

Schools of Mechanical and
Civil Engineering
Purdue University

2016-2017 ANNUAL REPORT

FALL 2017

RAY W. HERRICK LABORATORIES

Home of the
Center for High
Performance Buildings

177 S. Russell Street
West Lafayette, IN 47907-
2099

Phone: 765-494-2132
Fax: 765-494-0787
Email rhlab@ecn.purdue.edu



THE RAY W. HERRICK LABORATORIES

The Ray W. Herrick Laboratories turned 50 years old in 2008. Today we are part of the School of Mechanical Engineering, but the 25+ Mechanical Engineering faculty and Architectural Engineering faculty who do research here collaborate on interdisciplinary research projects with faculty in the other Schools of Engineering and also with the faculty in the College of Science and College of Health and Human Sciences and the College of Technology. There are four main technical areas of research with some overarching themes related to energy utilization and efficiency, reduction of pollutants in the environment, quality of life, and sustainability and safety.

The main technical areas are:

1. High Performance Buildings, Thermal Systems and Air Quality
2. Noise and Vibration Control, which includes research on Acoustics, Dynamics, and Materials
3. Electromechanical Systems & Advanced Engines: Controls, Signal Processing, Sensing, Estimation, Diagnostics and Prognostics
4. Perception-Based Engineering: Modeling of Human Response for Machine and System Optimization

The educational experience at the Herrick Labs combines the traditional training of aspiring researchers with exposure to industrial needs and culture. Students study in a strong peer education environment with active mentoring from faculty and sponsors. Over 900 Masters and PhD candidates have graduated from the Herrick Labs.

The engagement/service programs are highlighted by the well-established conference and short course activity sponsored by the Herrick Labs. In addition, technology transfer to sponsors is an integral part of a majority of the research programs. The researchers at the Herrick Labs are also widely published across the spectrum of publications from academic journals and technical conferences to the popular press.

MISSION

An institution dedicated to graduate education through engineering research with an emphasis on technology transfer

VISION

To overcome barriers between knowledge creating, transfer, and utilization for the advancement of society

GOALS

1. Grow educational outreach activities, including fundamental, applied, and experimental short courses.
2. Build on research excellence of following research areas: noise and vibration control, integrated thermal and power systems, and the built environment.
3. Provide the educational environment of the labs so that its graduate students are multi-disciplinary engineers who rate as the top engineering graduates in the country.
4. Recognize and promote the value of Herrick through effective brand management (internally and externally).
5. Maximize utilization of the new facilities (PBE, engine test, geothermal, etc.)
6. Continue recruiting top faculty, grad students, and staff to ensure long term stability and growth. Maintain world-class facilities.
7. Become a more multi- and inter-disciplinary laboratory by inviting researchers from additional departments across Purdue to become involved in research at Herrick.
8. Develop a testing program to support staff and infrastructure.

2016-2017 HIGHLIGHTS

Research	Last Year	This Year
Research Expenditures HLAB July 2016-June 2017	\$7,375,042	\$6,782,327
Proposals Pending	\$7,920,100	\$12,588,622
Number of Sponsors as of September 2017	83	75
Archival Journal Papers Published Jan-Dec 2016	102	99
Contracts in Force for July 2017-June 2018	\$4,661,793	\$6,859,414
	(\$5,171,661)	

Students

Graduate Students as of September 2017	115	124
MS	44	42
Ph.D.	71	82

Research Assistants	69	74
Fellowships	8	12
Teaching Assistants	18	16

Students Graduated-January-December 2016	20	32
MS	10	21
Ph.D.	10	11
Undergraduate/Graduate "Research Experience" Students	38	36

Visting Scholars, Post Doctoral Scholars

Visiting Researchers	14	17
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Technology Transfer

Conferences/Workshops Held-Aug 2016-July 2017	6	3
CHPB Members Meetings-Aug 2016-July 2017	1	2
Conferences Planned in the Next 2 Years-Aug 2017-July 2019	1	9
Short Courses Held Aug 2016-July 2017	4	3
Sponsor Reports (Herrick Lab Reports) to Sponsors	12	13
Conference & Journal Papers Jan-Dec 2016	185	193

ADMINISTRATIVE AND SUPPORT STAFF

Professor Patricia Davies is the Director of Ray W. Herrick Laboratories. Donna Cackley is her administrative assistant with Cindy Cory being the Herrick secretary. Kim Stockment serves as conference coordinator for all Herrick Laboratories' conferences and short courses. Orkan Kurtulus serves as the Senior Research Associate helping support the setup of the operation of projects that utilize experimental facilities within the thermal system laboratory. The various research programs are assisted by: Ron Evans, Technical Services Supervisor and Research Engineer; Bob Brown, Mechanical Shop Coordinator and Building Deputy; and Frank Lee, Mechanical Technician.

HERRICK LABS FACULTY RESEARCH INTERESTS

Andres Arrieta, Assistant Professor of Mechanical Engineering; PhD 2010, University of Bristol, United Kingdom; Adaptive structures, nonlinear vibrations, multi-stable structures, shape programmable adaptable matter, nonlinear metamaterials, dynamics of smart material systems, morphing of compliant structures, structural nonlinearity, and elastic instability.

Anil Bajaj, Head and Professor of Mechanical Engineering; PhD 1981, University of Minnesota; Nonlinear oscillations in structures, chaotic dynamics, stability analysis, flow-induced vibrations, perturbation techniques, mistuned structures, and localization of modes, drum and disk brake squeal-friction induced vibrations, modeling of carseat-occupant dynamics, and modeling/identification of polyurethane foam properties.

Stuart Bolton, Professor of Mechanical Engineering; PhD 1984, University of Southampton; Acoustics, models of porous noise control materials, optimal design of noise control materials and treatments, physical properties of noise control materials, microperforated noise control materials, analysis of tire vibration and sound radiation, fan noise control, nearfield acoustical holography, visualization of motor vehicle passby sound radiation, and machinery noise source identification.

