor: *Rachel Mayeri, Humanities and Social Sciences*

**12:00 Noon****▪ Lunch Break**

**1:00 P.M.–5:00 P.M.****■ Research Presentations**

- 1:00 P.M. **Mathematics Presentations** please see page 10
- 1:00 P.M. **Physics Presentations** please see page 11
- 1:15 P.M. **Biology Presentations** please see page 11
- 2:15 P.M. **Humanities and Social Science Presentations** please see page 13

**Computer Science—Galileo-McAlister**

- 1:00 P.M. **Kylie Evans: *Who's on First? Schedulers and Priorities in Practice***

An operating system scheduler is responsible for allocating the processor to various tasks. To help it make good decisions, the user can supply priorities to indicate whether a task is important or unimportant. We will present results of experiments with several different operating systems, showing that these priorities do not have the effects that a user might reasonably expect of them.

Faculty Advisor: *Geoffrey H. Kuenning, Computer Science*

- 1:15 P.M. **Elmer Kim: *Views and Cyclone: Extending a Language***

The Cyclone programming language, a variant of C, adds safety while preserving control over data representations and memory management. Cyclone also adds modern features to the language, including pattern matching. Views are a general method for combining data abstraction with pattern matching; the goal of this work was to design and implement a view extension for Cyclone.

Faculty Advisor: *Christopher A. Stone, Computer Science*

- 1:30 P.M. **Melissa Chase and George Kuan: *An Implementation of UAE Type Inference***

Type checking can identify many errors at compile-time that would otherwise become run-time errors. Type inference provides the advantages of type checking without the drawback of compelling users to explicitly assign types to all variables. Unfortunately, it also traditionally suffers from uninformative error messages. We implemented and extended the Unification of Assumption Environments (UAE) type inference algorithm to address this problem. Our implementation extends UAE to cover all of core Standard ML and to flag multiple conflicting sites via a multiway unification algorithm.

Faculty Advisor: *Christopher A. Stone, Computer Science*

- 2:15 P.M. **Brian Bentow and Joseph Malone: *Parallel Genetic Decision Trees***

One means of analyzing observational data is through decision trees. Automation of tree construction is used to decrease effort and create more and better trees. We designed and developed genetic programming software for this purpose. Using fitness evaluation and starting with random initial trees, highly fit individuals evolve through from crossovers and mutations. Because genetic programming is inherently computationally expensive, we implemented a version of the software that runs multiple demes for a single population in parallel on multiple processors using the MPI library.

Faculty Advisor: *Robert M. Keller, Computer Science*

- 2:30 P.M. **David Gleich: *Machine Learning Techniques in Computer Chess***

I describe two machine learning paradigms, genetic programming and inductive logic programming, and evaluate their results attempting to learn basic chess rules. Genetic programming exploits a simulation of Darwinian evolution to construct programs. Inductive logic programming builds rules from sample data to construct the most general hypothesis fitting the data.

Faculty Advisor: *Robert M. Keller, Computer Science*

## Computer Science Presentations Continued

2:45 P.M. **Geoffrey Romer: *Virtual Topology in Optical Networks***

This talk will discuss computational problems arising in the design of virtual topologies for optical communication networks. It will examine the topology-design problem for certain classes of networks, covering issues of algorithm design and computational complexity.

Faculty Advisor: *Ran Libeskind-Hadas, Computer Science*

3:30 P.M. **Humanities and Social Sciences Reception—Galileo Foyer****Mathematics—Beckman B 126**1:00 P.M. **Chris Pries: *Searching for Super-Symmetric Cayley-Cycles***

In order to unify two of the past century's most successful theories of physics, M-Theory and F-Theory (generalizations of String Theory) are being developed. In these theories, Spin(7) manifolds play an important role, similar to the role of Calabi-Yau three-folds in String Theory and mirror symmetry. In this context, Cayley manifolds play a similar role to the role played by D-branes in String Theory. However, very few nontrivial Cayley manifolds are known. Even the locally linear cases (generalizations of the platonic solids) are extremely interesting. In this talk I discuss some of their importance to String Theory and demonstrate the tools that I have developed for finding such submanifolds.

Faculty Advisor: *Weiqing Gu, Mathematics*

1:30 P.M. **Ross M. Richardson: *Computing Curves in Lie Groups***

How does one specify the motion of a camera in 3D? As the group of Euclidean motions—SE(3)—corresponds to the space of camera positions, we may formulate this problem as interpolation between points on SE(3). More generally, we may examine the problem of constructing interpolating curves on Lie groups. We shall present the current state of research on this problem, our own work, and a discussion of the trade-off between geometrically meaningful interpolating curves and efficient computation.

Faculty Advisor: *Weiqing Gu, Mathematics*

2:00 P.M. **Micah Smukler: *Geometry, Topology and Applications of the Minkowski Product and Action***

The Minkowski product can be viewed as a higher-dimensional version of interval arithmetic. We present a collection of geometric constructions based on the Minkowski product and on one of its natural generalizations, the quaternion action. We also will present some topological facts about these products, and discuss the applications of these constructions to computer-aided geometric design and Laguerre geometry.

Faculty Advisor: *Weiqing Gu, Mathematics*

2:30 P.M. **Kira Sushkoff: *Minkowski Actions of Quaternion Sets and Their Applications to Laguerre Geometry***

In this talk, I will present some applications of Laguerre Geometry to computer aided geometric design, realized through Minkowski actions. I will first describe Laguerre geometry. Then, I will discuss the use of quaternion sets to define Minkowski actions and achieve results used in geometric design, including Medial Axis Theory.

Faculty Advisor: *Weiqing Gu, Mathematics*

3:00 P.M. **John Cloutier: *A Combinatorial Analogue of the Poincaré-Birkhoff Fixed Point Theorem***

Results from combinatorial topology have shown that certain combinatorial lemmas are equivalent to certain topological fixed point theorems. For example, Sperner's lemma about triangulated simplices has been shown to be equivalent to the fixed point theorem of Brouwer. Moreover, since Sperner's lemma can be proved constructively, its equivalence to the Brouwer fixed point theorem provides a constructive method for actually finding the fixed points rather than just stating their existence. In this talk I will discuss work I have done toward developing a combinatorial analogue to the Poincaré-Birkhoff fixed point theorem.

