

## EDUCATION

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**University of Michigan, Ann Arbor, MI**

Ph.D. in Mechanical Engineering

M.S. in Robotics

Sep. 2021–Ant. Early 2027

Dec. 2024

**Purdue University, West Lafayette, IN**

B.S. in Mechanical Engineering with Honors and Distinction

Global Engineering Studies Minor

Aug. 2017–May 2021

## RESEARCH INTERESTS

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Design and control of lower-body orthoses, exoskeletons, and prostheses; gait biomechanics; biomechanical modeling; optimization; collaboration between clinicians and engineers; machine learning.

## RESEARCH EXPERIENCE

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**Neurobionics Lab, Ann Arbor, MI, PhD Candidate**

Aug. 2021–Ant. Dec. 2026

PI: Elliott J. Rouse, PhD

- **Variable Stiffness Orthosis (VSO):** Conducting a study with participants with foot drop to validate cam-based transmission designs in a quasi-passive ankle-foot orthosis.
  - Collecting and analyzing biomechanics data with optical motion capture, electromyography, and an instrumented treadmill.
  - Designing compact and durable housing for the VSO's embedded electronics (SOLIDWORKS).
  - Developed a qualitative assessment protocol, using validated measures (e.g., RPE, OPUS), to assess participant and clinician perspectives on the VSO's impact on activities of daily living.
  - Developed a genetic algorithm-based framework using MATLAB's optimization toolbox to efficiently personalize the VSO's cam modules.
  - Validated the passive mechanics of the VSO across multiple cam modules using the Neurobionics Lab's custom rotary dynamometer.
  - Adept at preparing IRB submissions and ensuring adherence to ethical and regulatory guidelines.
- **Jumping Exoskeleton:** Designed and tested a Python-based controller for increasing vertical jump height with powered ankle exoskeletons (Dephy ExoBoot).
  - Demonstrated that robotic exoskeletons can significantly enhance a transient, ballistic task ( $p < 0.05$ ,  $n = 19$ , linear mixed-effects model, MATLAB).
  - Identified that assistance can be decoupled from kinematics, with both preferred and deep squat depths yielding similar jump heights compared to the no-exoskeleton condition.

**Neural Engineering for Prosthetics and Orthotics Lab, Center for Bionic Medicine,**

**Shirley Ryan AbilityLab, Chicago, IL, Research Intern**

Sept. 2024–Jan. 2025

PI: Levi J. Hargrove, PhD

- **Powered Knee-Ankle Prosthesis:** Investigated the importance of incorporating early-stance knee flexion at heel contact during level-ground walking for individuals ( $n = 4$ ) with transfemoral amputation.
  - Designed a custom state machine controller to support walking with or without early-stance knee flexion and adapted it for participants with varying functional abilities.
  - Found that, despite biomechanical benefits shown via inertial motion capture, early-stance knee flexion did not immediately improve spatiotemporal metrics, 10MWT times, 2-minute walk distance at comfortable pace, or RPE.
  - Formulated a custom survey revealing participant preference against early-stance knee flexion.

**Human Injury Research and Regenerative Technologies (H.I.R.R.T.) Lab,***West Lafayette, IN, Undergraduate Research Assistant**Jan. 2019-Jul. 2021**PI: Eric A. Nauman, PhD*

- **Musculoskeletal Biomechanics:** Collected and analyzed kinematic/kinetic data to assist in validation of a skeletal muscle-force model (via optical motion capture, force-instrumented treadmill, OpenSim musculoskeletal modeling software).
- **Wearable Resistive Device:** Designed a study to assess runner muscle fatigue and collected data from electromyography to evaluate if training with a wearable resistive device reduced performance fatigue.

**Ottobock, Duderstadt, DEU, Research Intern***Jan. 2020-Apr. 2020**PI: Samuel Reimer, PhD*

- **Back Exoskeleton:** Conducted a pilot study to assess work-related musculoskeletal disorder risk with a passive back exoskeleton (now the IX BACK AIR, SUITX by Ottobock).
  - Showed the exoskeleton may reduce risk by lowering metabolic effort (via spiroergometry) and low-back loading (via electromyography) during manual materials handling.
  - Collected and analyzed optical motion capture and force-plate data to demonstrate the exoskeleton did not cause compensatory lifting patterns.
  - Developed a survey in German to study wearer satisfaction (Foreign language level – proficient).