Brandon Boor, Assistant Professor of Civil Engineering, (by courtesy) Mechanical Engineering, Herrick Labs; Indoor air quality, urban air pollution, ventilation and filtration strategies for low-energy buildings, aerosol science, bioaerosols (fungi, bacteria, pollen, viruses), airborne nanoparticles, particle resuspension, new particle formation, infiltration of outdoor air pollutants into residences, human exposure assessment, health effects of air pollution, air quality in occupational workplaces, air quality monitoring for communities with low-cost sensors, volatile organic compound (VOC) and semi-VOC (SVOC) emissions from building materials, furnishings, and consumer products.

James Braun, Herrick Professor of Mechanical Engineering; PhD 1988, University of Wisconsin; Thermal systems measurements, modeling, analysis, design optimization, and control optimization with applications to high performance building systems, advanced HVAC&R equipment and small-scale power production.

David Cappelleri, Assistant Professor of Mechanical Engineering; PhD 2008, University of Pennsylvania; Multi-scale robotic manipulation and assembly; mobile micro/nano robotics, micro/nano aerial vehicles, micro-bio robotics, mechatronics, MEMS/NEMS, and automation for the life sciences.

Jun Chen, Associate Professor of Mechanical Engineering; PhD 2004, Johns Hopkins University; Experimental fluid dynamics; development of flow diagnostic techniques; flow dynamics in stratified environment; and turbulent flow measurements and modeling.

Qingyan (Yan) Chen, Reilly Professor of Mechanical Engineering; PhD 1988, Delft University of Technology; Indoor and outdoor airflow modeling by computational fluid dynamics and measurements, protection of buildings from chemical/biological warfare attacks, building ventilation systems, indoor air quality, airline cabin environment.

George Chiu, Professor of Mechanical Engineering; PhD 1994, University of California at Berkeley; Mechatronics, modeling/control of digital imaging and printing systems, functional printing and digital fabrication, motion and vibration control and perception, and embedded system design.

Patricia Davies, Professor of Mechanical Engineering, Director of the Ray W. Herrick Laboratories; PhD 1985, University of Southampton; Signal processing and data analysis applied to mechanical systems, condition monitoring, vibration measurement, sound quality and perception-based engineering, nonlinear system identification, modeling of car seat-occupant dynamics and modeling and identification of foam properties.

Shirley Dyke, Professor of Mechanical and Civil Engineering, PhD 1996, University of Notre Dame; Structural dynamics and controls, damage detection and structural condition monitoring, cyber-physical systems, real-time hybrid simulation, cyberinfrastructure development, and machine vision.

James Gibert, Assistant Professor of Mechanical Engineering, PhD 2009; Dynamic modeling of nonlinear systems, modeling of manufacturing systems, dynamics of closed and open cell foam packaging system, energy harvesting systems, vibrations and rolling resistance of non-pneumatic tires, ultrasonic additive manufacturing and optimization of mechanical systems.



HERRICK LABS FACULTY RESEARCH INTERESTS

Marcial Gonzalez, Assistant Professor of Mechanical Engineering, PhD 2011, California Institute of Technology; Development of predictive, mechano-chemicals models and multi-scale numerical methods that provide new insight into the behavior of materials and structures, that enable design and optimization of manufacturing process and product performance.

Eckhard Groll, Professor of Mechanical Engineering, Director of Office of Professional Practice, PhD 1994, University of Hannover, Germany; Thermal sciences as applied to advanced HVAC&R systems, components, and working fluids: compressor research, alternative refrigeration technologies, vapor compression systems, components, natural refrigerants, heat exchangers analysis, and Organic Rankine Cycle analysis.

Travis Horton, Associate Professor of Civil Engineering, PhD 2002, Purdue University; Thermal sciences and energy conversion systems, including heating, air conditioning, refrigeration, and electrical systems; combined heat and power systems, and building energy modeling techniques.

Neera Jain, Assistant Professor of Mechanical Engineering, PhD 2013, University of Illinois at Urbana-Champaign; Dynamic modeling and optimal control of integrated energy systems (IES) for the purpose of more efficiently and effectively meeting society's energy needs. IESs typically span multiple energy domains: thermal, electrical, mechanical, and chemical. Use the thermodynamics-based approaches for designing

Panagiota Karava, Associate Professor of Civil Engineering, PhD 2008, Concordia University; Mixed-mode buildings, building-integrated solar energy systems, buildings systems modeling and identification, model-predictive control, human-building interactions.

Donghun Kim, Research Assistant Professor of Mechanical Engineering, PhD 2015, Purdue University; Dynamic modeling and control of thermal systems, high performance buildings, model order reduction, system identification, model predictive control.

Charles Krousgrill, Professor of Mechanical Engineering, PhD 1980, California Institute of Technology; Non-linear oscillation, elastic stability, dynamics, vibrations, rotor dynamics, chaos, automotive brake squeal/vibration, and vibration in gearing systems.

Kai Ming Li, Professor of Mechanical Engineering, PhD 1987, University of Cambridge, UK; Environmental acoustics, sound propagation outdoors, noise control in built environments, monitoring of natural and human produced sounds in the environment, computational acoustics, physical acoustics and wave propagation in a complex medium.

Peter Meckl, Professor of Mechanical Engineering, PhD 1988, Massachusetts Institute of Technology; Motion and vibration control of high-performance machines, adaptive control, virtual sensing, and diagnostics. Applications to manufacturing devices, robotics, and automotive engines.

Ming Qu, Associate Professor of Civil Engineering; PhD 2008, Carnegie Mellon University; Development & application of energy efficient technologies in buildings, solar cooling & heating systems, building energy supply systems, sustainable building design & analysis.

Jeff Rhoads, Professor of Mechanical Engineering; PhD 2007, Michigan State University; Nonlinear dynamics and vibration of macro-, micro-, and nanomechanical systems, micro- and nanoelectromechanical sensor design, mechanical and electromechanical amplifiers, parametrically-excited systems, mechanical and electromechanical radio-frequency (RF) components, system dynamics.

Fabio Semperlotti, Assistant Professor of Mechanical Engineering; PhD 2009, Pennsylvania State University; Structural health monitoring, structural dynamics, smart and adaptive structures, wave propagation, metamaterials, and energy harvesting.