Faculty Advisor: *Francis E. Su, Mathematics*

3:30 P.M. **Humanities and Social Sciences Reception—Galileo Foyer**

### Physics—Galileo-Edwards

1:00 P.M. **David Liao: *Photon Noise and the Dynamic Range of the Optical Coherence Microscopy***

The quantum nature of photons imposes a fundamental limit on the signal-to-noise ratio of images acquired with an optical coherence microscope (OCM). We have searched for the optimal interferometer configuration and detection scheme for the new Harvey Mudd College OCM instrument. After evaluating Bose-Einstein noise and rediscovering beat noise, we calculate for the optimal interferometer configurations currently proposed an improvement of no more than a factor of 2 to 3 in signal-to-noise ratio over a simple Michelson interferometer.

Faculty Advisors: *Richard C. Haskell, Daniel C. Petersen and Barbara Hoeling, Physics*

1:15 P.M. **Allison McCaffrey: *Adding Motion Sensitivity to an Optical Coherence Microscopy***

Motion sensitive optical coherence microscopy, sometimes called Doppler OCM, can provide images with substantially improved intrinsic contrast. We are adding motion sensitivity to the Harvey Mudd College OCM that operates at 850 nm and acquires three-dimensional images with lateral resolution of 5  $\mu\text{m}$  and a depth resolution of 10  $\mu\text{m}$  in tissue. We expect this new capability to enhance greatly the information content of acquired time-elapse movies of the developmental process of frog gastrulation (*Xenopus laevis*). We hope to test a recently proposed model for cell movement during invertebrate gastrulation.

Faculty Advisors: *Richard C. Haskell, Daniel C. Petersen and Barbara Hoeling, Physics*

1:30 P.M. **Melanie Lee and Rachel Lovec: *Engineering Corneal Replacement Tissue with the Help of Optical Coherence Microscopy***

Human corneal keratocytes have been cultured in a bovine collagen sponge with the aim of generating replacement tissue for damaged human corneas. An optical coherence microscope (OCM) was used to image these tissue cultures as they developed, providing important optical properties of the cultures as a function of time. Preliminary results suggest that sponges under radial tension, similar to intra-ocular pressure, become increasingly transparent and ultimately reach the transparency of excised rabbit corneas.

Faculty Advisors: *Elizabeth Orwin Engineering, Mary Williams, Biology, Daniel Petersen, Barbara Hoeling and Richard Haskell, Physics*

1:45 P.M. **Chris Raub: *Imaging Rabbit Corneas, Tissue-Engineered Corneal Replacements, and Corneal Keratocytes with Phagocytosized Beads Using the Optical Coherence Microscopy***

When seeded onto collagen sponges, corneal keratocytes influence sponge transparency and sponge contraction, and reorganize the collagen matrix. Modified collagen sponges are good choices for corneal replacements because they allow cellular infiltration and can become highly transparent. We compared the backscattering properties of rabbit corneas and cell-seeded collagen sponges using the optical coherence microscope (OCM), which quantifies backscattering and provides detailed 3D images without damaging living cells. Phagocytosized polystyrene beads allowed for quantification of cell population and migration in the collagen sponges.

Faculty Advisor: *Elizabeth J. Orwin, Biology and Engineering*

### Biology—Galileo-Pryne

1:15 P.M. **Patricia Brock: *The Effect of Temperature on the Locomotion of the Desert Spiny Lizard, Sceloporus magister***

*Sceloporus* lizards behaviorally thermoregulate, keeping their body temperature close to 35°C by moving into or out of the sun. In several *Sceloporus* species, physiological performance is optimized near 35°C. However, the physiological performance of most *Sceloporus* species has not been studied in the laboratory. I measured the thermal sensitivity of sprint locomotion in the desert spiny lizard, *Sceloporus magister*, to see if sprint performance in this species is optimized at 35°C, as predicted by its thermoregulatory behavior and by the sprint performance of other *Sceloporus* species.

Faculty Advisor: *Stephen C. Adolph, Biology*

## Biology Presentations Continued

1:30 P.M. **Dee Asbury: Perch Height Choice by Fence Lizards (*Sceloporus occidentalis*): Thermoregulatory Influences and Population Comparisons**

Habitat use by the western fence lizard, *Sceloporus occidentalis*, varies among populations. I investigated experimentally whether these differences are entirely due to behavioral flexibility (e.g., for thermoregulation), or if there are inherent (possibly genetic) differences in perch choice among populations. I examined perch choice by individuals collected from three field populations in simple experimental arenas at the Bernard Field Station. My results indicate that perching behavior is plastic and varies in response to the structural and thermal environments, and that observed differences between populations are most likely due to environmental factors.

Faculty Advisor: *Stephen C. Adolph, Biology*

1:45 P.M. **Erin Clancy: Optimal Daily Activity Patterns for the Lizard *Sceloporus undulatus***

Field research reveals that lizards spend much of their time hiding in a refuge, rather than foraging for prey. I suspect that this behavior has evolved as an optimal balance between the benefits of growth and the risks of predation. To test this hypothesis, I have constructed a dynamic state variable model of a female *Sceloporus undulatus* and used this model to predict the number of hours she should spend active on each day of her life. By varying the model's parameters, I calculated optimal strategies for lizards under a range of physiological and environmental conditions.

Faculty Advisor: *Stephen C. Adolph, Biology*

2:15 P.M. **Jeffrey Werbin: cAMP Driven Modulation of the Human Skeletal Muscle Voltage-Dependent Na<sup>+</sup> channel Deactivation**

Na<sup>+</sup> channels play a vital role in the transmission of biological information by action potentials. The voltage-dependent human skeletal muscle Na<sup>+</sup> channel (hNaV1.4) has three states: one conducting or open (O) state and two non-conducting states including inactivated (I) and closed (C) states. Channels deactivate to the closed state from either the open or inactivated states. I am studying the role of the cAMP second messenger system in channel deactivation. To do this I am determining the effect of the cAMP-dependent protein kinase on the kinetics of the O to C deactivating transition and the I to C deactivating transition using patch clamp techniques.

Faculty Advisor: *James R. Groome, Biology*

2:30 P.M. **Andrea Crofut: The Use of a 2D Elastin Matrix and Mechanical Loading in Tissue Engineering of Meniscal Cartilage**

Each year in the United States, nearly 600,000 surgeries are performed to repair torn or degraded knee menisci. The clinical need for tissue currently greatly outpaces supply, but engineering a replacement tissue *ex vivo* could eliminate this shortage. This project studied use of a bioreactor system to mimic the *in vivo* environment. We produced cell-matrix constructs using human dermal fibroblasts and protein-coated fibrous sheets, and designed and tested a system to mechanically load the constructs in a manner as similar to loading in the human knee as possible. Once stable cell-matrix constructs have been achieved, the impact on material properties will also be tested.