**Orthopedic Biomechanics Laboratory, Iowa City, IA,***Undergraduate Research Assistant**Jun. 2018-Aug. 2018**PI: Donald D. Anderson, PhD*

- **Musculoskeletal Biomechanics:** Segmented CT scans of patients with ankle and hip joint fractures and dislocations to assist in post-traumatic osteoarthritis risk analysis.

**RESEARCH FUNDING***Assessing Design Trade-Offs in an Orthosis with Enhanced Functionality and Customizability**Mar. 2024-Mar. 2027*

National Institutes of Health NICHD – NCMRR / F31

Role: PI

The major goals of this award include the investigation of how different cam-based transmission designs for the Variable Stiffness Orthosis can combat foot drop in people with ankle weakness or disability.

Budget: \$138,588

**PUBLICATIONS*****Peer-Reviewed Journal Publications***

Van Crey, N., Lam, D.J., **Bywater, E.A.**, Shepherd, M., and Rouse, E.J. (Accepted 2025). The Variable Stiffness Orthosis: Customizable Mechanics for Assistance and Rehabilitation. *Journal of NeuroEngineering and Rehabilitation (JNER)*. In press.

**Bywater, E.A.**, Van Crey, N., Rouse, E.J. (2024). Optimizing the Mechanics of a Variable-Stiffness Orthosis with Energy Recycling to Mitigate Foot Drop. *IEEE Transactions on Medical Robotics and Bionics (T-MRB)*, 7(1), pp. 130-140.

Knodel, N.B., Calvert, L.B., **Bywater, E.A.**, Lamia, J.P., Patel, S.N., and Nauman, E.A. (2023). Investigation of the Loading at the Knee Joint Complex Using an EMG-Based Constitutive Law for Skeletal Muscle Force. *Journal of Mechanics in Medicine and Biology*, 23(7), 2350082.

Knodel, N.B., Calvert, L.B., **Bywater, E.A.**, Lamia, J.P., Patel, S.N., and Nauman, E.A. (2022). An Electromyography-Based Constitutive Law for Force Generation in Skeletal Muscle—Part II: Model Validation on the Ankle Joint Complex, *J. Biomech. Eng.*, 144(10), 101006.

Schmalz, T., Colienne, A., **Bywater, E.**, Fritzsche, L., Gaertner, C., Bellmann, M., Reimer, S., Ernst, M. (2022). A Passive Back-Support Exoskeleton for Manual Materials Handling: Reduction of Low Back Loading and Metabolic Effort during Repetitive Lifting. *IIE Transactions on Occupational Ergonomics and Human Factors*, 10(1), 7-20.

Brodersen, K.M., **Bywater, E.A.**, Lanter, A.M, Schennum, H.H, Furia, K.N, Sheth, M.K., Kiefer, N.S., Cafferty, B.K., Rao, A.K., Garcia, J.M., Warsinger, D.M. (2022). Direct-drive ocean wave-powered batch reverse osmosis, *Desalination*, 523, 115393.

### **Peer-Reviewed Conference Publications**

**Bywater, E.A.**, Medrano, R.L., Rouse, E.J. (2023). Investigations into Customizing Bilateral Ankle Exoskeletons to Increase Vertical Jumping Performance, *Proceedings of the IEEE RSJ International Conference on Intelligent Robots and Systems (IROS)*, pp. 67117-6124.

### **Other Publications**

**Bywater, E.** (2020). Quantifying Changes in Muscle Force in the Presence of Fatigue. *Journal of Purdue Undergraduate Research*, 10(23). [Abstract].

## **PRESENTATIONS**

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### **Oral Presentations**

**Bywater, E.**, Rathi, A., Van Crey, N., and Rouse, E.J. (2026, June) *User-Informed Trade-Offs Between Cam Modules for Foot Drop Mitigation*. Dynamic Walking, Seattle, WA, USA.

**Bywater, E.**, Van Crey, N., and Rouse, E.J. (2024, September) *Optimizing the Mechanics of a Variable-Stiffness Orthosis with Energy Recycling to Mitigate Foot Drop*. IEEE RAS EMBS International Conference on Biorobotics and Biomechatronics (BioRob), Heidelberg, DEU.

**Bywater, E.**, Van Crey, N., and Rouse, E.J. (2024, May) *Optimizing the Mechanics of a Variable-Stiffness Orthosis with Energy Recycling to Mitigate Foot Drop* [Oral and Poster Presentations]. Dynamic Walking, Pensacola, FL, USA.

