RAY W. HERRICK LABORATORIES
ANNUAL REPORT
SUPPLEMENTAL INFORMATION
JULY 1, 2020 - JUNE 30, 2021

2021

HOME OF THE CENTER FOR HIGH PERFORMANCE BUILDINGS


HERRICK LABORATORIES

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RAY W. HERRICK LABORATORIES **AT A GLANCE**

The Ray W. Herrick Laboratories turned 60 years old in 2018. Today, we are part of the School of Mechanical Engineering, but the 28+ 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 faculty in the College of Science, College of Health and Human Sciences, and the Purdue Polytechnic Institute. There are five 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
5. Manufacturing and Materials

The educational experience at Herrick combines the traditional training of aspiring researchers with exposure to industrial and government needs and the culture. Students study in a strong peer education environment with active mentoring from faculty and sponsors. Nearly 900 Masters and Ph.D. candidates have graduated from the Ray W. Herrick Laboratories.

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

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

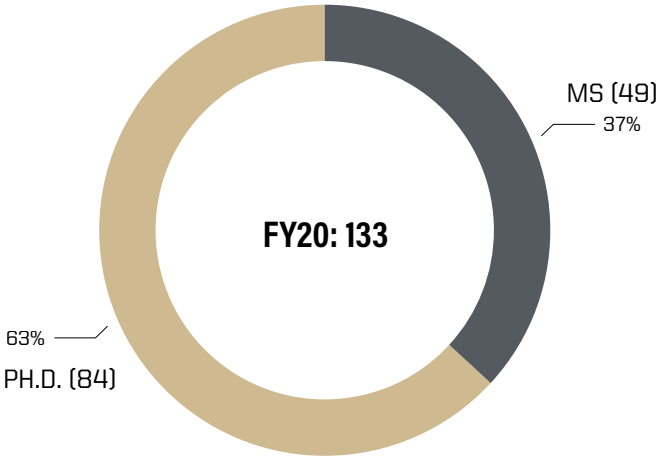
VISION
To overcoming barriers between knowledge creation, transfer, and utilization for the advancement of society.

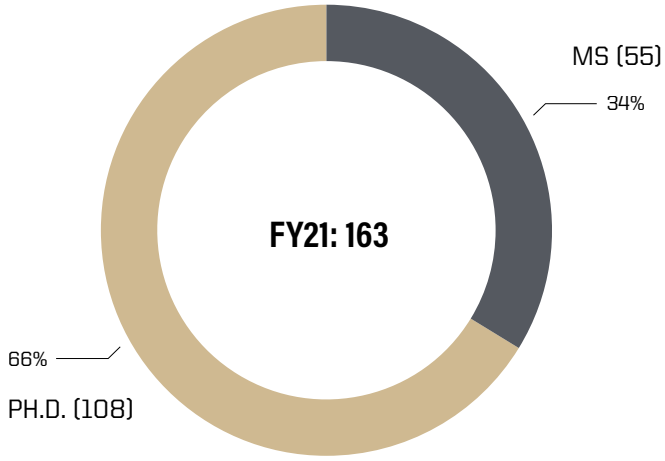
GOALS FROM OUR LAST STRATEGIC PLAN
1. Grow educational outreach activities, including fundamental, applied, and experimental short courses;
2. Build on research excellence in the following research areas: Noise and vibration control, integrated thermal and power systems, and the built environment;
3. Provide the education 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 new facilities;
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; and
8. Develop a testing program to support staff and infrastructure.

HERRICK PROGRAMS & DEMOGRAPHICS

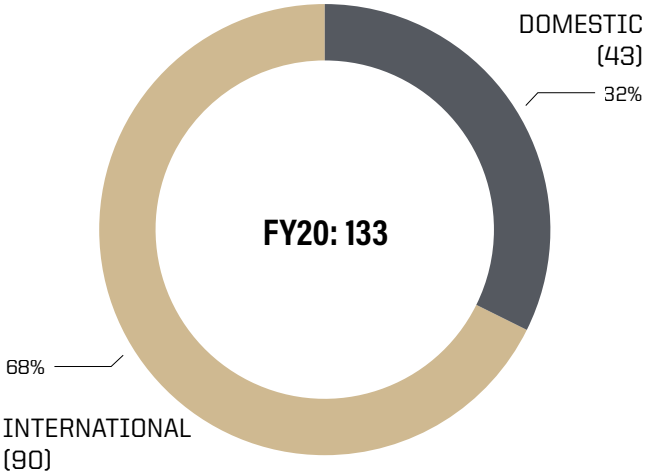
The primary educational mission at Herrick is thesis-based graduate programs and studies. We believe that the experiential learning, the open-ended, and integrative nature of thesis-based research is an outstanding preparation for both academic and industrial careers. To complement the student/advisor relationship, Herrick offers 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. There are also opportunities for students to do internships in industry or government laboratories. In total, Herrick provides an outstanding educational opportunity for our graduate students.