Faculty Advisor: *Elizabeth J. Orwin, Biology and Engineering*

2:45 P.M. **Roberta Harnett: Constructing a Phylogeny of the Soft Coral Genus *Alcyonium* Using Morphological Characters**

Taxonomic relationships among species in the poorly understood soft coral genus *Alcyonium* are of interest to ecologists and the pharmaceutical industry. I constructed a phylogeny of this genus using several morphological characters, including the shape and distribution of structural elements (sclerites) visualized with light and scanning electron microscopy. I compared this phylogeny with one based on molecular data to determine which morphological traits are most important when classifying similar soft coral species. Morphologically distinct clades within the phylogeny may also indicate that this genus should be divided into multiple genera.

Faculty Advisor: *Catherine S. McFadden, Biology*

## Biology Presentations Continued

3:00 P.M. **Alexander S. Bobbs: *Mercury Resistance Genes in a Gliding Bacterium***

Although mercury-resistance has been found in a wide variety of bacteria, the *mer* resistance genes in many environmentally important species have not been characterized. The gliding bacterium *Tenacibaculum iridescens*, the predominant mercury-resistant species in metal-contaminated salt marshes, bears a previously uncharacterized mercury-resistance gene that, from preliminary analysis, appears to be highly diverged from previously studied examples of the mercuric reductase gene *merA*. The goal of my project was to clone, sequence, and characterize this new gene.

Faculty Advisor: *Nancy V. Hamlett, Biology*

**Humanities and Social Sciences—Galileo-Edwards**2:15 P.M. **Humanities 2: *The Book in Western Culture***

**Humanities 2: The Book in Western Culture** examines the history of books as aesthetic objects, symbols of political and economic status, and disseminators of culture and ideas. In the second half of the semester, students working in groups were assigned an artifact (an illuminated manuscript, an early printed book, a nineteenth-century paperback, or a contemporary artist's book), which they subsequently researched and described in a series of web pages. Their presentations today will detail their research by displaying those pages. Each group will make a separate, ten-minute presentation. Questions will be taken at the end of the session.

**Group 1:** Christopher Dahlberg, Robin Kim, George Korir, Westin Kurlancheek, Marshall Pierce

**Group 2:** Elisa Celis, David Coyne, Nikolas Rauh, Karen Shi, Elizabeth Winton

**Group 3:** Dan Halperin, Michael Hansen, Tiffany Head, Alexander Himmel, Michael Le, Laura Moyer

**Group 4:** Nicholas Herman, Megan Marshall, Matthew Reynolds, Liam Robinson, Timothy Smith  
Course Instructor: *Jeffrey D. Groves, Humanities and Social Sciences*

3:15 P.M. **Kylie Evans: *Building Body, Mind, and Self Through Martial Arts***

Our sense of self is determined by the cultures of which we are members. While it is common to talk about culture in the singular, I argue that a person can be part of, and can be formed by, multiple, sometimes conflicting, cultural environments. The self, then, is not a passive reaction to one's environment; the formation of self is an act. I will present my anthropological research on martial arts, one of many subcultures in the United States. I will discuss how elements of the martial arts—kinship structure, philosophy, socialization, and attitudes towards pain—contribute to the fashioning of a particular kind of self.

Faculty Advisor: *Marianne de Laet, Humanities and Social Sciences*

3:30 P.M. **Humanities and Social Sciences Reception—Galileo Foyer**

**4:00 P.M.****■ Presentation Days Address****Galileo-McAlister****Welcome:** F. Sheldon Wettack, Vice President and Dean of Faculty, and Professor of Chemistry**Introduction:** Catherine S. Mc Fadden, Associate Professor of Biology**Keynote Speaker:** Michael H. Dickinson, Professor of Bioengineering and Biology, California Institute of Technology  
"How Flies Fly"

Michael Dickinson, a professor of bioengineering and biology at Caltech, researches the physiology and mechanics of flight behavior in insects. Specifically, he has focused on the flight control system of flies—arguably the most aerodynamically sophisticated of all flying animals.

His dissertation project at the University of Washington, which focused on the physiology of sensory cells on the wings of flies, led to an interest in insect aerodynamics and flight control circuitry. Dickinson worked briefly at the Max Planck Institute for Biological Cybernetics in Tübingen, Germany, and served as an assistant professor in the Department of Anatomy at the University of Chicago. He moved to University of California, Berkeley, in 1996 and was appointed the Williams Professor in the Department of Integrative Biology in 2000. He has been at Caltech since July 2002.

Dickinson has studied the flight behavior of insects simultaneously at several levels of analysis in an attempt to integrate cellular physiology, biomechanics, aerodynamics and behavior. More recently, his findings have been applied to the design and construction of biomimetic robots.

Dickinson has been honored with the Larry Sandler Award from the Genetics Society of America, the Bartholemew Award for Comparative Physiology from the American Society of Zoologists, a Packard Foundation Fellowship in Science and Engineering, and the Quantrell Award for Excellence in Undergraduate Teaching at the University of Chicago. In 2001, he received a MacArthur Foundation Fellowship.

**Tuesday, May 6 2003****PROJECTS DAY****HMC Computer Science, Engineering/Environmental Studies, Engineering, Mathematics and Physics Clinics**Please see Projects Day Program for further details or visit <http://www.hmc.edu/acad/clinic/>**10:30 A.M.****■ Registration and Poster Sessions:****Ronald and Maxine Linde Activities Center****1:15 P.M.****■ General Session:****Galileo-McAlister***Welcome:* President Jon C. Strauss*Remarks:* Michael C. Raugh, Director, Mathematics Clinic*Milestone Awards:* F. Sheldon Wattack, Vice President and Dean of Faculty, and Professor of Chemistry*Program:* Ryan Jackson '02/03**1:30 P.M.-5:00 P.M.****■ Clinic Presentations:****Classrooms, Galileo Halls and Labs**

**Wednesday, May 7 2003****9:00 A.M.—11:30 A.M.****■ Research Presentations**

- 9:00 A.M. Engineering 158 Presentations please see page 17
- 9:00 A.M. Mathematics Presentations please see page 17
- 9:30 A.M. Chemistry 112 Presentations please see page 18
- 9:30 A.M. Physics Presentations please see page 18
- 10:30 A.M. Computer Science Presentations please see page 19

**Chemistry Poster Session—Galileo Foyer**All Morning *Chemistry Research Posters Presented at the American Chemical Society Meeting***Rachel Gabor: *Kinetics of Metalloporphyrin-based Ligand Substitution with Surface-confined Ligands***

The kinetics for the chemisorption of RuP<sub>OR</sub>, where P<sub>OR</sub> is octaethylporphyrin (OEP) or tetraphenylporphyrin (TPP), onto a surface-confined isonicotinate ligand have been measured electrochemically. This chemisorption onto ligands present in mixed monolayers of 11-mercaptoundecylisonicotinate in decanethiol supported upon gold can be modeled with an irreversible Langmuir adsorption isotherm. The rates of chemisorption for micromolar concentrations of Ru(P<sub>OR</sub>)(MeCN)<sub>2</sub> from toluene solution are  $3300 \pm 160$  and  $550 \pm 14 \text{ M}^{-1}\text{s}^{-1}$  for the TPP and OEP species, respectively. The results of competitive kinetic measurements and other experiments are consistent with a dissociative mechanism of ligand exchange at the metal center.

