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June 1, 2009

To: Jeff Wright, Dean, SOE and Lead Dean of MEAM

From: Carlos F. M. Coimbra, Chair
Mechanical Engineering and Applied Mechanics Graduate Program

Re: MEAM Strategic Plan for AY 2009-10

Mechanical Engineering and Applied Mechanics represent two distinctive but overlapping research areas that together form some of the most fundamental pillars of the academic enterprise. While the various disciplines that compose the field of Applied Mechanics are associated with rigorous and rapidly developing branches of human thought, Mechanical Engineering is currently undergoing a fundamental transformation at several distinct levels. At the design level, computer aided engineering and fast prototyping automated tools are revolutionizing the way new products are conceptualized, evaluated and deployed into the market. At a more fundamental level, computational methods that are based on judicious use of advanced concepts in Applied Mechanics (including stochastic evolutionary methods, uncertainty analysis, artificial cognition, etc.) have expanded the portfolio of research methodologies much beyond the usual designer-based experience. Today, Mechanical Engineering is evolving into a discipline where more emphasis is placed on teaching a machine how to design, other than using the machine to optimize a pre-selected design. In other words, instead of using the engineering methodology to optimize a pre-existing concept, MEAM research is transitioning to a new paradigm where only the goals and constraints of the object are known to the designer, and a stochastic algorithm uses a variety of advanced computational methods to explore the complete space of solutions that satisfy the goals and constraints of the problem at hand.

The MEAM group at UC Merced emphasizes this new approach to Mechanical Engineering, and therefore is unique among all UC campuses in placing a much higher emphasis on advanced computational methods. Being only recently formed (August of 2007), the MEAM group is composed of eight faculty members from various disciplines, including Mechanical Engineering, Electrical Engineering, Physics, Applied Mathematics and Computer Science and Engineering.

2. Research Themes in the Mechanical Engineering and Applied Mechanics Group

Research programs

As mentioned above, there are many exciting research opportunities within the context of the MEAM program, and we have prioritized research areas that would better complement and add value to the overall research and educational mission of UC Merced. The chosen research themes also add a unique flavor to our program not only within the UC system, but also in comparison to other programs in the nation. The MEAM program will initially focus on two major themes, which are described below.

Research Themes

I) ***Energy Systems*** — Mechanical engineering is a core discipline for the development of energy conversion technologies, and the MEAM program at UC Merced is well poised to take the lead on the renewable energy initiative in our campus. Profs. Winston, Sun, Coimbra, and Diaz have all established track records in research funding in the energy research area. There is very strong synergy between the MEAM graduate program and the Merced Energy Research Institute (MERI), as well as with UC CITRIS (Center for Information Technology Research in the Interest of Society) and the new CITRIS initiative C-GRACE (CITRIS Global Research Alliance for Climate and Energy). Within the Energy Systems theme, the main areas of activities of the MEAM program include: solar concentrators, solar availability mapping, renewable fuel conversion, fuel cell technology, concentrator controls, direct solar conversion, and solar power applications to environmental health monitoring. The MEAM program has several overlapping research projects with other graduate groups within the energy systems theme, including Environmental Systems (ES) and Electrical Engineering and Computer Science (EECS). The MEAM faculty has been very successful in attracting sizeable research grants in this area.

II) ***Biologically Inspired Technologies*** — Although one of the primary goals of this MEAM research theme is in the development of advanced computational methodology, there is important synergy with experimental methods in bio-controls, mechatronics, multi-scale material properties, and complex fluids that will enable the maturation of this area into a new paradigm of engineering design. A strong computational component on novel genotype optimization methods will allow us to explore bio-inspired solutions beyond the traditional bio-mimetic approach. However, it is the concurrent and parallel experimental development of advanced materials (and the associated understanding of complex constitutive relations) that will enable the development of a full spectrum of engineering solutions for complex problems for engineered materials (as opposed to biological materials). An important component of the MEAM strategic plan is to build critical mass in this research theme. There is a very good opportunity for future collaboration between several graduate programs at UC Merced in this area, including Biological Engineering and Small Technologies (BEST), Electrical Engineering and Computer Science (EECS), Quantitative and Systems Biology (QSB), and Applied Mathematics (AM).

