Approved by the Regents
May 15, 2008

PROMOTION RECOMMENDATION
The University of Michigan
College of Engineering

Arthur D. Kuo, associate professor of mechanical engineering, with tenure, Department of Mechanical Engineering, and associate professor of biomedical engineering, without tenure, Department of Biomedical Engineering, College of Engineering, is recommended for promotion to professor of mechanical engineering, with tenure, Department of Mechanical Engineering, and professor of biomedical engineering, without tenure, Department of Biomedical Engineering, College of Engineering.

Academic Degrees:

Ph.D.	1993	Stanford University, Mechanical Engineering, Palo Alto, California
M.S.	1989	Stanford University, Mechanical Engineering, Palo Alto, California
B.S.	1987	University of Illinois, Electrical Engineering, Champagne-Urbana, Illinois

Professional Record:

2000-present	Associate Professor (with tenure), Department of Mechanical Engineering, University of Michigan, Ann Arbor
2000-present	Associate Professor (without tenure), Department of Biomedical Engineering, University of Michigan, Ann Arbor
1996-2000	Assistant Professor, Department of Biomedical Engineering, University of Michigan
1995-present	Faculty Associate, Institute of Gerontology
1994-2000	Assistant Professor, Department of Mechanical Engineering, University of Michigan, Ann Arbor
1993-1994	Senior Research Associate, R.S. Dow Neurological Sciences Institute
1992-1993	Research Associate, R.S. Dow Neurological Sciences Institute

Summary of Evaluation:

Teaching: Professor Kuo has an excellent teaching record. He has served as the instructor for more than 1000 students in 24 classes over 13 years, instructing two required courses (Eng101 and ME360) and six senior/graduate courses in dynamics, controls, and biomechanics. He updated and added a laboratory component to ME561 (Design of Digital Control Systems), developed the new ME646 (Mechanics and Control of Human Movement), and, along with Professor James Holloway, developed ENG101 (Introduction to Computing). This latter effort impacted the entire college, by implementing MATLAB as a significant course component, and exposed students early to higher-level programming. He has served as an instructor and mentor to eight undergraduate independent study students, seven M.S. students, and ten Ph.D. students (five completed and five in-progress). Professor Kuo has sponsored and advised four teams of ME seniors through the senior capstone design course. His evaluations have Q1/Q2 career averages of 4.14 and 4.30, respectively, including outstanding evaluations for ME360 (Modeling, Analysis and Control of Dynamic Systems). Since his last promotion, he taught ME360 four times with average Q1/Q2 scores of 4.30 and 4.60. His average evaluations far exceed the course average for all ME360 instructors for the most recent five year period. His students perceive him as a person who demands the best of them, and works very hard to promote excellence; they particularly appreciate his use of practical examples from engineering and biology to illustrate concepts.

Research: Professor Kuo has established an international reputation for his ability to develop elegant and simple models that provide real insights into the mechanics and control of human walking. These models of a very complex problem are simple enough to be tractable, yet contain essential concepts that can be

explored by experiments. Furthermore, he is recognized both for the elegance and utility of his modeling and for the experimental tests of his hypotheses. His work is truly interdisciplinary, and he has established a reputation as someone who crosses traditional boundaries. He works and collaborates with colleagues in robotics, bioengineering, and several clinical fields. He has maintained a steady volume of papers, with 41 archival publications, published in top-ranked journals and consistently well-cited by the community; his rate of citation puts him in the top dozen faculty in the ME department. His work on active and passive stabilization of human walking is regarded as seminal. This work extended a 2-D model of passive walking to 3-D, and showed that lateral sway, which is necessarily associated with a 3-D model, is unstable. However, he hypothesized that a fairly simple control algorithm for placement of the feet could stabilize this motion, and he then demonstrated experimentally that this strategy is actually used by humans. In related work, done in collaboration with a group at UC-Berkeley, he examined the metabolic costs of this lateral stabilization. This collaboration has shown that humans prefer a step width that minimizes metabolic cost, explored the issues associated with step-to-step transitions, and looked at how muscles do active braking to control the momentum changes associated with inverted-pendulum models of walking. Professor Kuo analyzed the energy transfer between leading and trailing limbs. This latter work is motivating others in the field to think about the additional issues that need to be considered beyond the simple inverted-pendulum models of walking. Finally, his early work was the first to recognize the contributions of ankle and hip joints to the maintenance of balance.