Faculty Advisor: *Hal Van Ryswyk, Chemistry***Eric W. Hall: *Mapping a DTAB-SDS-Water Ternary Phase Diagram using Laser-light Scattering and Fluorescence Spectroscopy***

We have investigated the ternary phase diagram in the dilute surfactant region for the aqueous system of cationic dodecyltrimethylammonium bromide (DTAB) and anionic sodium dodecyl sulfate (SDS). At certain compositions these surfactants with equal alkyl chain lengths form unilamellar vesicles. With the potential utility of vesicles for encapsulation and microreactor applications, we have sought a complete definition of the vesicle phase region using an innovative approach involving the fluorescence probe Prodan and light-scattering measurements.

Faculty Advisor: *Kerry K. Karukstis, Chemistry***Shelley A. McCormack: *Use of Fluorescence Spectroscopy to Map a CTAB/SOS/Water Ternary Phase Diagram***

We use fluorescence spectroscopy to map the type of surfactant aggregates formed in a ternary phase diagram of CTAB (cetyltrimethylammonium bromide) and SOS (sodium octyl sulfate) in aqueous solution. As the emission wavelength of the fluorescence probe Prodan is sensitive to the polarity of its environment, the spectral shape reflects where Prodan partitions in a surfactant aggregate. The phase regions were delineated using several fluorescence parameters, including a ratio of fluorescence intensities, similarities in curve shape and spectral deconvolutions.

Faculty Advisor: *Kerry K. Karukstis, Chemistry*

## Chemistry Presentations Continued

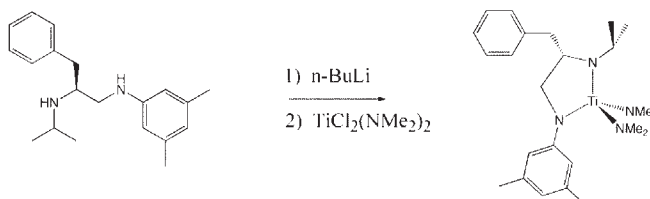
**Margot D. Molander: Spectroscopic Characterization of Nickel (II) PAMAM Dendrimer Complexes**

We have examined the interaction of the nickel(II) ion with full- and half-generation Starburst polyamidoamine dendrimers with an ethylenediamine core. A spectroscopic approach to characterizing metal-dendrimer complexes enables all potential complexes simultaneously present to be observed. Job's plot analysis determines the complex stoichiometry. Our findings reveal complex formation consistent with nickel coordination to internal tertiary nitrogens only. For half-generation dendrimers, stoichiometric ratios increase with both increasing generation and increasing pH. For full-generation dendrimers, complexes are observed with low generations only.

Faculty Advisor: *Kerry K. Karukstis, Chemistry*

**Kendra Nelson: Titanium Amido Complexes with Amino Acid Derived Ligands**

The chiral bis-amide ligand  $^i\text{PrNHCH}(\text{CH}_2\text{Ph})\text{CH}_2\text{NH}(3,5\text{-Me}_2\text{-C}_2\text{H}_4)$  ( $\text{H}_2\text{L1}$ ) has been prepared in high yield by a four-step synthesis from BOC-protected L-phenylalanine. The free ligand reacts with  $\text{TiCl}(\text{NMe}_2)_3$ , but does not give the desired titanium complex  $\text{TiCl}(\text{NMe}_2)(\text{L1})$ . Instead, NMR spectroscopy suggests that only the isopropyl amide nitrogen is coordinated to the titanium center. Deprotonation of  $\text{H}_2\text{L1}$  with  $n\text{BuLi}$  affords  $(\text{Et}_2\text{O})\text{Li}_2\text{L1}$ , which reacts with  $\text{TiCl}_2(\text{NMe}_2)_2$  to afford  $\text{Ti}(\text{NMe}_2)_2(\text{L1})$ . Initial reaction chemistry of this new complex and related complexes will be reported.



Faculty Advisor: *Adam R. Johnson, Chemistry*

**Monica Jo Patten: Regio- and Stereoselectivity of the Ketal Claisen Rearrangement**  
(please see abstract Monday, May, 5 at 11:00 A.M. on page 7)**Sarah Price: Thermodynamic Excess Functions in Anisole/Alcohol Mixtures**

The thermodynamic excess functions for refractive index, volume, Gibbs potential, entropy and enthalpy were studied for binary mixtures of anisole and various low molecular weight alcohols. In binary mixtures, non-zero excess functions indicate the existence of non-zero intermolecular interactions. The excess entropy and enthalpy functions could be determined by measuring excess Gibbs potential as a function of temperature. Solutions of anisole were studied with three different alcohols. The excess volume and Gibbs potential for the anisole/1-propanol system both show interesting trends with respect to composition and temperature.

Faculty Advisor: *Gerald R. Van Hecke, Chemistry*

**Kit T. Rodolfa: NPT Monte Carlo Simulation of Binary Mixtures of Gay-Berne Mesogens and Leonard-Jones Spheres**

Monte Carlo simulations were conducted on binary mixtures of the Gay-Berne mesogen [GB3,51,3] and the Leonard-Jones spheres at compositions ranging from 100 percent mesogens to 60 percent mesogens. Interactions between rods and spheres were modeled using the potential developed by Cleaver, et al. Ensemble average quantities such as energy, density, and orientational order parameter were observed to determine system equilibration and phase. Images generated using visualization software were analyzed to determine the nature of each observed phase. The data obtained was used to develop the beginnings of a phase diagram for binary mixtures.