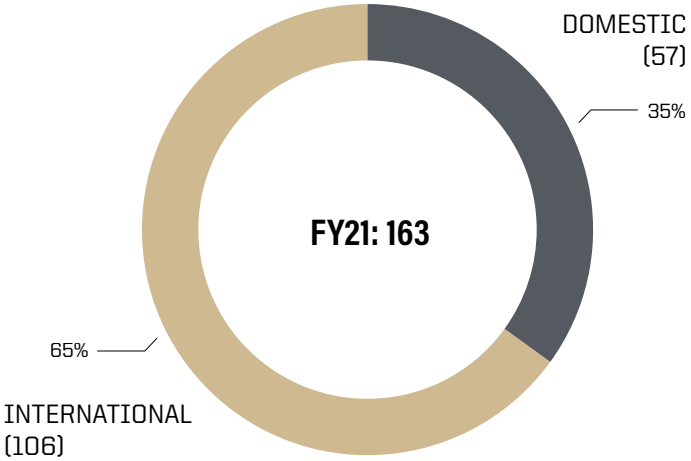
MASTERS & PH.D. STUDENTS





DOMESTIC & INTERNATIONAL



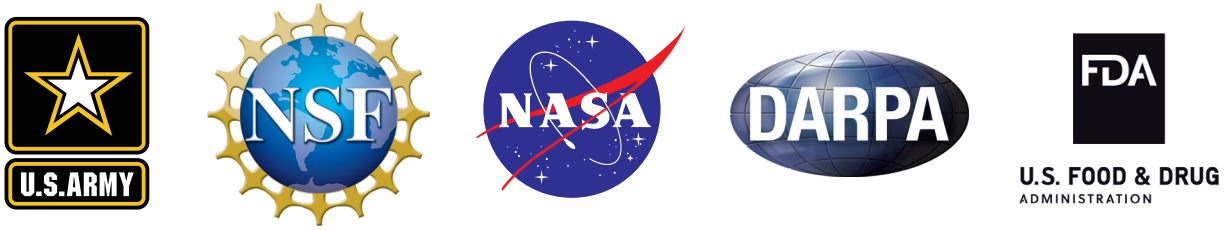


HERRICK SPONSORS

TOP 5 FEDERAL SPONSORS

2020

2021



TOP 5 INDUSTRIAL SPONSORS

2020

2021

MONIQUE MCCLAIN

ASSISTANT PROFESSOR OF MECHANICAL ENGINEERING
PH.D., PURDUE UNIVERSITY

BIO: Dr. Monique McClain is an assistant professor in the ME department at Purdue University. Her research interests are in the 3D printing of dissimilar materials, energetic materials (i.e. propellants, fuels, explosives), and high temperature materials (i.e. advanced ceramic matrix composites), as well as improving quality control in additive manufacturing (i.e. defect detection, model development).

EDUCATION

- Ph.D., Purdue University, '20
- M.S., Purdue University, '18
- B.S., University of California San Diego, '16

SELECTED HONORS AND AWARDS

- NASA Space Technology Research Fellowship (Awarded 2017)
- Purdue Doctoral Fellowship (Awarded 2016)
- GEM Associate Fellow (Awarded 2016)
- NACME Scholar (Awarded 2016)
- Ellen and Roger Revelle Scholarship (Awarded 2012)

SELECTED PUBLICATIONS

- "Development and Characterization of a Photopolymeric Binder for Additively Manufactured Composite Solid Propellant Using Vibration Assisted Printing", Propellants, Explosives, and Pyrotechnics, 45(6), 2020, pp. 853-863
- "Additive Manufacturing of Ammonium Perchlorate Composite Propellant with High Solids Loadings". Proceedings of the Combustion Institute, 37(3), 2019, pp. 3135-3142
- "3D Printing of Extremely Viscous Materials Using Ultrasonic Vibrations". Additive Manufacturing, 22, 2018, pp. 98-103

LINK TO CV: Monique McClain

2021 HERRICK FACULTY

ANDRES ARRIETA

ASSISTANT PROFESSOR OF MECHANICAL ENGINEERING
PH.D., UNIVERSITY OF BRISTOL, UNITED KINGDOM, '10

RESEARCH INTERESTS:
Adaptive structures ▪ Mechanical metamaterials ▪ Robotic materials ▪ Programmable structures ▪ Multistable structures ▪ Structural nonlinearity ▪ Elastic instabilities ▪ Structural dynamics ▪ Nonlinear vibrations

ANIL K. BAJAJ

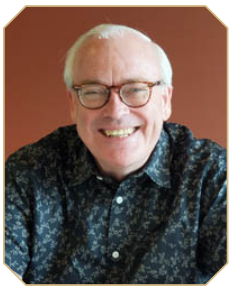
ALPHA P. JAMISON PROFESSOR OF MECHANICAL ENGINEERING
PH.D., UNIVERSITY OF MINNESOTA, '81

