EMILY A. BYWATER

CURRICULUM VITAE

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EDUCATION

University of Michigan, *Ann Arbor, MI*
Ph.D. in Mechanical Engineering — *Sep. 2021-Ant. Dec. 2026*
M.S. in Robotics — *Dec. 2024*

Purdue University, *West Lafayette, IN* — *Aug. 2017-May 2021*
B.S. in Mechanical Engineering with Honors and Distinction
Global Engineering Studies Minor

RESEARCH INTERESTS

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

RESEARCH EXPERIENCE

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. *IISE 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

Oral Presentations

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

- Mentor for Ka Hei Ng, Neurobionics undergraduate student *Nov. 2025-Ant. Aug. 2026*
  - *Project: Embedded electronics for the Variable Stiffness Orthosis*
- Mentor for Jack Brady, Neurobionics Lab Master's student *Nov. 2025-Ant. May 2026*
  - *Project: Embedded electronics for the Variable Stiffness Orthosis*
- Mentor for Isaac Tourner, Neurobionics Lab Master's student *Aug. 2025-Jan. 2025*
  - *Project: Embedded electronics for the Variable Stiffness Orthosis*
- Mentor for Chloe Stacey, Neurobionics Lab undergraduate student *May 2025-Dec. 2025*
  - *Projects: Variable Stiffness Orthosis Pilot Testing, Adaptive Rowing Blade-Grip Device*
- Mentor for Joshua Lian, Neurobionics Lab Master's student *Feb. 2025-Aug. 2025*
  - *Project: Embedded electronics for the Variable Stiffness Orthosis*
- Mentor for Hemanth Aroumougam, Neurobionics Lab Master's student *Aug. 2023-Jan. 2025*
  - *Projects: Motion capture data analysis pipeline, safety upgrades to a rotary dynamometer*
- Mentor for Emily Yuki, Neurobionics Lab undergraduate student *Feb. 2022-Apr. 2022*
  - *Project: Scalable footplate design for the Variable Stiffness Orthosis*
- Tutor, Gen. Chem. II, Purdue University Horizons Student Support Services *Jan. 2018-Dec. 2018*

LEADERSHIP AND SERVICE

- Women and Gender Minorities in Mechanical Engineering (WaGMiME), University of Michigan
  - Undergraduate Liaison *May 2025-Ant. 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, IEEE/RAS/EMBS Intl. Conf. Biomed. Rob. and Biomech. (BioRob) *Feb. 2026, Mar. 2024*
  IEEE Transactions on Medical Robotics and Bionics (T-MRB) *Jan. 2026, Oct. 2025*
  IEEE Transactions on Neural Systems and Rehabilitation Engineering (TNSRE) *Nov. 2025*
  Intl. Consortium for Rehabilitation Robotics (ICORR), *Jan. 2025*
  IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS) *Apr. 2023*
- 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

- 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

- 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.
    - **S**ponsors: Department of Energy and National Renewable Energy Laboratory.