Gregory Shaver, Professor of Mechanical Engineering; PhD 2005, Stanford University; Modeling, design and control of advanced powertrains for the purpose of developing clean, efficient and practical approaches to utilizing conventional and alternative fuels. Coordination of conventional and advanced combustion process with variable valve actuation (VVA) aftertreatment systems and hybrid powertrains.

Thanos (Athanasios) Tzempelikos, Associate Professor of Civil Engineering; PhD 2005, Concordia University; Design of energy-efficient buildings, indoor environment, dynamic facades, lighting controls, integration of green and renewable technologies, solar energy applications, building energy modeling & simulation.

Bin Yao, Professor of Mechanical Engineering; PhD 1996, University of California at Berkeley; Coordinated control of intelligent and high performance electro-mechanical/hydraulic systems; mechatronics; robotics; automotive control; optimal adaptive/robust controls; nonlinear observer design and neural networks for virtual sensing, modeling, fault detection, diagnostics, and adaptive fault-tolerant control; data fusion.



HERRICK FACULTY PROFESSIONAL ACTIVITIES

Andres Arrieta

Member: ASME Energy Harvesting Technical Committee and ASME Active and Multi-functional Materials Technical Committee

Anil Bajaj

Contributing Editor, Nonlinear Dynamics Journal

Stuart Bolton

Advisory Board Member, Noise Control Engineering Journal; Institute of Noise Control Engineering – Member Board of Directors; Institute of Noise Control Engineering – InterNoise 2015 – INCE/KSNVE Liaison

Brandon Boor

Member: American Society of Heating, Refrigerating & Air Conditioning Engineers (ASHRAE), 2008-Present; International Society of Indoor Air Quality & Climate (ISIAQ), 2010-Present; American Association for Aerosol Research (AAAR), 2010-Present; International Society of Exposure Science (ISES), 2012-Present; and Nordic Society for Aerosol Research (NOSA), 2014-Present

Jim Braun

Editorial Board, Journal of Building Performance Simulation and Building Simulation; An International Journal; Chairman, 2016 International Refrigeration and Air Conditioning Conference, Purdue University

David Cappelleri

Member, IEEE Robotics & Automation Society Technical Committee on Micro/Nano Robotics and Automation; IEEE Robotics & Automation Technical Committee on Mechanisms and Design; ASME Design Engineering Division Mechanisms and Robotics Committee; and ASME Design Engineering Division Micro and Nanosystems Technical Committee; Steering Committee, IEEE International Conference on Manipulation, Automation, and Robotics at Small Scales (MARSS) 2015-Present; Associate Editor, Journal of Micro-Bio Robotics, 2012-present; IEEE Robotics & Automation Letters (RA-L), 2015-Present; Co-Organizer, IEEE RAS MNRA Mobile Microrobotics Challenge, 2013-present; Symposium Organizer, ASME International Design Engineering Technical Conferences, Micro and Nano Systems Conferences, Micro and Nano- Mechanisms and Robotics, 2010-present Special Sessions Chair, 12th IEEE Conference on Automation Science and Engineering, 2016; Program Chair, 10th Inter. Conference of Micro- and Nanosystems; ASME Inter. Design Engineering Technical Conferences, 2016

Jun Chen

Co-Chair, Forum on Fluid Measurement and Instrumentation, ASME 2014 Fluids Engineering Summer Meeting, August, 2014 and Forum on Fluid Measurement and Instrumentation.

Qingyan (Yan) Chen

Consultant, The Canaan Company, 2012; Editor-in-Chief, Building and Environment (BAE) Journal; Member, Advisory Board, Energy and Buildings; Departmental Academic Advisor, Department of Building Services, Hong Kong Polytechnic University; Engineering Panel Member for Research Assessment Exercise, Hong Kong University Grant Council, 2014

George Chiu

Fellow: Society for Imaging Science and Technology (IS&T); American Society of Mechanical Engineers (ASME); Editorial Board, Frontiers of Mechanical Engineering, 2008-Present; Program Chair, 2016 American Control Conference, Boston, MA, June; Editor-in-Chief Elect, IEEE/ASME Transactions on Mechatronics, 2016 Chair; Member Editorial Board, Frontiers of Mechanical Engineering, 2008-Present

Patricia Davies

Fellow: Institute of Noise Control Engineering (INCE); Member: INCE Executive & Membership Committee, Acoustical Society of America (ASA); Planning Committee for InterNoise 2018, Chicago

James Gibert

Secretary: ASME Technical Committee on Modeling, Dynamics, and Control of Adaptive Systems

Marcial Gonzalez

Faculty Committee Member, National Institute for Pharmaceutical Technology and Education, (NIPTE), 2015-present; Member, Granular Materials Committee, Engineering Mechanics Institute, EMI, 2017-present

HERRICK FACULTY PROFESSIONAL ACTIVITIES

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Eckhard Groll

Regional Editor for the Americas: International Journal of Refrigeration; Member: Technology Council, ASHRAE, & USNC/IIR (U.S. National Committee of the Int'l Institute of Refrigeration); Vice President: IIR Commission B2 Steering Committee Member: General Conference Chair: 22nd Int'l Compressor Engineering Conference at Purdue, 15th Int'l Refrigeration and Air Conditioning at Purdue, and 3rd Int'l High Performance Buildings Conference at Purdue, July 14-17, 2016.

Travis Horton

Paper Reviewer for: International Journal of Refrigeration, Applied Energy, Energy, ASHRAE, and Renewable Energy; Secretary for TG1.Optimization, ASHRAE; Proposal Reviewer for projects related to sustainability for the USDA; Member of the United States National Commission for the International Institute of Refrigeration

Neera Jain

Vice Chair for Student Affairs-Operating Committee; American Control Conference 2015; Technical Program Committee, American Control Conference 2016

Panagiota Karava

Member: American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2008-Present; International Building Performance Simulation Association (IBPSA), 2005-Present; US Building Simulation Association, 2009-Present; Organizing Committee, 2nd and 3rd Int'l High Performance Buildings Conference at Purdue University, 2012 & 2014; and ASHRAE Technical Committee 4.3, TC 6.7, and TC 4.10, 2008-present