Faculty Advisor: *Gerald R. Van Hecke, Chemistry*

**Engineering—Galileo-Pryne****Engineering 158: Introduction to CMOS VLSI Design: VLSI Design Projects**Course Instructor: *David Harris, Engineering*9:00 A.M. **Dmitriy Kogan, Nils Napp, Utku Seekin, Cagatay Tarhan: MD5 Cracker**9:15 A.M. **Trevor Gile, Fatih Kamisli, Suat Tukul, Chris Wottawa: Audio Effects DSP**9:30 A.M. **Brett Bissinger, Mike Reynolds: Alarm Clock**9:45 A.M. **Kim Shultz, Damian Small: Four-Function Calculator**10:00 A.M. **Mathematics and Physics Departments Reception—Galileo Foyer**10:30 A.M. **Morgan Cross, Aileen Nuguid: Booth Multiplier**10:45 A.M. **Stephen Friedman, Nick Hertl: DES Decryptor**11:00 A.M. **Janet Lui, Raymond Fong: Data Loss Indicator**11:15 A.M. **Carl Larsen, Michael Linderman: Packed Adder****Mathematics—Beckman B126**9:00 A.M. **Melissa Chase: Multiple Paths on Stochastic Graphs**

Shortest path algorithms are useful in a variety of applications ranging from transportation planning to network routing to artificial intelligence. However, no research has been done on finding multiple paths within a probabilistic graph. In the problem that I am studying, each edge of the graph has a given probability of failure. The goal is to find a given number of paths through such a graph to maximize the probability that at least one will arrive at the destination. I have examined different topologies and probability values for the problem of finding two such paths.

Faculty Advisor: *Ran Libeskind-Hadas, Computer Science*9:30 A.M. **Jeremy Rouse: Combinatorial Proofs of Congruences**

The techniques used in combinatorics are useful in many contexts. We will provide combinatorial proofs of some well-known results in number theory. Among these will be Fermat's Little theorem, Wilson's theorem, and results about Lucas sequences. Finally, we will discuss an approach for proving a congruence due to Ramanujan involving the partition function.

Faculty Advisor: *Arthur T. Benjamin, Mathematics*10:00 A.M. **Mathematics and Physics Departments Reception—Galileo Foyer****Mathematics and Interdisciplinary Competitions in Modeling Presentations—Beckman B126**10:30 A.M. **Melissa Banister, Mathew Macauley, Micah Smukler: Jumping Over an Elephant**

We present a mathematical model of the collapsing of a box structure, which is to be used to protect a stunt motorcyclist who jumps over an elephant. Reasonable values of the model's parameters cause it to predict that we should construct the structure out of fifty 6"-by-28"-by 28" boxes, stacked five high, two wide and five long. In general, the model predicts that we should use boxes whose height is one-quarter of the harmonic mean of their length and width. We discuss the assumptions, derivation, and limitations of this model.

Faculty Advisor: *Jon T. Jacobsen, Mathematics*

## Mathematics Presentations Continued

11:00 A.M. **Tara Martin, Gautam Thatte, Michael Vrable: ICM Paper: "How I Learnt to Stop Worrying and Find the Bomb"**

In the aftermath of Sept. 11, aviation security has become central in the war against terrorism. In November 2001, the Aviation and Transportation Security Act (ATSA) mandated 100 percent checked baggage screening by December 2001. We present a model to assess the number of Explosive Detection System (EDS) machines required to implement the ATSA plan, as well as how scheduling and other factors might reduce costs. In particular, we look at emerging technologies and the role they may play in the baggage screening system.

Faculty Advisor: *Jon T. Jacobsen, Mathematics*

**Chemistry—Beckman B134****Chemistry 112: Mock Coroner's Inquest**

9:30 A.M. **Prosecution**

10:00 A.M. **Mathematics and Physics Departments Reception—Galileo Foyer**

10:30 A.M. **Defense and Deliberations**

Students in **Chemistry 112 (Instrumental Methods Laboratory)** will present their findings regarding the physical evidence gathered in a fictional death investigation. In this exercise the HMC CSI Laboratory has been retained by the Los Angeles County District Attorney, whereas the HMC ASHMC Independent Laboratory has been retained by the family of a person of interest to the investigation. Class members representing each laboratory will have an opportunity to present their case and cross-examine the opposing laboratory's case. A list of the physical evidence and crime scene photos are available at <http://www4.hmc.edu/chemistry/112/CSI>. Members of the community are invited to participate as the jury in this mock coroner's inquest.

Faculty Advisor: *Hal Van Ryswyk, Chemistry*

**Physics—Galileo-Edwards**

9:30 A.M. **Eric Deyo: Decoherence with a View Towards Quantum Computation**

The interaction of several spins in a quantum system is investigated. Decoherence arises as relative phase information is traded amongst spins until it can no longer be extracted. These types of spin-spin interactions are important for the physical realization of an NMR-based quantum computer.

Faculty Advisor: *John S. Townsend, Physics*

9:45 A.M. **David Clarke: The Diffraction of Electrons by Light, A QED Approach to the Kapitza-Dirac Effect.**

The Kapitza-Dirac effect is similar to the canonical experiment on diffraction of electrons through slits in an opaque screen, except that the diffraction grating has been replaced by a standing wave of light. Remarkably, incident electrons are diffracted by the standing light wave almost as if by a standard diffraction grating. Only recently has this effect been confirmed experimentally in this form [1], although it was originally predicted by Kapitza and Dirac almost 70 years ago. This talk will examine the relativistic effects involved in this phenomena using the formalism of quantum field theory.

Faculty Advisor: *John S. Townsend, Physics*

10:00 A.M. **Mathematics and Physics Departments Reception—Galileo Foyer**

10:30 A.M. **Alan Arney: Supercontinuum Generation in Optical Sapphire**

A femtosecond white-light source is developed using a small portion of the output of a 1-kHz Ti:sapphire laser system. Gentle focusing of a pulse with appropriate intensity into a sapphire crystal leads to the propagation of a single intense filament by self-focusing. Self-phase modulation within the filament produces a supercontinuum pulse with spectral components spanning the entire visible spectrum. This white-light pulse is compressed with a prism pair; sum-frequency generation is used to measure the chirp and achieve optimum recompression.

Faculty Advisor: *Peter N. Saeta, Physics*

## Physics Presentations Continued

10:45 A.M. **Dustin Barnard: *Sum-Frequency Generation in Multilayers***

A phenomenological theory of sum-frequency generation in centrosymmetric multilayers is developed. Electric dipole interactions are considered at surfaces and interfaces, while magnetic dipole and electric quadrupole terms are used in the bulk. The theory treats non-collinear beams of different colors. Numerical calculations are obtained from this theory and will be compared with experimental results on silicon/oxide multilayers.

Faculty Advisor: *Peter N. Saeta, Physics*

11:00 A.M. **Nicole J. Carlson: *Time-Dependent Second Harmonic Generation from the Si/SiO<sub>x</sub> Interface***

Time-dependent second harmonic generation (TDSHG) has been observed from the interface between silicon and silicon (di)oxide, where the oxide films are thin (<10 nm) and explained by “harpooning” reactions. Similar TDSHG effects on samples with much thicker oxide layers were observed, calling into question the feasibility of this mechanism. I report measurements of the time dependence of second-harmonic generation from silicon samples covered with oxide layers of varying thickness, using an amplified Ti:sapphire laser producing ~50-fs pulses at 1 kHz.