RESEARCH INTERESTS:
Modeling of nonlinear systems ▪ Structural dynamics and localization ▪ Flow-induced vibrations ▪ Impacting systems ▪ Bifurcations and chaos

ANTONIO BOBET

EDGAR B. AND HEDWIG M. OLSON PROFESSOR OF CIVIL ENGINEERING
PH.D., MASSACHUSETTS INSTITUTE OF TECHNOLOGY, '97

RESEARCH INTERESTS:
Engineering geology ▪ Underground construction ▪ Rock mechanics ▪ Fracture mechanics



J. STUART BOLTON

PROFESSOR OF MECHANICAL ENGINEERING
PH.D. SOUTHAMPTON, '84

RESEARCH INTERESTS:
Acoustics ▪ Active and passive noise control ▪ Sound field visualization ▪ Structural acoustics and wave propagation in structures ▪ Noise control material modeling ▪ Applied signal processing

BRANDON E BOOR

ASSISTANT PROFESSOR OF CIVIL ENGINEERING
PH.D., THE UNIVERSITY OF TEXAS AT AUSTIN, '15

RESEARCH INTERESTS:
Indoor air quality (IAQ) ▪ HVAC filtration ▪ Human exposure assessment ▪ Airborne nanoparticles ▪ Bioaerosols (fungi, bacteria, pollen, allergens) ▪ Air quality in occupational workplaces ▪ Particle adhesion & resuspension ▪ Early-life/infant exposures ▪ Combustion aerosols & wood smoke ▪ New particle formation ▪ Urban air pollution ▪ Low-cost air quality monitoring ▪ Health effects of air pollution ▪ Fate & transport of VOCs/SVOCs.

JAMES E. BRAUN

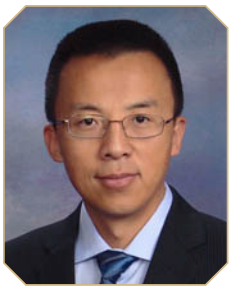
HERRICK PROFESSOR OF ENGINEERING
DIRECTOR OF THE CENTER FOR HIGH PERFORMANCE BUILDINGS
PH.D., UNIVERSITY OF WISCONSIN, '88

RESEARCH INTERESTS:
Modeling, analysis, and control of thermal systems

DAVID CAPPELLERI

ASSOCIATE PROFESSOR OF MECHANICAL ENGINEERING
PH.D., UNIVERSITY OF PENNSYLVANIA, '08

RESEARCH INTERESTS:
Multi-scale robotic manipulation and assembly ▪ Mobile micro/nano robotics ▪ Micro/nano aerial vehicles ▪ Micro-Bio robotics ▪ Mechatronics ▪ MEMS/NEMS ▪ Automation for the life sciences



JUN CHEN

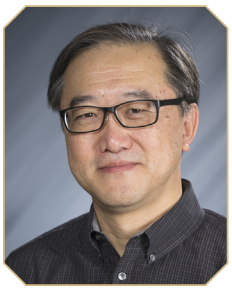
ASSOCIATE PROFESSOR OF MECHANICAL ENGINEERING
PH.D., JOHNS HOPKINS UNIVERSITY, '04

RESEARCH INTERESTS:
Experimental fluid dynamics ▪ Development of flow diagnostic techniques ▪ Flow dynamics in stratified environment ▪ Turbulent flow measurements and modeling

QINGYAN (YAN) CHEN

JAMES G. DWYER PROFESSOR OF MECHANICAL ENGINEERING
PH.D., DELFT UNIVERSITY OF TECHNOLOGY, '88

RESEARCH INTERESTS:
Indoor and outdoor airflow modeling by computational fluid dynamics (CFD) and measurements ▪ Building ventilation systems ▪ Indoor air quality (IAQ) ▪ Energy analysis



GEORGE T. C. CHIU

ASSISTANT DEAN FOR GLOBAL ENGINEERING PROGRAMS
PROFESSOR OF MECHANICAL ENGINEERING
PH.D., UNIVERSITY OF CALIFORNIA-BERKELEY, '94

RESEARCH INTERESTS:
Dynamic systems and control ▪ Mechatronics ▪ Digital and functional printing and fabrication ▪ Motion and vibration control and perception ▪ Embedded systems and real-time control

2021 HERRICK FACULTY

REBECCA CIEZ

ASSISTANT PROFESSOR OF MECHANICAL ENGINEERING
PH.D., CARNEGIE MELLON UNIVERSITY, '18

RESEARCH INTERESTS:
Energy technologies ▪ Economics ▪ Decision-making processes ▪ Decarbonized energy systems

