ALEXANDER H. SLOCUM

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Professor Alexander H. Slocum earned the S.B. (1982), S.M. (1983), and Ph.D. (1985) from MIT in Cambridge Massachusetts in Mechanical Engineering. Prof. Slocum teaches and conducts research in the area of precision machine design.

Professor Slocum's research focuses on making dominantly mechanical devices achieve higher levels of performance for less cost by using deterministic design practices founded in fundamental principles of precision engineering catalyzed by appropriate analysis and experimentation. Of particular interest are machine tools and manufacturing equipment, medical devices, renewable energy machines, and tools for the petroleum industry. His design efforts have yielded over 7 dozen patents, numerous design awards and an important precision alignment standard for the semiconductor industry.

In addition to working with industry to create new machines, Prof. Slocum also works in his lab to create new fundamental machine elements and design analysis tools to enable industry to adopt and scale them for use in their own products. An example is the simple kinematic coupling which was used in precision instruments for hundreds of years. Prof. Slocum then wrote a spreadsheet that allows for the contact surfaces and materials to be designed to carry very high relative loads. The resulting papers and design tools are presented on a website his group maintains for industry to use: www.kinematiccouplings.com

Another area of focus is bearings, particularly hydrostatic bearings which Slocum's group has developed to be self tuning and self cleaning which has enabled them to be used with water. Water bearings are particularly important for machines in the ceramics and paper industries as well as in marine propulsion. With these bearing advances, new machine tools have been created to enable faster more precise materials processing machines and machine tools to be developed.

Prof. Slocum's group helps to develop medical devices via his long running project design class 2.75 Precision Machine Design (http://web.mit.edu/2.75). Doctors present their particular challenges and teams work with them during the course of a 14 week semester to develop solutions. Over the past years, this course has become a highly effective mechanism for generating new research ideas and collaborations, with patents filed and projects receiving subsequent funding to assist in accelerating the class prototypes to become products. This course demonstrates an efficient, low risk method of prototyping new medical technologies, while simultaneously teaching mechanical engineering design. Numerous conference and journal papers as well as some patents and several products and startups have resulted from this class.

Prof. Slocum has also become involved in the development of renewable energy systems. Recently he led a team to create the CSPonD concept which uses hillside mounted heliostats to direct sunlight into a volumetric absorption molten salt receiver with integral storage. The concentrated sunlight penetrates and is absorbed by molten salt in the receiver through a depth of 4-5 meters, making the system insensitive to the passage of clouds. The receiver volume also acts as the thermal storage volume eliminating the need for secondary hot and cold salt storage tanks. A small aperture and refractory-lined domed roof reduce losses to the environment and reflect thermal radiation back into the pond. Hot salt is pumped from the

top of the tank through a steam generator and then returned to the bottom of the tank. An insulated barrier plate is positioned within the tank to provide a physical and thermal barrier between the thermally stratified layers, maintaining hot and cold salt volumes required for continuous operation. As a result, high temperature thermal energy can be provided 24/7 or at any desired time.

Current energy research is focusing on offshore energy storage. Slocum's group has developed the design theory for and built and tested a small-scale prototype of a seafloor-based pumped hydro storage system based on a hollow concrete sphere to mitigate the intermittency problem associated with wind power. Each full scale sphere will have an inside diameter on the order of 25 m and a wall thickness of about 2.6 m and have a mass of 21,000 tons. The thick wall will withstand pressures at depths up to 750 meters; the mass provides enough ballast to keep the unit on the seafloor and act as a mooring ball for a tension leg platform to which ocean energy harvesting devices can be attached. Such a sphere operating at 70% efficiency in 320 m of water will store 5 MWh of energy.

Prof. Slocum has supervised 53 SM theses and 48 Ph.D theses, as well as being on 30 other Ph.D. thesis committees. He.is the author of over seven dozen journal articles and over 12 dozen conference papers. He is also the author of text/reference books *Precision Machine Desig*n (Dearborn, MI, SME 1985) and *FUNdaMENTALS of Design* (Cambridge, MA, MIT 2005, http://web.mit.edu/2.75/resources/FUNdaMENTALS.html).

Dr. Slocum was awarded a Department of Commerce Bronze Medal in 1995 for Federal Service, seven dozen patents issued/pending, and has helped create 11 products that have been awarded R&D 100 awards, each for annually being one of one hundred most technologically significant new products. Dr. Slocum received the Martin Luther King Jr. Leadership Award in 1999 and was the Massachusetts Professor of the Year in 2000. Dr. Slocum has also received the SME Frederick W. Taylor Research Medal, and the ASME Leonardo daVinci and Machine Design Awards. Dr. Slocum has completed 9 Ironman triathlon events, many marathons and half-Ironman triathlons, is a rescue certified SCUBA diver, an avid snowboarder, woodworker, and has for many years helped coach a FIRST robotics team with his wife Debra.