Faculty Advisor: *Peter N. Saeta, Physics*

11:15 A.M. **Nathaniel P. Stern: *Exchange Anisotropy and Giant Magnetoresistance in Iridium-Manganese Spin Valves***

Thin-film magnetic devices offer promising applications of spin physics to magnetic recording technology. By harnessing the magnetic phenomena of exchange anisotropy and giant magnetoresistance, structures known as spin valves can operate in two resistance states, thereby acting as a magnetic sensor. My research examines the transport and magnetic properties of a variety of spin valves based upon Iridium-Manganese (IrMn) antiferromagnetic layers. The results characterize the behavior of IrMn-based spin valves at temperatures ranging from 5 K to 300 K and reveal important considerations in the thin-film deposition of IrMn-based structures.

Faculty Advisor: *James C. Eckert, Physics*

**Computer Science—Galileo-McAlister**10:00 A.M. **Mathematics and Physics Departments Reception—Galileo Foyer**10:30 A.M. **Benjamin FrantzDale: *Realistic Real-Time Rendering of Relief Textures***

While conventional texture mapping can greatly improve the realism of a scene, the illusion deteriorates when surfaces are viewed at an angle. This is particularly true of textures with a great deal of relief such as grass, bricks, and trees. We explored and extended many alternate texture-mapping techniques, including generalized billboarding and anisotropic mipmapping.

Faculty Advisor: *Elizabeth Z. Sweedyk, Computer Science*

10:45 A.M. **Geoffrey Romer: *A C++ Ray-Tracer Library***

This talk will describe the design and implementation of a software library for ray tracing, a common rendering technique in computer graphics. This library differs from other ray tracing packages in that it is designed from the ground up to be modular, extensible, and well documented, in order to facilitate future development as an open source project.

Faculty Advisor: *Elizabeth Z. Sweedyk, Computer Science*

11:00 A.M. **Richard Fujiyama, William Berriel, and Avani Gadani: *Implementation and Operational Experience with a Secure Transport Protocol***

We have implemented the Intrusion Detection Exchange Protocol (IDXP), an Internet protocol for the transporting of intrusion alerts. We will discuss implementation issues and interoperability issues between Java and C implementations.

Faculty Advisor: *Michael A. Erlinger, Computer Science*

**11:30 A.M.**

■ **Lunch Break**

**1:15 P.M.—5:15 P.M.**

■ **Research Presentations**

- 1:15 P.M. Chemistry Presentations please see page 22
- 1:15 P.M. Mathematics Presentations please see page 23
- 1:15 P.M. Physics Presentations please see page 24
- 2:15 P.M. Interdisciplinary Studies please see page 24
- 3:00 P.M. Engineering 191 Presentations please see page 25

**Computer Science—Galileo Foyer**

All Computer Science 155: *Computer Graphics Projects*  
 Afternoon Michael Bailey, Will Chang, Charles d’Avis, Matthew Ferlo, Edward Heaney, Adrian Mettler, Corey O’Connor, Tatsuya Oiye, Brian Roney, Jeffrey Scherpelz, Michael Terkowitz, Rafael Vasquez and Andrew Yip

A wide arrange of course projects will be on display.

Faculty Advisor: *Elizabeth Z. Sweedyk, Computer Science*

2:45 P.M. **Engineering and Computer Science Departments Reception—Galileo Foyer**

**Engineering—Galileo-Hall**

**Engineering 4: Introduction to Engineering Design**

1:15 P.M. *Water Recycling/Reuse System*  
 Galileo- Client: Pomona Valley Center for Community Development  
 Edwards Liaison: Tomas Ursua  
 Faculty Advisors: *Patrick Little and Ruye Wang, Engineering*

**Initial Problem Statement:** The Pomona Valley Center for Community Development (PVCCD) is in the process of converting a former convalescent care facility to a community center. PVCCD wishes to use adjacent land for gardening and educational purposes. As part of its overall mission, PVCCD would like this to be economical and environmentally benign. The project team will research, design, develop and demonstrate proof of concept for a so-called “gray water” project, safely using certain wastewater from the Center to support the Center’s gardens and landscaping.

- Team A:** Michaela Reagan, Erik Shimshock, Kirsten Shinnamon, Eric Wolfinger
- Team B:** Karen Hsin, Beau LeBlanc, Amanda Rainer, Nate Yoder
- Team C:** Eph Lanford, Ian Miller, Che Silkiss-Hero
- Team D:** Jim Castelaz, Victoria Luyapan, Kawika Maunupau, Zach Morriss
- Team E:** Stephanie Bohnert, Benjamin Howard, Arran McNabb, Catherine Meyers

Engineering Presentations Continued

1:15 P.M.     *Viscometer/Densitometer System*  
**Galileo-**     **Client:** Engineering Department, Harvey Mudd College  
**McAlister**   **Liaison:** Jennifer Rossman and Mary Cardenas  
**Faculty Advisors:** *Anthony Bright and Ruye Wang, Engineering*

**Initial Problem Statement:** One of the experiments in E80, Experimental Engineering, requires students to measure the density and viscosity of fluids used in an engineering design project. The current techniques used are messy, inaccurate, and difficult to understand. The project team will design, build, and test a combined viscometer and densitometer.

- Team A:**     Paul Arpin, Ruben Betancourt, Michael Bigelow, Ghyrn Loveness
- Team B:**     Steve Lin, Peter Paras, Colin Parker, Radjeep Roy
- Team C:**     Sheldon Logan, Michael Pemstein, Octavi Semonin, Rob Sweney
- Team D:**     Andy Fischer, Rami Hindeyeh, Justin Kauwale, Kenneth Maples

2:45 P.M.     **Engineering and Computer Science Departments Reception—Galileo Foyer**

3:15 P.M.     *Retinal Imaging System*  
**Galileo-**     **Client:** Surgical Devices Laboratory, UC-Irvine  
**Edwards**     **Liaison:** Dr. Brian Wong  
**Faculty Advisors:** *Patrick Little and Ruye Wang, Engineering*

**Initial Problem Statement:** Recently, HMC students developed an otoscope that could be used to transmit video images of the inner ear from one location to another. The Surgical Devices Laboratory is interested in modifying this technology to work with an ophthalmoscope. The optical issues have been successfully addressed by an HMC summer student at the lab as part of the otoscope project, but it is not obvious how to image thru the pupil nor how you get a sufficiently wide field of view of the retina. The team will design, develop and test a device using a phantom of the eye.