Kai Ming Li

Fellow: Acoustical Society of America and Institution of Mechanical Engineers (UK); Associate Editor: Journal of Acoustical Society of America, Applied Acoustics; Member: Membership Committee of the Acoustical Society of America; Co-Chair: American National Standards Institute (ANSI) Working Group on "Method for determining the acoustic impedance of ground surface"

Peter Meckl

Finance Chair, 2013 American Control Conference; Member, ASME Dynamic Systems and Control Executive Committee, 2014; Editor, ASME Dynamic Systems and Control Magazine, 2015

Jeff Rhoads

Associate Editor: ASME Journal of Vibration and Acoustics, 2013-Present; Member: ASME Design, Materials, and Manufacturing (DMM) Segment Leadership Team, 2015-Present; ASME International Design Engineering Division Technical Committee on Sound and Vibration, 2010-Present; ASME International Design Engineering Division Micro/Nanosystems Technical Committee, 2009-Present

Fabio Semperlotti

Member: Program Committee of SPIE's Smart Structure/NDE Symposium, 2013-Present; ASME Technical Committee for Vibration and Sound (TCVS), 2014-2017; ASME Structural Health Monitoring Technical Committee, 2013-Present; ASCE EMI Structural Health Monitoring Technical Committee, 2014-Present

Greg Shaver

Associate Editor, International Journal of Engine Research and Frontiers in Engine and Automotive Research

Thanos Tzempelikos

Member, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE); Voting Member, Vice Chair and Program Subcommittee Chair of ASHRAE Fenestration Technical committee (4.5); Member: International Building Simulation Association and International Solar Energy Society; Chairman, 1st, 2nd and 3rd International High Performance Buildings Conferences, Purdue University, 2010, 2012, 2014; Member of technical review panels for EPA, DOE, and other government-funded research proposals

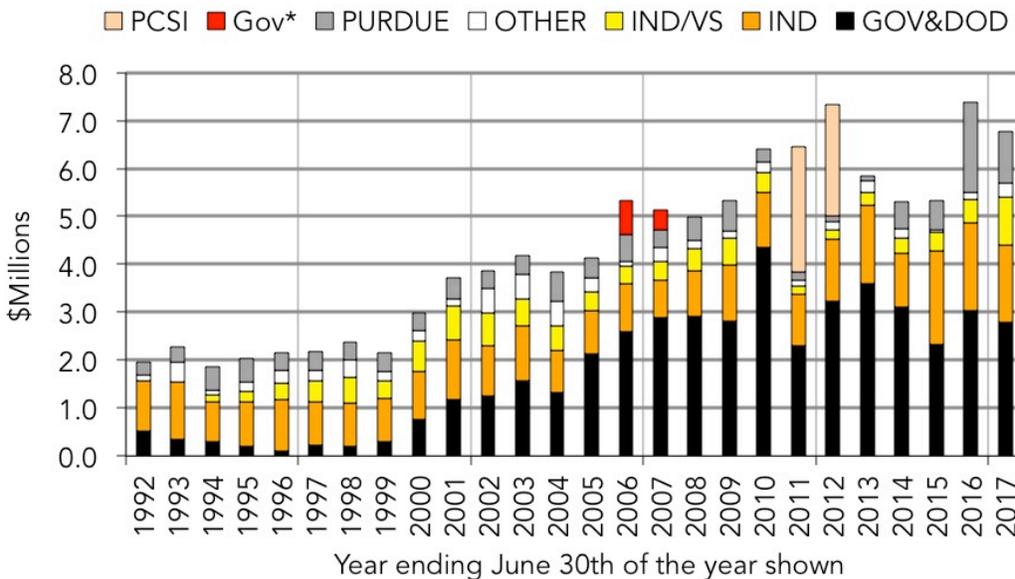
Bin Yao

ASME Fellow, Senior Member of IEEE; Member: Editorial Board of the International Journal of Control, Automation and Systems (ICASE); Management Committee of IEEE/ASME Trans. Mechatronics, 2012-2014; Award Committee and International Advisory Committee of IEEE/ASME Int. Conference on Advanced Intelligent Mechatronics, Besancon, France, July 8-11, 2014; Past Technical Editor: IEEE/ASME Trans. Mechatronics Granular Materials Committee, Engineering Mechanics Institute, EMI, 2017-present

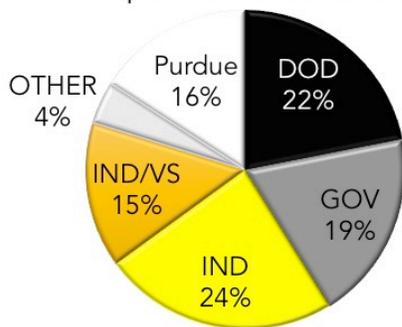
The Ray W. Herrick Laboratories

2016-2017 RESEARCH EXPENDITURES

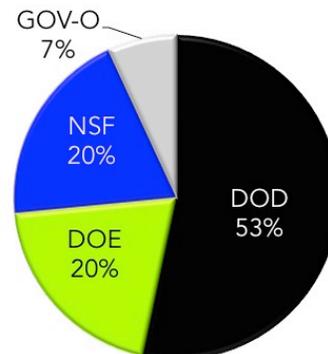
Shown below is the distribution of research expenditures from July 1987 - June 2017. Total Herrick Laboratories Research Expenditures \$6,782,327, 2016-2017 (\$7,375,042, 2015-2016).