The two research themes above reflect a sensible compromise between depth, breadth, impact and quality of MEAM research. Equally relevant is our effort to combine the needs of the very popular undergraduate program in Mechanical Engineering with the development of a strong research program in MEAM.

3. Synergistic Growth with the Undergraduate Program in Mechanical Engineering

The mechanical engineering (ME) undergraduate major was launched during Fall 2006 accepting only freshman students. The plan was to start accepting transfer students only in the Fall 2008. However, a large number of current upper division students at UC Merced have approached ME faculty or the engineering student counselors to explore the possibility of transferring to the ME

major before they complete their degree. There is increasing evidence that ME will become one of the most popular engineering majors at UC Merced. For instance, out of 300 freshman students accepted in engineering for fall 2007, 53 students (17.7%) chose ME. Last year, a significant fraction of the undeclared students decided to enroll in ME, so we expect a similar trend for this year. Currently in its second year, the ME program has already the second largest enrollment in the SOE with more than 160 students, a six-fold increase from the first year, when we had 26 ME students. ME also has currently the largest student-to-faculty ratio in the SOE by a large margin.

In order to evolve into a top ME program, it is absolutely necessary to develop a strong and comprehensive foundation in key areas, with a sufficient number of faculty to build a modern program with state-of-the-art research infrastructure. In addition, because ME is a key component of any modern engineering academic program in serving key and foundational needs for many engineering sub-disciplines. Delaying the hiring of ME faculty will dramatically constrain the growth of our engineering program and could significantly impair the image and reputation of the ME program and the college of engineering as a whole.

Currently, ME provides service to other majors by teaching a number of engineering fundamentals courses that include: ENGR 57 (Dynamics), ENGR 151 (Strength of Materials), ENGR 130 (Thermodynamics), ENGR 135 (Heat Transfer), and others. This situation increases dramatically the teaching load of ME faculty.

From the outset, there was a concerted effort to provide a seamless experience to SOE undergraduate students interested in pursuing post-graduate education in the MEAM program. The MEAM program offers research opportunities for students interested in projects at the interface between Complex Analysis, Mechanics, Manufacturing, Bio-Inspired Engineering, Applied Computational Sciences, Mechatronics, Advanced Materials, Energy Conversion, and Controls. Due to the interdisciplinary nature of the topics covered in MEAM courses, a number of these courses serve graduate students from many different disciplines. This also increases the teaching load of ME/MEAM faculty. For instance, in the past the following courses were populated by graduate students from other programs: ME 135/ES 235 (Heat Transfer), MEAM 201 (Advanced Dynamics), ME 210 (Linear Controls), and MEAM 251/ES 237 Viscous Flows.

There are currently five FTE positions filled in mechanical engineering (listed here in order of hiring): Professor Diaz, Professor Coimbra, Professor Sun, Professor Modest and Professor Ma. The expertise of the current faculty covers a relatively unbalanced portion of the overall research area in Mechanical Engineering and Applied Mechanics since 4 out of the 5 faculty hired have main expertise in Thermofluids, and only one faculty (Prof. Sun) has expertise on Solid Mechanics.

A total of eight desired positions have been identified and described below in descending level of priority for both the ME and the MEAM programs (Roman numerals in parenthesis indicate the corresponding research theme for the MEAM program in Section 2):

1) Bio-Controls (I)
2) Computational Engineering (I and II)
3) Bio-Inspired Mechanics (I)
4) Energy (with emphasis in Fuel Cells or Hybrid Systems) (II)
5) Nonlinear Analysis (I and II)
6) Computational Fluid Dynamics (I and II)
7) Mechatronics (I and II)
8) Turbulence (I and II)

The ME requested positions for AY 2008/2009 were described as:

- **ME-6: Senior/junior position complementing research of existing ME faculty**
- **ME-7: Senior/junior position complementing research of existing ME faculty**

The program is also requesting ***two security-of-employment instructors***. One will concentrate on the engineering fundamentals (ENGR) courses that serve all programs in the SOE, and the other on ME electives that may serve BIOE, ES, ME, MSE and CSE students, as well as to serve as an industry liaison for the capstone design competitions.