PATRICIA DAVIES

PROFESSOR OF MECHANICAL ENGINEERING
PH.D., SOUTHAMPTON, '85

RESEARCH INTERESTS:
Sound quality ▪ Signal processing ▪ Data analysis ▪ System modeling and identification ▪ Condition monitoring of machinery ▪ Perception-based engineering ▪ Seat-occupant modeling

SHIRLEY J. DYKE

PROFESSOR OF MECHANICAL ENGINEERING AND CIVIL ENGINEERING
PH.D., UNIVERSITY OF NOTRE DAME, '96

RESEARCH INTERESTS:
Structural dynamics and control ▪ Cyber-physical systems ▪ Machine vision ▪ Real-time hybrid simulation ▪ Damage detection and structural condition monitoring ▪ Cyberinfrastructure development

JAMES GIBERT

ASSISTANT PROFESSOR OF MECHANICAL ENGINEERING
PH.D., CLEMSON UNIVERSITY, '09

RESEARCH INTERESTS:
Vibrations and nonlinear dynamics ▪ Smart material systems ▪ Non-pneumatic tires ▪ Optimization of mechanical systems ▪ Additive manufacturing

MARCIAL GONZALEZ

ASSOCIATE PROFESSOR OF MECHANICAL ENGINEERING
PH.D., CALIFORNIA INSTITUTE OF TECHNOLOGY, '11

RESEARCH INTERESTS:
Predictive, multi-scale modeling and simulation of microstructure evolution in confined granular systems, with an emphasis in manufacturing processes and the relationship between product fabrication and performance ▪ Particulate products and processes ▪ Continuous manufacturing ▪ Performance of pharmaceutical solid products

ECKHARD A. GROLL

WILLIAM E. AND FLORENCE E. PERRY HEAD OF MECHANICAL ENGINEERING
REILLY PROFESSOR OF MECHANICAL ENGINEERING
"DOKTOR-INGENIEUR" (DOCTOR OF ENGINEERING), UNIVERSITY OF HANNOVER, '94

RESEARCH INTERESTS:
Thermal sciences as applied to HVAC&R systems and equipment

W. TRAVIS HORTON

ASSOCIATE PROFESSOR OF CIVIL ENGINEERING
PH.D., PURDUE UNIVERSITY, '02

RESEARCH INTERESTS:
Advanced thermal energy conversion systems ▪ Energy utilization in buildings, and the interactions between a building and its environment ▪ Development of advanced, highly integrated, heating, ventilating, air conditioning, and refrigeration systems

MOHAMMAD REZA JAHANSHAHI

ASSOCIATE PROFESSOR OF CIVIL ENGINEERING
PH.D., UNIVERSITY OF SOUTHERN CALIFORNIA, '11

RESEARCH INTERESTS:
Autonomous sensing ▪ Data interpretation ▪ Intelligent condition assessment of structures

NEERA JAIN

ASSISTANT PROFESSOR OF MECHANICAL ENGINEERING
PH.D., UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN, '13

RESEARCH INTERESTS:
Dynamic modeling and optimal control ▪ Model predictive control ▪ Decentralized control ▪ Thermodynamics-based optimization ▪ Entropy generation minimization ▪ Exergy analysis ▪ Integrated energy management and storage in distributed energy systems ▪ Building systems

PANAGIOTA KARAVA

JACK AND KAY HOCKEMA PROFESSOR OF CIVIL ENGINEERING
PH.D., CONCORDIA UNIVERSITY, '08

RESEARCH INTERESTS:
Smart buildings, intelligent building operation, system identification, model predictive control ▪ Human-building interactions, personalized control, self-tuned environments ▪ Smart and connected energy-aware residential communities ▪ Energy efficient and mixed-mode buildings, innovative energy and comfort delivery systems ▪ Solar technology integration in building operation

2021 HERRICK FACULTY

CHARLES M. KROUSGRILL

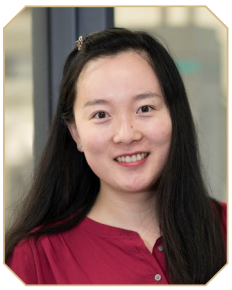
150TH ANNIVERSARY PROFESSOR OF MECHANICAL ENGINEERING
PH.D., CALIFORNIA INSTITUTE OF TECHNOLOGY, '80

RESEARCH INTERESTS:
Dynamics ▪ Nonlinear vibration of continuous systems ▪ Stability analysis

KAI MING LI

PROFESSOR OF MECHANICAL ENGINEERING
PH.D., UNIVERSITY OF CAMBRIDGE, '87

RESEARCH INTERESTS:
Computational acoustics ▪ Physical acoustics ▪ Control of environmental noise ▪ Outdoor sound propagation ▪ Prediction and abatement of transportation noise ▪ Speech intelligibility in built environments