Expenditures 2016-17



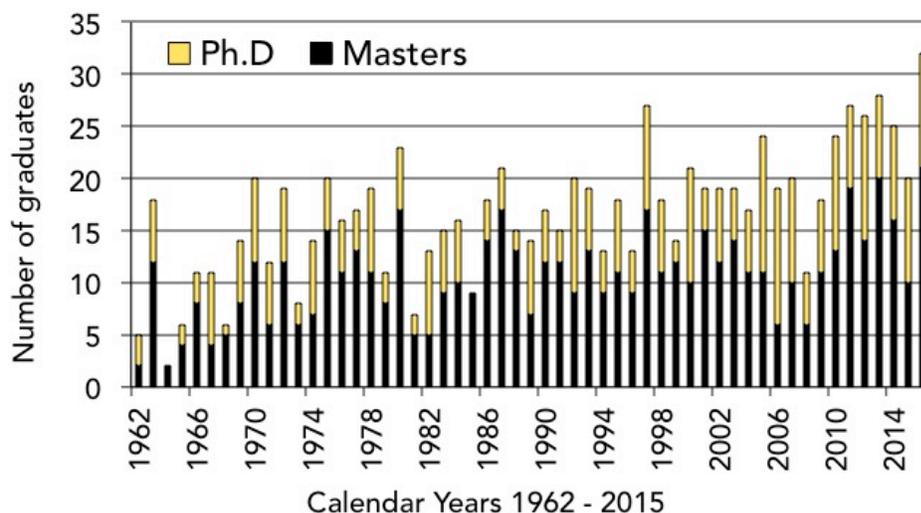
Expenditures Distribution Government & Department of Defense



DOD - Department of Defense
 IND - Industry; IND - Industry Voluntary Support
 GOV - Government Agencies
 NSF - National Science Foundation
 DOE - Department of Energy
 GOV-O - Other Government Agencies

HERRICK LABS EDUCATION PROGRAMS

The primary educational program at the Herrick Labs is thesis-based graduate education. We believe that the experiential learning, the open-ended and integrative nature of thesis based research is outstanding preparation for both academic and industrial careers. To complement the student/advisor relationship, the Labs offer a learning community to the student. This community includes an outstanding cohort of graduate students as well as a staff prepared to support and teach. In many cases, the student's research is sponsored. Sponsor representatives also participate in educational activities with the student. We also have programs where graduate students do internships in industry or government laboratories. In total we believe this is an outstanding educational opportunity for our graduate students.



The Ray W. Herrick Laboratories

Fellowships

Youyi Bi received the Lambert Teaching Fellowship

Caleb Heitkamp and Dennis Lyle received the Arrasmith Fellowship

Wei Liu received the Bilsland Dissertation

Conor Pyles received the National Science Foundation Graduate Research Fellowship

John Hollkamp received the National Defense Science & Engineering Graduate (NDSEG) Fellowship

Assistantships

Katie Riley and Trevor Kyle received the Lozar Assistantship

ASHRAE Grants-in-Aid

Seungjae Lee received the ASHRAE Grad Student Grant-in-Aid

Awards

Daniel Carr received the Classic Papers in Noise Control Engineering, Noise-Con 2016

Jiawei Liu & Tongyang Shi each received an award for their paper at Noise-Con 2016

Andy Hjortland & Nelson James each received an award for their paper at the Purdue International Refrigeration and Air Conditioning Conference

Davide Ziviani received a 3rd place, Student Paper at Purdue's Compressor Conference

Yangfan Liu received the Teaching Academy Graduate Teaching Award

Harshad Inamdar received the Summer Research Grant

Hyunjun Shin received the Hallberg Foundation Travel Award (Noise-Con 2016)

Tongyang Shi received the Michiko So Finegold Memorial Trust Award (Noise-Con 2016)

John Hollkamp received 3rd place-Student Oral Presentation, 3rd Annual Midwest Workshop of Mechanics of Materials and Structures

Chul Min Yeum received the CE Outstanding Graduate Student

Seungjae Lee received the Best Student Paper Award at the 4th International High Performance Buildings Conference, Purdue University

CURRENT HERRICK LAB STUDENTS

Agarwal, Ankit	Gonzalez	Thermo-mechanical characterization of energetic and mock-energetic materials
Akash, Kumar	Jain	Mathematical characterization of human-machine interactions
Allen, Cody	Shaver	Ultra-high engine systems efficiency via flexible valve actuation
An, Ze	Cappelleri	Mobile robotics
Angre, Harshil	Meckl	SCR controls
Bahman, Ammar	Groll	High efficiency air conditioning systems for hot climate zones
Barta, Riley	Groll	Multi-temperature refrigerated container systems (MTRCS) analysis
Bird, Trevor	Jain	Dynamic modeling & control of a PEM fuel cell-micro-CHP system
Boston, (Matt) David Matthew	Arrieta	Experimental and numerical studies of selectively compliant morphing structures
Brendel, Leon	Groll/Braun	Characterization of next generation vehicle sounds
Browne, Florian (Rian)	Jain	Advanced control of Castrip LLC caster roll gap
Cao, Rui	Bolton	Tire noise
Carr, Daniel	Davies	Ford road and wind noise
Caskey, Stephen	Groll	Low-temp heat pump
Cheng, Li	Horton/Braun	Geothermal
Choi (Brad), Jongseong	Dyke	Active citizen science for lifecycle assessment
Chowdhury, Arindam Bhanja	Cappelleri	Perce option for mobile robotic systems
Chowgule, Revati	Davies	Polyurethane foam characterization
Deng, Zhipeng (Steven)	Chen, Y	Recognition of building occupant behaviors from indoor environment parameters by a data mining approach
Desai, Akash	Shaver	ARPA-E NEXTCAR
Dhillon, Parveen	Braun	Advanced control of rooftop units
Fei, Yifan	Davies	Sound Metric Calculation
Feng, Jianxiong	Li	Quantification of uncertainties in predicting aircraft noise
Fleck, Trevor	Rhoads	Energetic materials printing
Ganti, Sai Sanjit	Semperlotti	Topological acoustics
Gosala, Dheeraj	Shaver	Enabling ultra-high engine system efficiency via flexible valve actuation
Guerrero de la Peña, Ana	Jain	What's next in freight transportation
Hahn, Jaesik	Reid	Thermal transport in natural fiber bundles
Halbrooks, David	Braun/Groll	Load-Based Testing of HVAC Equipment
Ham, Sang Woo	Karava	Cyber-sees
Han, Dong	Groll	Optimizing heat pump performance
Hao, Haitian	Semperlotti	Thermoacoustics
Heitkamp, Caleb	Rhoads	Acoustics-based IED detection and defeat
Henry, Ashwin Clement	Arrieta	Smart morphing structures
Hollkamp, John	Semperlotti	Acoustic metamaterials for vibration and noise control
Hoshing, Vaidehi	Shaver	Controls
Hou, Xiaodong	Braun	CPS: Synergy: Plug-and plug cyber-physical systems to enable buildings
Hurkat, Yash	Chen, Y/Braun	Modeling the performance of the ReNEW House
Hwang, Myungwon	Arrieta	Nonlinear dynamics of bi-stable unit cell lattices
Ibitayo, Ifeoluwa	Shaver	Advanced diesel engine systems
Inamdar, Harshad	Groll	Analysis of air-side heat exchanger fouling
Jain, Kaushal K.	Meckl	SCR controls of Eco CAR
James, Nelson	Braun/Groll	Cold climate heat pump
Jana, Aniruddha	Shaver	HEV project w/Cummins
Jaramillo, Rita	Braun/Horton	Free cooling technologies
Joe, Jaewan	Karava	High performance buildings
Jokar, Mehdi	Semperlotti	Holographic damage detection