**Bywater, E.**, Van Crey, N., and Rouse, E.J. (2024, April) *Optimizing a Variable Stiffness Orthosis with Energy Recycling*. Grand Rounds, University of Michigan Orthotics & Prosthetics, Ann Arbor, MI, USA

**Bywater, E.**, Medrano, R.L., and Rouse, E.J. (2023, October). *Investigations into Customizing Bilateral Ankle Exoskeletons to Increase Vertical Jumping Performance* [Oral and Poster Presentations]. IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Detroit, MI, USA.

**Bywater, E.**, Rawal, N., and Rouse, E. (2023, May). *Wearable Robotics at the Ankle Joint*. Neural Engineering Training Program (NETP) Symposium, University of Michigan, Ann Arbor, MI, USA.

**Bywater, E.**, Van Crey, N., and Rouse, E.J. (2023, March). *Variable Stiffness Orthosis*. DEI Alliance Disability Visibility Symposium, University of Michigan Mechanical Engineering, Ann Arbor, MI, USA.

**Bywater, E.**, Medrano, R.L., and Rouse, E.J. (2022, June). *Investigations into Increasing Vertical Jumping Abilities with Bilateral Ankle Exoskeletons* [Oral and Poster Presentations]. Dynamic Walking, Madison, WI, USA.

**Invited Talks**

**Bywater, E.**, Medrano, R.L., Best, T.K., and Rouse, E.J. (2023, April). *A powered exoskeleton vs. a collegiate high jumper. Who will win?* University of Michigan, Ann Arbor, MI, USA. ([Watch](#))

**Bywater, E.**, Medrano, R.L., Ayyappan, S., Gregg, R.D., Mungai, M.E., Mooney, L., and Rouse, E.J. (2023, April). *The Testing Lab: Exoskeletons Tech Talk and Panel*. University of Michigan, Ann Arbor, MI, USA. ([Watch](#))

**Poster Presentations**

**Bywater, E.A.**, Simon, A.M., Rouse, E.J., and Hargrove, L.J. (2025, May). *After Minimal Accommodation Time, Stance-Phase Knee Flexion at Heel Contact Improves Biomechanical but not Clinical Outcomes for Above-Knee Amputees*. RehabWeek, Chicago, IL, USA.

**Bywater, E.A.**, Simon, A.M., Rouse, E.J., and Hargrove, L.J. (2025, May). *After Minimal Accommodation Time, Stance-Phase Knee Flexion at Heel Contact Improves Biomechanical but not Clinical Outcomes for Above-Knee Amputees*. ROBOSYM, University of Michigan, Ann Arbor, MI, USA.

**Bywater, E.**, Medrano, R.L., and Rouse, E.J. (2023, June). *Investigations into Customizing Bilateral Ankle Exoskeletons to Increase Vertical Jumping Performance*. Summer School on Neurorehabilitation, Baiona, ESP.

**Bywater, E.** and Nauman, E.A. (2019, November). *Quantifying Changes in Muscle Force After a Fatiguing Run*. Purdue Undergraduate Research Expo, Purdue University, West Lafayette, IN, USA.