TIAN LI

ASSISTANT PROFESSOR OF MECHANICAL ENGINEERING
PH.D. UNIVERSITY OF MARYLAND, '15

RESEARCH INTERESTS:
Naturally nanostructured materials ▪ Energy, water, and wearable technology ▪ Manufacturing

YANGFAN LIU

ASSISTANT PROFESSOR OF MECHANICAL ENGINEERING
PH.D., PURDUE UNIVERSITY, '16

RESEARCH INTERESTS:
Acoustic Source Modeling and sound field reconstruction ▪ Active noise control ▪ Room acoustics simulation and auralization ▪ Noise control treatments ▪ Human perception of noise

AMIN MAGHAREH

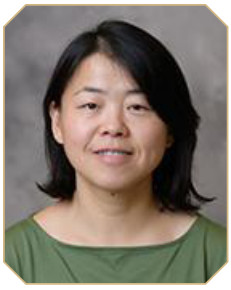
RESEARCH ASSISTANT PROFESSOR OF MECHANICAL ENGINEERING
PH.D., PURDUE UNIVERSITY, '17

RESEARCH INTERESTS:
Design ▪ High-performance buildings

PETER H. MECKL

ASSISTANT HEAD FOR FACILITIES AND OPERATIONS
PROFESSOR OF MECHANICAL ENGINEERING
PH.D., MASSACHUSETTS INSTITUTE OF TECHNOLOGY, '88

RESEARCH INTERESTS:
Motion and vibration control ▪ Adaptive control ▪ Intelligent control using fuzzy logic and neural networks ▪ Engine and emissions diagnostics ▪ Robotics



MING QU

PROFESSOR OF CIVIL ENGINEERING
PH.D., CARNEGIE MELLON UNIVERSITY, '08

RESEARCH INTERESTS:
Solar cooling and heating systems ▪ Building heat transfer ▪ Building energy supply systems ▪ Building controls and operations ▪ Building and building system modeling & simulation ▪ Sustainable building design and analysis ▪ Building system integration dedicated to sustainable and healthy built environments

JULIO A RAMIREZ

KARL H. KETTELHUT PROFESSOR OF CIVIL ENGINEERING
NHERI-NCO CENTER DIRECTOR
PH.D., UNIVERSITY OF TEXAS AT AUSTIN, '83

RESEARCH INTERESTS:
Structural analysis and design of reinforced and prestressed concrete structures, with emphasis on seismic performance of concrete buildings and infrastructure ▪ Structural models and experimental methods ▪ Design codes for structural concrete

JEFFREY RHOADS

DIRECTOR OF HERRICK LABS AND PROFESSOR OF MECHANICAL ENGINEERING
PH.D., MICHIGAN STATE UNIVERSITY, '07

RESEARCH INTERESTS:
Nonlinear dynamics and vibration ▪ Resonant micro/nanosystems ▪ Microscale sensors and actuators ▪ Solid mechanics ▪ Energetic materials ▪ Additive manufacturing

FABIO SEMPERLOTTI

ASSOCIATE PROFESSOR OF MECHANICAL ENGINEERING
PH.D., THE PENNSYLVANIA STATE UNIVERSITY, '09

RESEARCH INTERESTS:
Structural health monitoring ▪ Wave propagation ▪ Structural dynamics and vibration control ▪ Adaptive structures ▪ Periodic structures and acoustic metamaterials ▪ Energy harvesting ▪ Thermoacoustics

2021 HERRICK FACULTY

GREGORY M. SHAVER

PROFESSOR OF MECHANICAL ENGINEERING
PH.D., STANFORD UNIVERSITY, '05

RESEARCH INTERESTS:
Model-based system and control design of commercial vehicle power trains ▪ Connected and automated commercial vehicles ▪ Internal combustion engine & after-treatment system design and controls ▪ Flexible valve actuation in diesel and natural gas engines

ATHANASIOS (THANOS) TZEMPELIKOS

PROFESSOR OF CIVIL ENGINEERING
PH.D., CONCORDIA UNIVERSITY, '05

RESEARCH INTERESTS:
Design, operation and optimization of high performance buildings ▪ Daylighting, design and control of dynamic facade and shading systems ▪ Indoor environmental (thermal and visual) quality and comfort ▪ Occupant preferences and interaction with building systems ▪ Radiant building systems ▪ Solar energy applications in buildings ▪ Building energy modeling and simulation

BIN YAO

PROFESSOR OF MECHANICAL ENGINEERING
PH.D., UNIVERSITY OF CALIFORNIA-BERKELEY, '96

RESEARCH INTERESTS:
Adaptive and robust control ▪ Nonlinear control ▪ Precision control of mechanical systems ▪ Vehicle control ▪ Robotics

DAVIDE ZIVIANI

ASSISTANT PROFESSOR OF MECHANICAL ENGINEERING
ASSOCIATE DIRECTOR OF THE CENTER FOR HIGH PERFORMANCE BUILDINGS
PH.D., GHENT UNIVERSITY (BELGIUM), '17