The description of the two requested FTE positions for 2008-09 is as follows. We note that these positions were originally advertised in 2009 but were subsequently cancelled due to budget cuts.

a) ME-6: Bio-Controls

Mechanical Engineering sees a need for an FTE working on research in one or more areas of the emerging domain of Bio-Control. This senior/junior position will add an important and strategic area of research in ME to broaden and strengthen its actual capabilities. This position will cover, but will not be limited to, the design and construction of self-assembled structures, bio-mimetic surfaces, sensors and actuators that will allow external control of biological and bio-technology systems. Mechanical Engineering and the MEAM Graduate Group see such a hire as necessary to position the campus competitively in this promising area of research. The undergraduate program in Mechanical Engineering will benefit with courses such as mechatronics (ME 142), vibration and controls (ME-140), and the capstone design (ME-170). The graduate program will benefit with courses in the particular areas of research of this FTE. Natural synergies with other programs include Bio-Engineering, Computer Science and Engineering, and Applied Mathematics. The space needs are expected to be adequate for a senior/junior level position in the wet lab area.

b) ME-7: Computational Engineering

This senior/junior position is an important and strategic area of research in ME and it is intended to strengthen the actual capabilities of ME faculty. It will cover, but will not be limited to, the development of numerical schemes to treat problems in structural, fluids, and/or thermal/fluids systems. It can relate to parallel computing and high performance algorithm development applied to engineering problems. The undergraduate program in Mechanical Engineering will benefit with courses such as FEA (ME 135) and CAE (ME-137). The graduate program will benefit with courses in the particular areas of research of this FTE. Natural synergies with other programs include Computer Science and Engineering, and Applied Mathematics. The space needs are expected to be adequate for a senior/junior level position in the dry lab area.

Clearly, the ME/MEAM program is falling way below the number projected by the School of Engineering Resources Committee on its 2006 5-Year Hiring Plan (see Table 8 below).

Table 8 School of Engineering Faculty 5-year Hiring Plan

Academic Year	ENVE		CSE		BIOE		ME		MSE		EE		ChE		EEM		CE		Cumulaive Faculty FTEs
	Name	FTE	Name	FTE	Name	FTE	Name	FTE	Name	FTE	Name	FTE	Name	FTE	Name	FTE	Name	FTE	
	Bales	1.0	Newsam	1.0	Chin	1.0	Diaz	1.0	Viney	1.0	Chiao	0.5							
	Conklin	1.0	Kallmann	1.0	McCloskey	1.0	**Sun**	1.0	Leppert	1.0	EE-2	1.0							
	Harmon	1.0	Cerpa	1.0	Khine	1.0	Coimbra	1.0	Lu	1.0									
	Winston	0.5	Carpin	1.0	BIOE-4	1.0	ME-4	1.0	MSE-4	1.0									
	Guo	1.0	(Bajcsy)	1.0	BIOE-5	1.0	ME-5	1.0	MSE-5	1.0									
	EnvE-6(Air)	1.0	CSE-6*	1.0	BIOE-6	1.0	*ME-6*	0.5											
	EnvE-7(x)	*0.5*	Noelle	0.5	*BIOE-7*	0.5	ME-7	1.0											
	Westerling	0.5	CSE-8*	1.0	BIOE-8	1.0	*ME-8*	0.5											
	Chen	0.5	CSE-9*	1.0	BIOE-9(x)	0.5	ME-9(x)	0.5											
	EnvE-10(x)	0.5	CSE-10	1.0															
	EnvE-11(x)	0.5	*CSE-11*	0.5															
	EnvE-12	1.0	CSE-12(x)	0.5															
			CSE-13(x)	0.5															
			CSE-14(x)	0.5															
AY 05-06	5.5		6.0		4.0		2.0		2.0		0.5		0.0		0.0		0.0		20.0
AY 06-07	7.0		6.5		4.0		3.0		4.0		1.5		0.0		0.0		0.0		26.0
AY 07-08	7.0		7.5		5.0		4.0		4.0		1.5		0.0		0.0		0.0		29.0
AY 08-09	9.0		11.5		8.0		7.5		5.0		1.5								42.5
AY 09-10																			0.0
AY 10-11																			0.0
AY 11-12																			0.0