**INSTRUCTIONAL MENTORING EXPERIENCE**

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| ▪ Mentor for Elliot Drake, Neurobionics Lab visiting high-school student                          | Jun. 2026-Ant. Aug. 2026 |
| ○ <i>Project: Variable Stiffness Orthosis Human Subject Study</i>                                 |                          |
| ▪ Mentor for Alan Murillo-Soto, Summer Research Opportunity Program                               | Jun. 2026-Ant. Jul. 2026 |
| ○ <i>Project: Embedded electronics for the Variable Stiffness Orthosis</i>                        |                          |
| ▪ Mentor for Xiuyi (Zoe) Wu, Neurobionics Lab Master's student                                    | May 2026-Ant. Aug. 2026  |
| ○ <i>Project: Variable Stiffness Orthosis Human Subject Study</i>                                 |                          |
| ▪ Mentor for Haven Ahn, Neurobionics Lab Master's student                                         | May 2026-Ant. Aug. 2026  |
| ○ <i>Project: Variable Stiffness Orthosis Human Subject Study</i>                                 |                          |
| ▪ Mentor for Ka Hei Ng, Neurobionics undergraduate student                                        | Nov. 2025-Ant. Aug. 2026 |
| ○ <i>Project: Embedded electronics for the Variable Stiffness Orthosis</i>                        |                          |
| ▪ Mentor for Jack Brady, Neurobionics Lab Master's student                                        | Nov. 2025-May 2026       |
| ○ <i>Project: Embedded electronics for the Variable Stiffness Orthosis</i>                        |                          |
| ▪ Mentor for Isaac Tournier, Neurobionics Lab Master's student                                    | Aug. 2025-Jan. 2025      |
| ○ <i>Project: Embedded electronics for the Variable Stiffness Orthosis</i>                        |                          |
| ▪ Mentor for Chloe Stacey, Neurobionics Lab undergraduate student                                 | May 2025-Dec. 2025       |
| ○ <i>Projects: Variable Stiffness Orthosis Pilot Testing, Adaptive Rowing Blade-Grip Device</i>   |                          |
| ▪ Mentor for Joshua Lian, Neurobionics Lab Master's student                                       | Feb. 2025-Aug. 2025      |
| ○ <i>Project: Embedded electronics for the Variable Stiffness Orthosis</i>                        |                          |
| ▪ Mentor for Hemanth Aroumougam, Neurobionics Lab Master's student                                | Aug. 2023-Jan. 2025      |
| ○ <i>Projects: Motion capture data analysis pipeline, safety upgrades to a rotary dynamometer</i> |                          |
| ▪ Mentor for Emily Yuki, Neurobionics Lab undergraduate student                                   | Feb. 2022-Apr. 2022      |
| ○ <i>Project: Scalable footplate design for the Variable Stiffness Orthosis</i>                   |                          |
| ▪ Tutor, Gen. Chem. II, Purdue University Horizons Student Support Services                       | Jan. 2018-Dec. 2018      |

## LEADERSHIP AND SERVICE

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- Women and Gender Minorities in Mechanical Engineering (WaGMiME), University of Michigan
  - Undergraduate Liaison *May 2025-Apr. 2026*
    - Advising the undergraduate executive board during their chapter's inaugural year.
  - President *May 2024-Apr. 2025*
    - Expanded this primarily graduate-student group to comprise of both graduate and undergraduate chapters.
    - Led the organization through significant university policy changes and ensured all members were supported during a period of heightened campus concerns.
  - Social Chair *Jan. 2023-Apr. 2024*
- Outreach Ambassador, Robotics, University of Michigan *Aug. 2022-Ant. Dec. 2026*
- Mentor, ME Graduate Student Council, University of Michigan *Aug. 2023-Aug. 2024*
- Accessibility Ally, 10-Week Accessibility Challenge, University of Michigan *Dec. 2023*
- Reviewer, Wearable Technologies *Jun. 2026*
- IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS) *Apr. 2023, Apr. 2026*
- IEEE/RAS/EMBS Intl. Conf. Biomed. Rob. and Biomech. (BioRob) *Mar. 2024, Feb. 2026*
- IEEE Transactions on Medical Robotics and Bionics (T-MRB) *Oct. 2025, Jan. 2026*
- IEEE Transactions on Neural Systems and Rehabilitation Engineering (TNSRE) *Nov. 2025*
- Intl. Consortium for Rehabilitation Robotics (ICORR), *Jan. 2025*
- Ambassador, Mechanical Engineering, Purdue University *Aug. 2020-May 2021*
- Ambassador, Honors College, Purdue University *Aug. 2018-May 2021*
- Ambassador, Global Eng. Alliance for Research and Education (GEARE), Purdue University *Aug. 2018-May 2021*
  - Team design project with students from the Karlsruhe Institute of Technology, Karlsruhe, DEU

## PROFESSIONAL AFFILIATIONS

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- International Consortium for Rehabilitation Robotics (ICORR) *Since Feb. 2025*
- IEEE Robotics and Automation Society *Since Mar. 2024*
- IEEE Student Member *Since Mar. 2023*
- IEEE Young Professionals *Since Jan. 2023*
- Phi Beta Kappa – Academic Honor Society *Since Mar. 2021*
- Honor Society of Phi Kappa Phi *Since Mar. 2021*
- Tau Beta Pi – the Engineering Honor Society *Since Jan. 2020*
- Alpha Lambda Delta Phi Eta Sigma – Academic Honor Society *Since Apr. 2018*

## HONORS AND AWARDS

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- Team Champion, Marine Energy Collegiate Competition
  - Warsinger Water Lab, *West Lafayette, IN, Modeling Team Lead* *Oct. 2020-Apr. 2021*
    - Designed a mechanical coupling (model and prototype) between a wave energy converter and a batch reverse osmosis system.
    - Sponsors: Department of Energy and National Renewable Energy Laboratory.