- Team A:**     Ekaterina Kniazeva, George Korir, Erika Palmer, Philip Tam
- Team B:**     Daniel Barcay, Rob Chambers, Josh Slater
- Team C:**     Chris Dahlberg, Garry Newland, Lauren Pomeroy, Tristan Sharp
- Team D:**     Jed Harmson, Keane Kaneakua, Michael Le, John Silny

*Nasal Stapling Device*  
**Client:** Surgical Devices Laboratory, UC-Irvine  
**Liaison:** Dr. Brian Wong  
**Faculty Advisor:** *Ruye Wang, Engineering*

**Initial Problem Statement:** Surgeons currently suture the nasal septum after surgery using traditional needle and thread, which is a time-consuming procedure. (The process has been compared to attaching ham to bread in a quiltlike pattern.) Surgical staplers have been developed which are used to connect segments of bowel together, and are pretty complicated mechanical devices. The Surgical Devices Laboratory is interested in adapting this technology to reduce the time and complexity of post surgical procedures. Any device must work under very tight constraints regarding the use of FDA approved materials and processes. The device must also be faster and simpler than the current approach.

- Team E:**     Mark Brenneman, Mary Chen, Jon Huang, Matt Johnson
- Team F:**     Megan Arman, Rafael Guevara, Audra Nemir, Chris Prounh

## Engineering Presentations Continued

3:15 P.M. **Galileo-McAlister** *Algesic Demonstration Device*  
**Client:** Harvey Mudd College  
**Liaison:** Dr. Mario Maldonado  
**Faculty Advisors:** Anthony Bright and Ruye Wang, Engineering

**Initial Problem Statement:** The algesic effect is the phenomenon by which two stimuli, neither of which causes a painful reaction in a patient, are combined to create the appearance of pain in a subject. As part of his course on pain, Prof. Maldonado has requested the design, building, and testing of a simple machine that demonstrates the algesic effect. The device must be inexpensive, safe, easy to use in a classroom, and able to obtain repeatable results for a large number of users.

**Team A:** Mark Festini, Alexis Fiechter, Esteban Molina-Estolano, James O'Grady  
**Team B:** Matthew Gnaizda, Oliver Hou, Karen Shi, Wayne Tanaka  
**Team C:** Dustin Brekke, Conor Flynn, Glenn Hudson, Tyler Jank  
**Team D:** Robert Panish, Raymond Ryckman, Ben Swanson  
**Team E:** Zack Burstein, Kevinn Lloyd, Gus Porter  
**Team F:** Sara Al-Beaini, Faye Massen, Sarah Thomson

**Chemistry—Galileo-Pryne**

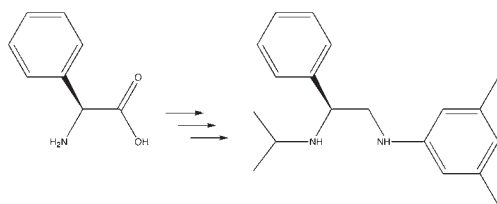
1:15 P.M. **Emily Cukier:** *Systematic Investigation of the Pathway Model in Models for Biological Electron Transfer*

The pathway model was developed to predict the distance dependence of electron transfer in proteins based on the nature of the intervening medium between the donor and acceptor. In the model, intervening bonds enhance the observed electronic coupling over that seen when interactions are either H-bonds or through-space. The goal of this study is to investigate the parameters of the pathway model by calculating the electronic coupling element for a variety of model systems. The method dependence of the results is also considered.

Faculty Advisor: Robert J. Cave, Chemistry

1:30 P.M. **Kendra Nelson:** *Synthesis of Ligands for the Study of Chiral Titanium Complexes*

The syntheses of three bidentate ligands will be described. Phenylglycine was used as a precursor because a variety of ligands could be synthesized from it by a series of short steps. These ligands will be used in the study of chiral titanium complexes. The syntheses of several titanium complexes will also be described.



Faculty Advisor: Adam R. Johnson, Chemistry

1:45 P.M. **Lucas Baker:** *Mesomorphic Behavior of 2,7-Diacyl Fluorenes*

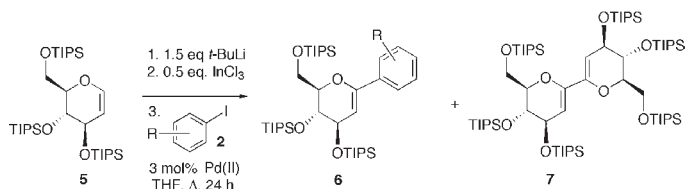
Fluorene (2,2'-methylenebiphenyl) is well-known for its ability to form liquid crystals when substituted at the 2 and 7 positions. Previous studies have focused on the use of polar or chiral side chains to create industrially useful nematic or twisted nematic phases. None, however, have isolated the effect of molecular length and asymmetry on phase behavior, an issue that this study is designed to address. An isomeric series of 2,7-diacylfluorenes were synthesized by Friedel-Crafts acylation, and their smectic phase behavior measured to identify trends resulting from various degrees of side-chain asymmetry.

Faculty Advisor: Gerald R. Van Hecke, Chemistry

## Chemistry Presentations Continued

2:00 P.M. **Smita Awasthi: Environmentally Friendly Carbon-Carbon Bond Synthesis**

The environmentally friendly synthesis of carbon-carbon bonds in the context of C-aryl glycoside synthesis using indium (III) trichloride proved to be successful. Six carbohydrates were synthesized through a palladium-catalyzed cross-coupling reaction of triorganoindium compounds with various aryl halides and subsequently characterized. Protic solvents decreased the yield by a predictable amount, whereas the addition of water to the reaction gave no product.



Faculty Advisor: *Thomas G. Minehan, Chemistry*

**Mathematics—Beckman B126**1:15 P.M. **Ariel E. Barton: Convergence of Planar Regions and of Their Harmonic Measure Distribution Functions**

For a region in the plane, a harmonic measure distribution function measures the probability that a particle, released from a fixed basepoint and traveling by Brownian motion, first exits the region within a given distance from the basepoint. It has been proven that a sequence of convergent regions will have convergent distribution functions. We investigate the converse of this statement: given a sequence of convergent distribution functions, what can be said about the behavior of the underlying regions?

Faculty Advisor: *Lesley A. Ward, Mathematics*

1:45 P.M. **Stephen Haas: The Hausdorff Dimension of the Julia Set for Cubic Polynomials**

One of the most fundamental and interesting sets that arises out of the study of complex dynamics is the Julia set of a function, the set of points in the complex plane for which the behavior under iteration by the function is chaotic. This set typically has a complicated, fractal structure. Therefore, it is natural to consider the Hausdorff dimension, a method of assigning a non-integer dimension to such complicated sets where no integer dimension is adequate. In particular we will discuss for which values of  $c$  the Hausdorff Dimension of the Julia set varies continuously with  $c$  for the family of functions  $f(z)=z^3+c$ .