Alexander H Slocum
Pappalardo Professor of Mechanical Engineering

Education			
	DEGREE	YEAR(s)	FIELD OF STUDY
Massachusetts Institute of Technology	BS	1982	Mechanical Engineering
Massachusetts Institute of Technology	MS	1983	Mechanical Engineering
Massachusetts Institute of Technology	Ph.D	1985	Mechanical Engineering

Positions and Employment

Positions and Employment

1983-1986 Mechanical Engineer, National Institute of Standards & Technology (NIST)

1986-1989 George Macomber Assistant Professor of Civil Engineering; Massachusetts Institute of Technology, Cambridge, MA.

1989-1990 Visiting Professor, Cranfield Institute of Technology (CUPE), Cranfield, Bedford, England.

1991-1999 Alex & Brit d'Arbeloff Professor of Mechanical Engineering; Massachusetts Institute of Technology, Cambridge, MA.

1999-present Pappalardo Professor of Mechanical Engineering; Massachusetts Institute of Technology, Cambridge, MA.

Honors

1986 U.S. Dept. of Commerce Bronze Medal Award for Outstanding Federal Service.

1986-1991 NSF Presidential Young Investigator Award.

1989-1990 British Royal Society Fellowship: Visiting Professor at CUPE.

1989-1990 Oak Ridge Optics MODIL Fellowship to support research at CUPE.

1993 Society of Manufacturing Engineers: Earl E. Walker Outstanding Young Mfg Engineer Award.

1994 ASCE Thomas Fitch Rowland Prize for Best Paper.

1996 R&D 100 Award: HydroSpindle™ water hydrostatic self-compensating spindle for precision machine tools (with NCMS)

1997 Society of Manufacturing Engineers: Frederick W. Taylor Research Medal.

1997 R&D 100 Award: ShieldBeam™ high frequency electric al contact (with Teradyne)

1997 R&D 100 Award: TurboTool™ water hydrostatic self compensating turbine drive integral tool for 100,000 rpm, 100kW machining (with NCMS)

1997 R&D 100 Award: PreciseDesign™ statistical error budget design tool and finished part shape predictor for precision machine tools.

1997 R&D 100 Award: KinDock™ servo controlled kinematic coupling (with Teradyne)

1998 R&D 100 Award: Q-Tool™ damped tooling system (with Ford Motor Co.)

1999 Martin Luther King Leadership Award

1999 R&D 100 Award: Quasi Kinematic Coupling for Engine Assembly (with Ford)

2000 Massachusetts Professor of the Year, Carnegie Foundation

2004 ASME Leonardo da Vinci Award

2008 ASME Machine Design Award

2008 R&D 100 Award: Saber Furnace

2009 R&D 100 Award: Micro-ESR (with Active Spectrum).

Selected peer-reviewed publications (in chronological order).