Recent and Significant Publications:

Kuo, A. D., "The six determinants of gait and the inverted pendulum analogy: A dynamic walking perspective," *Human Movement Science*, 26, pp. 617-56, 2007.

Doke, J. and Kuo, A. D., "Energetic cost of producing muscle force rather than work to swing the human leg," *Journal of Experimental Biology*, 210, pp. 2390-2398, 2007.

Adamczyk, P. G., Collins, S. H., and Kuo, A. D., "The advantages of a rolling foot in human walking," *Journal of Experimental Biology*, 209, pp.3953-3963, 2006.

Kuo, A. D., "An optimal state estimation model of sensory integration in human postural balance," *Journal of Neural Engineering*, 2, pp.S235-S249, 2005.

Dean, J.D., Alexander, N. B., and Kuo, A. D., "Age-related changes in maximal hip strength and movement speed," *Journal of Gerontology: Medical Sciences*, 59A, pp. 286-292, 2004.

Donelan, J. M., Kram, R., and Kuo, A. D., "Mechanical and metabolic determinants of the preferred step width in human walking," In *Proceedings of the Royal Society of London B*, 268, pp. 1985-1992, 2001.

Kuo, A. D., "Energetics of actively powered locomotion using the simplest walking model," *Journal of Biomechanical Engineering*, 124, pp. 113-120, 2002.

Kuo, A. D., "The relative roles of feedforward and feedback in the control of rhythmic movements," *Motor Control*, 6, pp. 129-145, 2002.

Service: Professor Kuo has served on the ME Graduate Committee, ME and BioMed Faculty Search Committees; the College Discipline Committee; and the Rackham Divisional Board. In his external service he has been active in organizing conferences and workshops in biomechanics, and in promoting mathematical methods in biomechanics. His active participation in professional activities has enabled him to influence the development of the field and to enhance the reputation of the University. He has advised female graduate students and graduate students from under-represented groups. He has always worked to increase the intellectual diversity of the department and college. This is manifested by the style and multi-disciplinary nature of his research. His efforts to modify the ME Ph.D. qualifying exams aimed to make them, among other goals, more welcoming to students with non-traditional intellectual backgrounds.

External Reviewers:

Reviewer A: "Among them I would place Art in the top group, of about six people... referring to his work in control of lateral balance: brilliantly simple experiment was a most valuable contribution to our understanding of the control of walking."

Reviewer B: "I have been continually impressed with the generally simple but elegant modeling approach that Dr. Kuo takes which results in testable experimental predictions."

Reviewer C: "In short, Art is the *top* modeler in the international biomechanics and sensorimotor community. He is a real star. ... Art has a real talent for developing and identifying models that lend themselves to rigorous analysis while remaining relevant to the physiological system under study. ... [His work on active and passive stabilization in human walking] is viewed as a seminal study in biomechanics and bioengineering ..."

Reviewer D: "I regard Art as one of the current leaders in biomechanics. ... a role model for how a theoretician can successfully collaborate with experimentalists."

Reviewer E: "His paper in the Journal of Experimental Biology (209:2953-3963, 2006) provides an example. It is a masterly blend of a series of simplified engineering models with ingenious human experimentation..."

Reviewer F: "... an exceedingly bright, vibrant and creative thinker whose breadth and insights have launched ideas whose impact measurably endures..."

Reviewer G: "He has assumed the role of a major theorist in the field of human motor control, especially in areas relating to posture and balance. ... I would place Art as being at the very top of the field, ..."

Reviewer H: "[his] record of academic achievement and continued ground-breaking research combining control theory with gait and posture analysis is outstanding,..."

Summary of Recommendation: Professor Kuo is extremely well regarded by his peers. He has a steady research productivity rate, with funding and consistent Ph.D. student graduation. The quality and impact of his work is universally recognized, as evidenced by external letters and citations. He is a dedicated and accomplished teacher, and a contributor to service requirements of the University and his scholarly community. It is with the support of the College of Engineering Executive Committee that I recommend Arthur D, Kuo for promotion to professor of mechanical engineering, with tenure, Department of Mechanical Engineering, and professor of biomedical engineering, without tenure, Department of Biomedical Engineering, College of Engineering.

David C. Munson Jr.

David C. Munson, Jr.
Robert J. Vlasic Dean of Engineering
College of Engineering

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