CURRENT HERRICK LABS STUDENTS

Joodaky, Amin	Gibert	Transient & random packing dynamics
Joshi, Mrunal	Shaver	Enabling ultra-high engine system efficiency via flexible valve actuation
Kim, Huijeong	Karava	Human/building interactions
Kim, Michael	Tzempelikos	Integrated occupant comfort in commercial buildings
Kumra, Anurag	Chiu	NSF-SNM roll to roll manufacturing of films and laminates
Kyle, Trevor	Rhoads	Acoustics-Based IED detection and neutralization
Lavernia, Alejandro	Groll	Organic Rankin cycle as a bottoming cycle for waste heat recovery
Law, Che Kun	Cappelleri	Mobile robotics
Lee, Seungjae	Tzempelikos	Living labs experimentation
Lenjani, Ali	Dyke	Active citizen engagement to enable lifecycle management
Li, Ang	Chen, J.	Noise control of high speed centrifugal fan
Li, Ruoyi	Bin Yao	Intelligent & high-performance control of industrial robots
Liu, Haotian	Groll	Compressor calorimeter commissioning
Liu, Liheng	Davies	Sound Quality Metrics
Liu, Ting-Wei	Semperlotti	Design and testing of topological acoustic metamaterials
Liu, Xiaoqi (Claire)	Karava	Uncertainty impact on predictive control of buildings
Liu, Xiaoyu	Dyke	3D mapping indoor locations for navigation
Lu, Zechao	Chen, Y & J	Aerodynamic optimization of next generation range hood
Lumpkin, Dominique	Groll	Regenerative air cycle heat pump for commercial and individual appliances
Lyle, Dennis	Gibert	Macroscopic modeling & control of UAM
Ma, Jiacheng	Braun	Dynamic modeling of air conditioners and heat pumps
Ma, Jie	Horton/D. Kim	Separate sensible and latent cooling systems for residential and light commercial buildings
McArthur, Daniel	Cappelleri	Micro aerial vehicles
McConnell, Miranda	Rhoads	DTRA-Secure MEMS
Mina, Tamzidul	Yao	Dynamics and controls of mobile robots
Murray, Allison	Rhoads	Portable integrated microscale sensors
Nash, Austin	Jain	Dynamic modeling and control of MicroCHP systems
Odstrcil, Troy	Shaver	Enabling ultra-high engine system efficiency via flexible valve actuation
Panicker, Malavika	Meckl	Fuel system diagnostics
Paripovic, Jelena	Davies	Identification of material properties
Patil, Akash	Braun	Virtual sensors for RTU's
Prasad, Sudarshan	Semperlotti	Fractional continuum mechanics
Pyles, Conor	Rhoads	Coupled MEMS resonators
Ramanujam, Ganesh Ram	Cappelleri	Micro aerial vehicles
Ramaraj, Sugi	Braun/Horton	Free cooling technologies
Ramesh, Aswin	Shaver	Variable valve actuation in diesel engines
Range, Allison	Rhoads	Thermomechanics of energetic materials
Rayasam, Sree Harsha	Shaver	Natural gas engine controls
Riley, Katherine	Arrieta	Programmable structures with spatially distributed mechanical properties
Rivas, Jose	Arrieta	Selective compliance for morphing structures
Rohleder, Cai	Groll	Vapor compression refrigeration system for cold storage on spacecrafts
Sadeghi, Seyed Amir	Tzempelikos/Karava	Energy efficient buildings hub
Saha, Tridib	Shaver	Cummins-Design/control of advance hybrid power train
Salts, Nick	Groll	Optimizing heat pump system performance
Schuster, Dan	Horton	Campus sustainability
Shah, Vatsal	Groll/Braun	Next generation unitary air conditioning & high performance equipment
Shang, Weixiao	Chen, J.	Laser diagnostic of complex flow field

CURRENT HERRICK LABS STUDENTS

Shi, Tongyang	Bolton	Acoustic holography
Shi, Zhu	Chen, Y.	ASHRAE research project
Shin, Hyun Jun	Bolton	Optimal sound packages
Son, Forrest	Groll	Heat pump performance testing
Sun, Mingyu	Meckl	EcoCAR2-Power management of plug-in hybrid vehicle
Sung, Weonchan	Davies	Sound quality of HVAC equipment
Tam, Aaron	Braun/Jain	Investigation of ice storage systems for residential buildings
Tao, Hongcheng	Gibert	Dynamic behavior of discontinuous metamaterial unit cells
Taylor, Alexander	Shaver	Enabling ultra-high engine system efficiency via flexible valve actuation
Thakkar, Aman	Arrieta	Nonlinear metamaterials
Thomas, Josiah	Chiu	Bandwidth limited control systems
Udani, Janav Parag	Arrieta	Control of bi-stable structure
Van Voorhis, Matthew	Shaver	Enabling ultra-high engine system efficiency via flexible valve actuation
Vos, Kalen Russell	Shaver	Enabling ultra-high engine system efficiency via flexible valve actuation
Wagner, Danielle	Boor	Nandi clean kitchen study
Wang, Jie	Chiu	Substrate modeling and control for functional roll-to-roll printing
Wang, Xuchen	Bolton	Active noise control
Wang, Yiming	Li	Computational acoustics
Wickham, Jason	Son/Rhoads	Interface affects between explosive crystals and binder in vibratory heating
Wu, Puyuan	Chen, J.	Laser diagnostic of complex flow field
Wu, Tianren	Boor	Indoor particulate matter and filtration
Xiao, Yingying	Braun	CPS: Synergy: Plug-and-plug cyber-physical systems to enable buildings
Xiong, Jie	Tzempelikos	Living labs experimentation
Xu, Xueyang	Groll	Compressor performance analysis
Xue, Yutong	Bolton	Structural damping
Ye, Tianqi	Cappelleri	Micro aerial vehicles
Yedla, Abhilash	Meckl	Supervisory control of hybrid vehicle
You, Ruoyu	Chen	Energy efficient building hub
Zhang, Xinye	Groll	Performance analysis of HVAC systems
Zhang, Xu	Shaver	Natural gas engine control