RESEARCH INTERESTS:
Advanced heat pumping/heat engine technologies and their equipment ▪ Positive displacement compressors and expanders ▪ High performance buildings ▪ Thermal management systems

FACULTY PUBLICATIONS

Recent Herrick faculty publications can be found **on the Herrick website.**

2021 HERRICK STAFF

ASHLEY ANCIL
SAFETY OFFICER

BRIAN BARRETT
MARKETING AND COMMUNICATIONS SPECIALIST

DIANE COLLARD
RESEARCH SCIENTIST

HEMANTH DEVARAPALLI
CHPB RESEARCH SUPPORT ANALYST

BRYCE GEESEY
RESEARCH ENGINEER

AMY GREENAN
MANAGING DIRECTOR, ENERGETIC MATERIALS

MARALEE HAYWORTH
MANAGING DIRECTOR, RAY W. HERRICK LABORATORIES

ERIC HOLLOWAY
DIRECTOR, INDUSTRY RESEARCH

ROBERT R HUGHES
ENGINEERING TECHNICIAN

2021 HERRICK STAFF

KWOK (FRANK) LEE
ENGINEERING TECHNICIAN

LINDSEY MACDONALD
WRITER/EDITOR

DEAN SMOLL
ENGINEERING TECHNICIAN

RYAN THAYER
RESEARCH TECHNICIAN

SARAH WILLIAMS
ADMINISTRATIVE ASSISTANT

2020 - 2021 HERRICK LAB GRADUATES

ANKIT AGRAWAL

DEGREE: PH.D., 2020 **PROFESSOR:** MARCIAL GONZALEZ

THESIS: PARTICLE MECHANICS AND CONTINUUM APPROACHES TO MODELING PERMANENT DEFORMATIONS IN CONFINED PARTICULATE SYSTEMS

KUMAR AKASH

DEGREE: PH.D., 2020 **PROFESSOR:** NEERA JAIN

THESIS: REIMAGINING HUMAN-MACHINE INTERACTIONS THROUGH TRUST-BASED FEEDBACK

RILEY BARTA

DEGREE: PH.D., 2020 **PROFESSOR:** ECKHARD GROLL

THESIS: EXPERIMENTAL & NUMERICAL ANALYSIS OF PERFORMANCE ENHANCEMENTS TO A MULTI-STAGE TWO-EVAPORATOR TRANSCRITICAL CARBON DIOXIDE REFRIGERATION CYCLE