1. Hale, L, Slocum, A, "Optimal design techniques for Kinematic Couplings", Jou. Int. Soc. of Precision Engineering and Nanotechnology, 24(2), 114-127, April 2001.
2. Balasubramaniam, M., Dunn, H., Golaski, E., Son, S., Sriram, K., Slocum, A., "An Anti Backlash Two-Part Shaft Coupling with Interlocking Elastically Averaged Teeth", Precis Eng., Volume 26, July 2002, No. 3 pp. 314-330, 2002
3. Slocum, A., Weber, Alexis, "Precision Passive Mechanical Alignment of Wafers", IEEE JMEMS, Dec. 2003, Vol. 12, No. 6, pp 826-834.
4. *Brenner M.P., Lang J. H., Li J., Qiu, J., Slocum A. H., "Optimal, design of a bistable switch," PNAS, August 19, 2003, Vol. 100, No. 17, 9663-9667.
5. White, J., Ma. H., Lang, J. and Slocum, A. "An instrument to control parallel plate separation for nanoscale flow control," Rev. Sci. Inst. v. 74 no. 11, Nov. 2003.
6. Hart, A.J., Slocum, A., Willoughby, P., "Kinematic Coupling Interchangeability," Jou. Int. Soc. of Precision Engineering and Nanotechnology, 28:1-15, 2004.
7. J. Qiu, J. Lang, and A. Slocum, "A curved-beam bistable mechanism", JMEMS , Volume 13 page 137-147, April 2004.
8. Li, J, Brenner, M., Christen, T., Lang, J., Slocum, A. "DRIE Etched Compliant Starting Zone Electrostatic Zipping Actuators", Accepted by JMEMS, Nov. 2004
9. Culpepper, M. L., A. H. Slocum, F. Z. Shaikh and Vrsek, G., "Quasi-kinematic Couplings for Low-cost Precision Alignment of High-volume Assemblies," ASME Jou. of Mech. Design, Vol. 126 (4), pp. 456-63, 2004.
10. El-Aguizy, T., Vogan, J.D., Plante, J.S., Slocum, A.H., "Frictionless compression testing using load-applying platens made from porous graphite aerostatic bearings", Rev. Sci. Instrum. 76, 075108, 2005.
11. Hou, S.M., Lang, J.H., Slocum, A.H., Weber, A.C., White, J.R., "A High-Q Widely-Tunable Gigahertz Electromagnetic Cavity Resonator", JMEMS, vol. 15, no. 6, pp. 1540-1545, Dec. 2006.
12. Robertson, A.P., Slocum, A.H., "Measurement and characterization of precision spherical joints," Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 30, 1–12, 2006.
13. Awtar, S., Slocum, A.H., "Analysis and Synthesis of Modular Parallel Kinematic Flexure Mechanism," submitted to ASME Jou. of Mech. Design, Nov., 2004
14. Bamberg E, Grippo CP, Wanakamol P, Slocum AH, Boyce MC, Thomas, EL, "A tensile test device for in situ atomic force microscope mechanical testing," Precision Engineering, 30 (2006), pp. 71-84.
15. Figueredo, S, Brugge, W, Slocum, A.H., "Design of an Endoscopic Biopsy Needle With Flexural Members", Journal of Medical Devices, 1(1), pp. 62-69, March 2007.
16. H. Ma, J. H. Lang, and A. H. Slocum, "Permittivity Measurements using Adjustable Microscale Electrode Gaps between Millimeter-Sized Spheres," Review of Scientific Instruments, vol. 79, p. 035105, 2008.
17. McEuen, S., Tzeranis, D., Hemond, B., Dirckx, M., Lee, L., Slocum, A., "Design of an Endoscopic Full-Thickness Lesion Removal Device", Journal of Medical Devices, March 2008, Vol. 2
18. Walsh, C., Hanumara, N., Slocum, A., Shepard, J., Gupta, R., "A Patient-Mounted, Telerobotic Tool for CT-Guided Percutaneous Interventions", Journal of Medical Devices, March 2008, Vol. 2 , pp 1-9
19. H. Ma, J.H. Lang, A.H. Slocum, Calibration-free Measurement of Liquid Permittivity and Conductivity using Electrochemical Impedance Test Cell with Servomechanically Adjustable Cell Constant, IEEE Sensors Journal, 9.5 (2009): 515-524.

20. E. K. Bassett1, A.H. Slocum, P.T. Masiakos, H.I. Pryor II, O.C. Farokhzad, J. M. Karp, "Design of a Mechanical Clutch-based Needle Insertion Device", PNAS, cgi, doi, 10.1073, pnas.0808274106, March 23, 2009.
21. A. Slocum, "Kinematic couplings: A review of design principles and applications," Int. Jou. of Machine Tools and Manufacture (2009), doi:10.1016/j.ijmachtools.2009.10.006
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23. A.P. Mitha, M. S. Ahmad, S. J. Cohen, J. S. Lieberman, M.R. Udengaard, A.H. Slocum, J.-V. C. E. Coumans, "A Modified Footplate for the Kerrison Rongeur," Jou. Med. Dev., MARCH 2010, Vol. 4 / 1-1
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25. A.H. Slocum, D.S. Codd, J. Buongiorno, C. Forsberg2, T. McKrell, J.C. Nave , C.N. Papanicolas , A. Ghobeity, C.J. Noone, C. Passerini, F. Rojas, A. Mitsos, "Concentrated Solar Power on Demand," Solar Energy 85, 1519-1529, 2011.
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27. P. J. Lu, M. M. Hoehl, J. B. Macarthur, P. A. Sims, H. Ma, A. H. Slocum, "Rugged, portable, multi-sample, multi-wavelength UV/vis absorption and fluorescence detector", AIP Advances 2, 032110; doi: 10.1063/1.4738962, 2012.
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30. P. J. Lu, M. H. Hoehl, J.B. Macarthur, P. A. Sims, H. Ma, A.H. Slocum, "Robust and economical multi-sample, multi-wavelength UV/vis absorption and fluorescence detector for biological and chemical contamination," AIP Advances, V. 2, I3, Sept. 2012
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32. T. Cervantes, E. K. Summers, R. Batzer, C. Simpson, R. Lewis, N. Dhanani, A. H. Slocum, "Evaluation of a minimally invasive renal cooling device using heat transfer analysis and an in vivo porcine model", accepted to Medical Engineering and Physics, August 2012.
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