Underlined (x) denotes cross-School hire - *Italics* denote cross-engineering hires - (Paranthetical) entries denote individuals under consideration - **Bold** denotes senior FTE

3. 2010 Resource needs for the MEAM graduate program and associated ME program

There is a minimum number of specialized faculty members required to deliver a comprehensive program such as Mechanical Engineering in parallel to a successful graduate program in MEAM. Although we are falling short of the projected need for FTEs, an even more pressing problem is space allocation for both instructional and research use. The ME/MEAM faculty believe that the instructional laboratory allocation to ME-lead classes is insufficient for achieving success in the accreditation process with ABET. The resource needs for both faculty and facilities are discussed next.

Faculty

The MEAM group critically needs new faculty hires to enable the research programs described above. The MEAM group is therefore requesting that 1 additional position in Bio-Inspired Mechanics be released for the next academic year. This position will allow the MEAM group to develop a critical mass in an area where the current faculty members have been actively pursuing research funding. A description of the position follows:

ME-6: Bio-Inspired Mechanics

This position will cover, but will not be limited to, the design, construction and testing of bio-inspired locomotion mechanisms for both flight and underwater propulsion. The undergraduate program in Mechanical Engineering will benefit with courses such as mechanisms (ME 190), mechatronics (ME 142), vibration and controls (ME-140), and the capstone design (ME-170). The graduate program will benefit with courses in the particular areas of research of this FTE. Natural synergies with other programs include Bio-Engineering, Computer Science and Engineering, and

Applied Mathematics. The space needs are expected to be adequate for a senior/junior level position, which includes an area between 600sf to 900sf of dry-lab research area.

Core Facilities

Both the MEAM research program and the ME instructional program need adequate lab space and machine shop support to exist. The current machine shop is not supported at a level that will allow Capstone Design and MEAM research programs. This limitation will severely impact the ability of the ME program to be ABET accredited in the coming years. All ME faculty members, in collaboration with the SOE staff, have been actively involved in extracting the most out of the limited instructional lab space available to deliver the ME classes. However, even considering the best use of the instructional labs (which include rotating schedules, sharing of the labs by several different disciplines, and modular educational benches that are put aside after use) it is very clear that the currently available space will not withstand ABET scrutiny. The same is true with the machine shop support.

The MEAM needs in terms of space include extra 5,000sf laboratory space beyond what is available now for ME faculty at the SE building (Castle, modular buildings?), of which about 2,000sf need to be “damp” lab space. Given our emphasis on computational methods, this need is rather modest in comparison to other graduate programs in Mechanical Engineering at other campuses, but it is critical for us in order to attract the few experimentalists needed for reaching critical mass in both energy systems and bio-inspired technologies.

In summary, the MEAM group is requesting (in consonance with the SOE strategic plan), the following resources for AY 2008:

Faculty

a) **ME-6: Bio-Inspired Mechanics**
b) **Two full-time lecturer positions with possibility of S-o-E.**

Facilities

The MEAM program needs additional 5,000sf of laboratory space (at least 2,000sf of “damp” lab space) plus resources to transform our small machine shop into a consolidated research-grade machine shop (which will serve the whole university). Instructional laboratory space for Mechanical Engineering is also an important concern of our faculty.