BRADY BLACK

DEGREE: M.S., 2020 **PROFESSOR:** GREG SHAVER

THESIS: OPTIMIZATION OF VEHICLE DYNAMICS FOR ENHANCED CLASS 8 TRUCK PLATOONING

PATRICK BOWERS

DEGREE: M.S., 2021 **PROFESSOR:** JEFF RHOADS ▪ STEVE BEAUDOIN

THESIS: FUSED DEPOSITION OF LOW TEMPERATURE MELTABLE POLYMERS

FLORIAN BROWNE

DEGREE: PH.D., 2020 **PROFESSOR:** NEERA JAIN

THESIS: ROBUST ITERATIVE LEARNING CONTROL FOR LINEAR PARAMETER-VARYING SYSTEMS WITH TIME DELAYS

LI CHENG

DEGREE: PH.D., 2020 **PROFESSORS:** TRAVIS HORTON ▪ JAMES BRAUN

THESIS: LABORATORY LOAD-BASED TESTING, PERFORMANCE MAPPING AND RATING OF RESIDENTIAL COOLING EQUIPMENT

2020 - 2021 HERRICK LAB GRADUATES

JONGSEONG CHOI

DEGREE: PH.D., 2020 **PROFESSOR:** SHIRLEY DYKE

THESIS: AUTOMATIC BIG VISUAL DATA COLLECTION AND ANALYTICS TOWARD LIFECYCLE MANAGEMENT ENGINEERING SYSTEMS

ARINDAM BHANJA CHOWDHURY

DEGREE: PH.D., 2021 **PROFESSOR:** DAVID CAPPELLERI

THESIS: DEEP LEARNING FOR ROBOTICS APPLICATIONS

JOHN FOSTER

DEGREE: M.S., 2020 **PROFESSOR:** GREG SHAVER

THESIS: ADVANCED CONTROL STRATEGIES FOR DIESEL ENGINE THERMAL MANAGEMENT AND CLASS 8 TRUCK PLATOONING

KARAN GOHIL

DEGREE: M.S., 2020 **PROFESSOR:** NEERA JAIN

THESIS: REDUCED-ORDER MODELING AND DESIGN OPTIMIZATION OF METAL-PCM COMPOSITE HEAT EXCHANGERS

JOHN HOLLKAMP

DEGREE: PH.D., 2021 **PROFESSOR:** FABIO SEMPERLOTTI

THESIS: APPLYING FRACTIONAL-ORDER OPERATORS TO DUCTS WITH ACOUSTIC BLACK HOLE TERMINATIONS

AMIN JOODAKY

DEGREE: PH.D., 2020 **PROFESSOR:** JAMES GIBERT

THESIS: MECHANICS AND DESIGN OF POLYMERIC METAMATERIAL STRUCTURES FOR SHOCK ABSORPTION APPLICATIONS

WESAAM LEPAK

DEGREE: M.S., 2020 **PROFESSOR:** PATRICIA DAVIES

THESIS: DEVELOPMENT OF SOURCE-PATH MODELS TO SYNTHESIZE PRODUCT SOUNDS OF AN OUTDOOR HVAC UNIT

2020 - 2021 RECENT HERRICK LAB GRADUATES

XIAOQI LIU

DEGREE: PH.D., 2020 **PROFESSOR:** PANAGIOTA KARAVA

THESIS: EXPLORATION OF INTELLIGENT HVAC OPERATION STRATEGIES FOR OFFICE BUILDINGS

JONATHAN ORE

DEGREE: PH.D., 2021 **PROFESSOR:** ECKHARD GROLL

THESIS: THE DC MICROGRID HOUSE PHASE II: RESIDENTIAL CONVERSION OF AC TO DC POWER TO PROMOTE ENERGY EFFICIENCY

CONOR PYLES

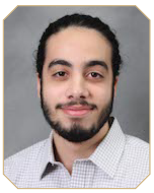
DEGREE: PH.D., 2020 **PROFESSOR:** JEFF RHOADS

THESIS: THE DYNAMICS OF COUPLED RESONANT SYSTEMS AND THEIR APPLICATIONS IN SENSING

NICK SALTS

DEGREE: PH.D., 2020 **PROFESSOR:** ECKHARD GROLL

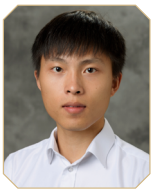
THESIS: CHILLER EXPERIMENTAL TESTING FACILITY



MUHAMMAD B. SHAHIN

DEGREE: M.S., 2021 **PROFESSOR:** MARCIAL GONZALEZ

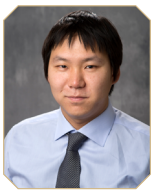
THESIS: EXPERIMENTAL CHARACTERIZATION AND MODELING OF THE VISCO-ELAS-TO-PLASTIC FINITE-STRAIN RESPONSE OF PARTICLE-BINDER COMPOSITES



GUOCHENHAO SONG

DEGREE: M.S., 2020 **PROFESSOR:** PATRICIA DAVIES

THESIS: ANNOYANCE THRESHOLDS OF TONES IN NOISE AS RELATED TO BUILDING SER-VICES EQUIPMENT



WEONCHAN SUNG

DEGREE: PH.D., 2020 **PROFESSOR:** PATRICIA DAVIES

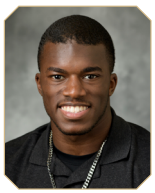
THESIS: SOUND QUALITY EVALUATION OF HVAC&R EQUIPMENT

2020 - 2021 RECENT HERRICK LAB GRADUATES

JANAV PARAG UDANI

DEGREE: PH.D., 2021 **PROFESSOR:** ANDRES ARRIETA

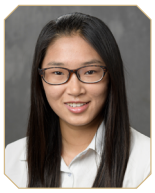
THESIS: DYNAMIC DESIGN OF BI-STABLE OSCILLATORS WITH SYNCHRONIZED SWITCHING



MARLON WALLS

DEGREE: M.S., 2020 **PROFESSOR:** JEFF RHOADS

THESIS: INVESTIGATING THE ABILITY TO PREHEAT AND IGNITE ENERGETIC MATERIALS USING ELECTRICALLY CONDUCTIVE MATERIALS



XU ZHANG

DEGREE: PH.D., 2020 **PROFESSOR:** GREG SHAVER

THESIS: MODEL-BASED CO-DESIGN OF SENSING AND CONTROL SYSTEMS FOR TURBO-CHARGED, EGR-UTILIZING SPARK-IGNITED ENGINES

CENTER FOR HIGH PERFORMANCE BUILDINGS (CHPB)

2020 CHPB MEMBERSHIPS & PROJECT FUNDING

During 2020, CHPB featured 15 company members and 10 projects were funded spanning equipment, sensing, and building envelope topics.

CHPB CENTER FOR HIGH PERFORMANCE BUILDINGS AT PURDUE

2020 CHPB MEMBERS

BELIMO, Carrier, Duke Energy, Emerson, GMCC, Goodman a member of DAIKIN group, GREE, Honeywell, LENNOX, LG, Johnson Controls, REGAL, Southern California Edison An EDISON INTERNATIONAL Company, Trane Technologies, Whirlpool Corporation

2021 PROJECT FUNDING

CHPB has funded 10 projects with 12 different faculty members as PI/Co-PI. In addition, CHPB also seed-funded 2 additional projects through the first two quarters to enable additional research and attract new companies.