2016 HERRICK LAB GRADUATES

Accorsi, Felipe	MSME	Experimental Characterization of scroll expander for small-scale power generation in an organic Rankine cycle
Aguilera, Giovanni	MSME	Characterization of particle emissions from desktop 3D printers: A look at the effect of part design and build pathing
Bae, YeonJin	Ph.D.	Integrated design tool of building system optimization for building life cycle cost
Balasubramanian, Shambhavi	MSME	Fuel type estimation using fuel systems parameters
Chan, Ying-Chieh	Ph.D.	Integrated Analysis of building perimeter zones with multi-functional facade systems
Chen, Wei Tai	MSME	Non-Thesis: Real-time defect detection for roll-to-roll thin film process
Cheng, Li	MSME	Non-Thesis: Assessment of alternative technologies for sustainable housing developments
Czapla, Nicholas	MSME	Performance testing of a unitary split-system heat pump utilizing an energy recovery expansion device
Deshpande, Ameya	MSME	Non-Thesis: Exhaust temperature management
Gao, Mengqi	MSME	Toner usage prediction for laser electro-photographic printers
Graban, Allison	MSME	Non-Thesis: Heat pump dryer
Graham, Todd	MSME	Non-Thesis: TIRA-Thermally integrated residential appliances
Gupta, Rohinish	MSME	Modelling and control of a parallel through-the-road plug-in hybrid vehicle
Jeon, BongGil	Ph.D.	A method for selecting HVAC retrofit solutions for existing small- and medium-sized commercial buildings
Keivan Esfahani, Darious	MSME	Non-Thesis: Gear vibration analysis
Kesto, Nathan	MSME	Non-Thesis: Dryer end-of-cycle detection
Kim, Janghyun	Ph.D.	Evaluating the performance of passive chilled beams with respect to energy efficiency and thermal center
Kim, Nicholas	Ph.D.	Optimal design of sound absorbing systems with microperforated panels
Konstantzos, Iason	Ph.D.	A Human-Centered Approach for the Design of Perimeter Office Spaced based on Visual Environment Criteria
Kulkarni, Mukta	MSME	Determining fuel type from estimates of bulk modulus using rail pressure measurements
Liu, Yangfan	Ph.D.	Efficient Modeling of Sound Source Radiation in Free-Space and Room Environments
Lu, Xueting (Sylvia)	MSME	Improving fuel economy during high load diesel engine system operations through valve train flexibility
Lumpkin, Dominique	MSME	Non-Thesis: Performance of an air-cycle heat pump
Miller, Jacob	Ph.D.	The thermomechanical response of composite energetic materials under high- and low-frequency mechanical excitations
Nayyar, Soumya	MSME	Implementation and analysis of reverse breathing, rebreathing, and cylinder deactivation for aftertreatment thermal management and overall efficiency benefit on diesel engines
Panuganti, Chaitanya	MSME	Control-oriented modeling validation, and analysis of a natural gas engine architecture
Taylor, Alex	MSME	Modelling and Control of a Parallel Through-the-Road Plug-In Hybrid Vehicle
Thomas, Josiah	MSME	Non-Thesis: High speed 1 bit feedback control
Venkatachalam, Sanjeev	MSME	Non-Thesis: Modeling of desiccant wheel-based cooling system
Vora, Ashish	Ph.D.	Modeling the impact of battery degradation within lifecycle cost based design optimization of heavy-duty hybrid electric vehicles
Woods, Daniel	Ph.D.	On the use of mechanical and acoustical excitations for selective heat generation in polymer-bonded energetic materials
Yeum, Chul Min	Ph.D.	Computer vision-based structural assessment exploiting large volumes of images

MAJOR RESEARCH FACILITIES

The Thermal Systems Laboratories



These areas are where the HVAC and Refrigeration component level and system level technology research is conducted as well as research on Air Quality. In the original building there are two psychrometric rooms (1 pair) and in the new building there are four psychrometric rooms (2 pairs) with a temperature range of -10° to 130° F. Each psychrometric room is 7000 cu ft. The psychrometric rooms are designed to accommodate ASHRAE/ARI standard test procedures used in rating unitary air-conditioners and heat pumps up to a capacity of 5 tons of refrigeration (18 kW). There are two indoor air quality (IAQ) laboratories that can simulate indoor and outdoor conditions. Instrumentation includes ultrasonic anemometers, omni-directional anemometers, tracer-gas sampler and analyzer, and particle generators and analyzers. Other facilities include a psychrometric wind tunnel with dust injection system; a large HVAC equipment lab with 90 ton centrifugal chiller, various computer controlled compressor load stands for small compressors.

The Living Laboratory

The whole of the new building is a living laboratory where the building environment is being studied. It includes a 16 bore geothermal field and plug-and-play heat rejection for experiments in the engines and thermal sciences laboratories, and four nearly identical office spaces with each unit housing 20 graduate students. Each 34ft by 37ft office is reconfigurable in different ways and have separate support systems. This enables direct comparisons of alternative technologies for windows, lighting, comfort delivery, controls, and acoustic treatments. The normal temperature range is 65F to 75F but this can be extended to 55F to 85F. Relative humidity can be varied from 20% to 80%. Comfort delivery options include air supply from the ceiling, floor, or side wall along with radiant floor heating and radiant chilled beam cooling. Three of the units have double skin facades with different options for ventilation and energy recovery. All of the offices spaces have separate equipment for providing space conditioning that is well instrumented to allow direct energy comparisons.