Faculty Advisor: *Lesley A. Ward, Mathematics*

2:15 P.M. **Andrew Iannaccone: The Conformal Center of a Triangle or Quadrilateral**

Every triangle has a unique point, called the conformal center, from which a random (Brownian motion) path is equally likely to first exit the triangle through each of its three sides. Certain other polygons also have a conformal center. My thesis explores which quadrilaterals have a conformal center, as well as how to locate it.

Faculty Advisor: *Byron Walden (Santa Clara University, Mathematics)*

2:45 P.M. **Engineering and Computer Science Departments Reception—Galileo Foyer**3:15 P.M. **Nate Eldredge: An Eigenspace Approach to Fourier Transforms on Iterated Wreath Product Groups**

We present a method for computing generalized Fourier transforms on iterated wreath product groups, which arise in connection with regularly branching trees. This method uses linear algebra tools to attack a problem in group theory in an approachable way.

Faculty Advisor: *Michael E. Orrison, Mathematics*

## Mathematics Presentations Continued

3:45 P.M. **Matthew Macauley: *Braids and Juggling Patterns***

There are several combinatorial ways to represent juggling patterns. I am using braid groups to describe juggling patterns both algebraically and topologically. In particular, I am looking at the braids of one-hand juggling patterns. A new type of graph arises upon analyzing these braids. I will show how certain properties of these graphs are related to the algebraic structure of jugglable braids.

Faculty Advisor: *Michael E. Orrison, Mathematics*

4:15 P.M. **David T. Uminsky: *Generalized Spectral Analysis of Large Sets of Approval Voting Data***

Generalized spectral analysis is a method used to detect coalitions in voting data. Unfortunately, as the number of voters grow, the data space becomes prohibitively large to carry out this analysis. We present a method for analyzing voting data that relies on partitioning the underlying data set, thus drastically reducing the size of the set while retaining the necessary characteristics of the data. The approach draws upon results in representation theory, probability, and statistics.

Faculty Advisor: *Michael E. Orrison, Mathematics*

**Physics—Beckman B134**1:15 P.M.— **Physics 170: *Computational Physics***4:30 P.M. **Kyle Barbary, Dan Beutel, Joe Checkelsky, Eric Deyo, Emily Henage, Thomas Henage, Jason Hogan, Steve Kolthammer, Jim Norwood, Trevor Oliver, Jonathan Pearson, Michael Shimogawa, Darci Snowden, Gautam Thatte, Creighton Thomas**

Students in the computational physics course will present their work simulating a variety of systems. These are likely to include (but may change without notice) the following:

- a magnetic toy consisting of two spinning three-fold symmetric rotors
- a leaking waterwheel that exhibits chaotic motion
- percolation
- the ferromagnetic transition in the Ising and Heisenberg models
- a "strange" bead-string toy somewhat akin to a double pendulum, but of varying length

Faculty Advisor: *Peter Saeta, Physics*

**Interdisciplinary Studies 198—Galileo-Pryne**2:15 P.M. **ID 198: *Cultural Explorations in Role Playing Games*****Charles d'Avis, Matthew Ferlo, Edward Heaney, Michael Terkowitz, Andrew Yip**

Our team researched and developed a plausible fantasy world consisting of several distinct cultures. Each culture possesses unique technologies, rituals and social goals. The technology for implementing the role playing game was developed parallel to this exploration. We will present a brief introduction of the different cultures, including stories and art, as well as a demo of the role playing game engine that will be used to implement the game.

Course Instructors: *Elizabeth A. Sweedyk, Computer Science and Marianne de Laet, Anthropology*

**Engineering—Galileo-Pryne****Engineering 191: Advanced Problems in Engineering**

3:15 P.M. **Warren Katzenstein, Jason Komadina, Andres Del Campo, Mike Le, Sara Al-Beaini, Colin Marsh, Kevin Alley, Elaine Hart, Daniel Rinzler:** *The Macro and Micro Application of Fuel Cells*

Fuel cells are electrochemical devices that efficiently produce electricity while generating minimal if any pollutants. Their uses range from powering laptops to powering thousands of houses. During the Fall Semester, our team determined fuel cells to be a viable option for providing electricity and heat for Harvey Mudd College. In the Spring Semester, a fuel cell test-bed was built to design and test a fuel cell stack capable of powering a remote-control car.

Advisor: *Samuel B. Tanenbaum, Engineering*

3:45 P.M. **Stephen MacVicar, Joseph Majkut, Brian Putnam, Emily Ross:** *LEED Certification for HMC's New Dining Hall*

Harvey Mudd College plans to obtain LEED certification, a standard for sustainable building design, for its new dining hall and dormitory. The team has studied the economic and environmental impact of meeting some of the LEED requirements in both buildings and has performed an analysis of the energy loads for the proposed dining hall.

Faculty Advisor: *Samuel B. Tanenbaum, Engineering*

4:00 P.M. **Lindsay Allen, Henry Chen, Angie Cho, Mark Locascio:** *Automated Music Transcription*

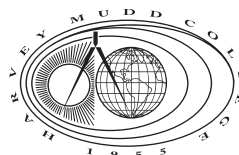
The team designed a system for transcribing music—converting audio into a sequence of rests and semitones. The team first recorded audio performances, via a microphone and “wav” files, of Professor Belinda Thom playing her violin, and used Matlab to analyze these data, producing spectral “signatures” for different tones and articulations. The team then explored how these signatures could be used to identify tones in new audio samples produced by the same instrument.

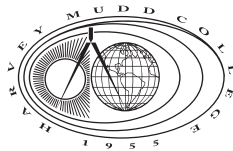
Faculty Advisor: *Samuel B. Tanenbaum, Engineering*

4:15 P.M. **Jeffrey Lin, Daniel Chan, Eric Flynn, Karen Lee, Nathan Mitchell, Shane Ouchi:** *Giving Jay a USB Upgrade*

Jay, HMC's own six-legged walking robot, was built and first demonstrated in May 1997. The original algorithm that controls Jay's movements resides in his on-board circuitry. By Professor Zachary Dodd's request, we are modifying this circuitry to give Jay a USB interface. Jay can then be controlled using computers with USB ports, so his movement algorithm can easily be modified through simple reprogramming.

Faculty Advisor: *Samuel B. Tanenbaum, Engineering*





Harvey Mudd College  
301 East 12th Street  
Claremont, CA 91711-5990