2021 MEMBERS

BELIMO, Carrier, Duke Energy, Emerson, GMCC, Goodman a member of DAIKIN group, GREE, LENNOX, LG, Johnson Controls, REGAL, Southern California Edison An EDISON INTERNATIONAL Company, Trane Technologies

13 COMPANY MEMBERS

10 FUNDED PROJECTS

12 FACULTY PIs

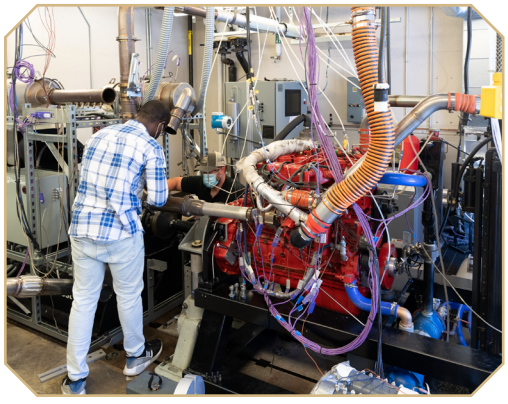
MAJOR RESEARCH FACILITIES

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. Three pairs of psychometric chambers: each 7,000 cubic feet, with 5-ton testing capacity and precise temperature and humidity control. Designed to accommodate ASHRAE/ARI test procedures. Sixteen geothermal bores: 300 feet deep, with variable flow rates and numerous temperature sensors. A 90-ton centrifugal chiller and ice storage test facility; computer-controlled compressor load stands; psychometric wind tunnel with dust injection system. 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.

THE LIVING LABORATORY & SUSTAINABLE BUILDINGS

Herrick Laboratories is a living laboratory where the built 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. Four, almost-identical 34' x 37' office spaces for human-building interaction and building technology studies; completely customizable temperature, humidity, airflow patterns, and acoustic treatments; reconfigurable indoor lighting, daylighting/shading controls, mechanical cooling and ventilation controls, and more; thermal delivery by ceiling, floor or side walls, including radiant-floor heating and radiant-chilled beam cooling; replaceable south-facing building envelopes. The normal temperature range is 65° F to 75° F but this can be extended to 55° F to 85° F. Relative humidity can be varied from 20% to 80%. 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 are well instrumented to allow direct energy comparisons.

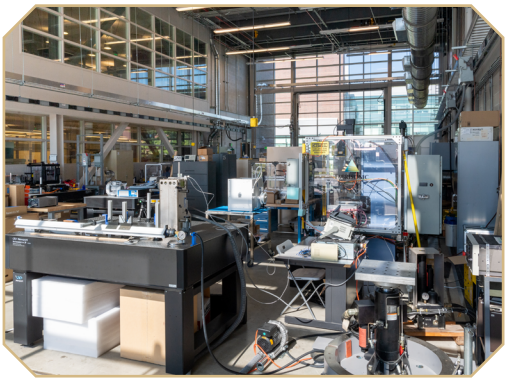


ENGINES RESEARCH LABORATORY

There are four test cells that 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. The four test cells support 670, 350, 150 and 150 HP engine testing respectively. A hydraulic variable valve actuation system capable of controlling 12 valves, a single cylinder rig for testing piezoelectric valve actuation, and 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

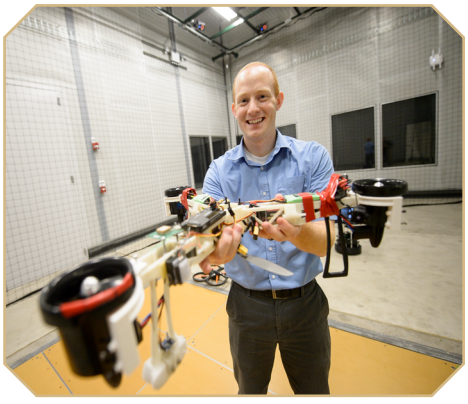


These spaces house electro-mechanical systems, additive manufacturing, and vibrations research. This is comprised of two parts: an open 36 by 87 ft. high-bay area with segmented floors for vibration isolation between experiments, and a smaller laboratory for smaller scale experiments. The high-bay area 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 700 sq. ft. small-scale laboratory includes apparatus for the 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, these facilities 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 120 mph. Instrumentation includes a 64 microphone acoustical holography array and 90 channel data acquisition system, various microphones, accelerometers, shakers, laser vibrometers, 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 43 ft. by 28 ft. laboratory houses a TEAM 6 degree-of-freedom shaker, which can be covered when not in use. Lighting, temperature (55° F - 85° F), 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 simulating various types of environments.