Engines Research Laboratory



The two engine test stands in the original building and the four test cells in the new building are home to engine and hybrid systems controls research that is focused on improving efficiency, reducing engine emissions and developing efficient and environmentally friendly systems for using alternative fuels. Currently the four new test cells and associated systems will support 670, 350, 150 and 150 HP engine testing, respectively, but space and utilities are planned so that upgrading to higher horsepower and higher levels of emissions testing are possible as research progresses. Other instrumentation includes a hydraulic variable valve actuation system capable of controlling 12 valves, a single cylinder rig for testing piezoelectric valve actuation, an AC dynamometer and several eddy-current engine dynamometers, as well as emissions sensing systems.

MAJOR RESEARCH FACILITIES

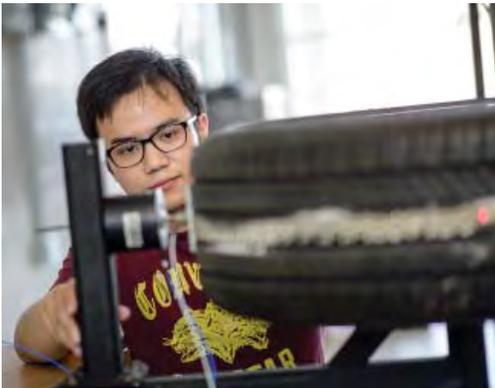
High-Bay Flexible Laboratory & Small -Scale Vibrations Laboratory

These house Electro-Mechanical and Vibrations research. This is comprised of two parts: an open 36 ft by 87 ft high-bay area with segmented floors for vibration isolation between experiments, and a smaller laboratory for smaller scale experiments. The high-bay area has high ceilings to accommodate large systems for testing. It can house large shakers, such as a 35 kN TIRA electrodynamic shaker that can be used to reproduce vibration profiles and has in-built hydraulic power supplies for hydraulic shakers. In this area the vibration and dynamics of larger structures can be examined such as building components, vehicle suspension systems, wind turbine blades, road vehicle and aircraft and space structures. The small-scale laboratory includes apparatus for dynamic testing of materials and small structures to investigate nonlinear dynamic behavior and to identify structural and material parameters.



Acoustics, Noise and Vibration Research Area

In addition to the facilities in the High-Bay Flexible Laboratory and Perception-based Engineering areas in the new building, these facilities, currently housed in the original building, include a 25 by 20 by 18 ft reverberation room, an anechoic room with useful volume of 12 by 12 by 12 ft, a hemi anechoic room with useful volume of 41 by 27 by 18 ft and an 8 by 8 ft audiometric room for sound quality testing. There is also an acoustical materials laboratory with several types of impedance tubes for standardized acoustic material testing. The reverberation room is configured for sound transmission testing of acoustical systems. Additional facilities include a tire pavement test apparatus (TPTA) for testing tires on realistic pavements at speeds up to 50 km/hr, a two wheel chassis dynamometer with 67 inch rollers, an anechoic wind tunnel with 18 by 24 inch test section and flow velocity up to 120 mph, Instrumentation includes a 64 microphone acoustical holography array and 90 channel data acquisition system, various microphones, accelerometers, shakers, a laser vibrometer, and a high speed camera.



Perception-Based Engineering Laboratory

Perception Based Engineering (PBE) researchers study people's perceptions of stimuli, their influence on satisfaction, comfort, annoyance and performance and the relationship between those outcomes and the system, design and operational parameters. PBE faculty at Purdue work on projects related to touch interfaces, sound and vibration quality, image quality and depth perception, display design and graphics optimization, effects of noise on performance, and human-computer interaction. This 43ft by 28ft laboratory houses a TEAM 6 degree-of-freedom shaker, which can be covered when not in use. Lighting, temperature (55F-85F), humidity (20% to 80%) and sound can be finely controlled, and the room can be re-configured as several small isolated rooms or one larger room, thus simulated various types of environments.



TECHNOLOGY TRANSFER ACTIVITIES

2018

July 9-12

24th International Compressor Engineering Conference, West Lafayette, Indiana, USA
 17th International Refrigeration and Air Conditioning Conference, West Lafayette, Indiana, USA
 5th International High Performance Buildings Conference, West Lafayette, Indiana, USA
 General and Conference Chairs: Professors E. Groll, J. E. Braun, W. T. Horton and T. Tzempelikos

July 8

Short Course: Compressor 103 - Generalized Simulation Framework for Positive Displacement Compressors and Expanders, West Lafayette, Indiana, USA
 Short Course: The Transition to Flammable Refrigerants, West Lafayette, Indiana, USA
 Workshop: 2018 Intelligent Building Operations (IBO), West Lafayette, Indiana, USA

For more information on these 2018 conferences and short courses, see:
<https://engineering.purdue.edu/Herrick/conferences/about>

2017

April 13-14

Short Course: Smart and Programable Structures, Colombian School of Engineering, Bogota, Colombia, Professor A. Arrieta

May 16-19

Short Course: Acoustics and Noise Control, GIAN IIT Kharagpur, India, Professor J.S. Bolton

July 18-20

Short Course: Digital Signal Processing, Cummins, Columbus, Indiana, Professor P. Davies

2016

July 11-14

23rd International Compressor Engineering Conference, West Lafayette, Indiana, USA
 16th International Refrigeration and Air Conditioning Conference, West Lafayette, Indiana, USA
 4th International High Performance Buildings Conference, West Lafayette, Indiana, USA
 General and Conference Chairs: Professors E. Groll, J. E. Braun, W. T. Horton and T. Tzempelikos

July 10

Short Course: Oil Management in Compressors and Their Systems, West Lafayette, Indiana, USA
 Short Course: Final Frontiers in Vapor Compression Cycle Efficiency, West Lafayette, Indiana, USA
 Workshop: 2016 Intelligent Building Operations (IBO), West Lafayette, Indiana, USA

2015

August 2-5

General Chair, 2015 ASME International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, Boston, Massachusetts, Professor J. Rhoads

March 16-20

Short Course: HVAC&R System Modeling and Simulation using Engineering Equation Solver, Kulthorn-Kirby, Bangkok, Thailand, Professor W. T. Horton

