

Horses in Motion: A History of the Biomechanics of Movement

Instructor: Laura Miller, Professor of Mathematics and Adjunct Professor of Biomedical Engineering, University of Arizona

Location: University of Arizona's AI Marah Equine Center

Schedule: Thursdays, 10 AM - 12 PM

Dates: March 20, 27, April 3, 10, 17, 24, 2025

Format: In Person Only

Course Overview

This course explores the deep connection between horses and humans throughout history, from shaping our methods of travel to influencing warfare and sports. We'll look at the science of horse movement and how selective breeding has created specialized breeds, like draft horses built for power and thoroughbreds bred for speed.

Our discussions will include recent technology that allows us to analyze horse movement more accurately than ever before. Using tools like high-speed videography and inertial measurement units, we can understand gaits, identify lameness, and improve performance. You'll see these tools in action through live demonstrations with horses at the AI Marah Equine Center, where we'll study the horses' gaits up close. We'll also discuss how what we learn from horses can lead to breakthroughs in robotics, increasing agility as well as improving interactions with humans.

If you're a horse enthusiast, curious about biomechanics, or interested in the history of human-animal partnerships, this course will provide new insights into how we learn from horses and how they continue to shape our world.

Weekly Schedule and Summaries

Week 1: The Ancient Partnership Between Horses and Humans

Summary: We begin by looking at the history of horses and humans, starting with early domestication. Horses changed human life—from transportation to warfare to recreation. We'll explore the unique bond between people and horses and how it evolved over time.

Readings:

- *Taylor, W. T. (2023). Hoof Beats: How Horses Shaped Human History, Chapters 1-2*
- **Supplementary:** *Barras, C. (2023). When Did Humans Domesticate the Horse? Smithsonian Magazine*

Week 2: The Evolution of Horse Breeds and Their Movements

Summary: This week, we'll look at how selective breeding created breeds specialized for different tasks, from draft horses to racehorses. We'll discuss the physical traits that allow these horses to excel in their roles and see how their gaits and movement patterns changed with these adaptations.

Readings:

- Harris, S. E. (2016). *Horse Gaits, Balance, and Movement: Revised Edition*, Chapters 1-3

Week 3: The Story of the Al Marah Arabian and the University of Arizona

Summary: This week we'll explore the history of the Al Marah Arabian—a breed known for endurance and agility—and the legacy of Bazy Tankersley. We'll take a tour of the Al Marah Equine Center, seeing first-hand how these horses contribute to modern research and education.

Readings:

- Spataro, L. (2012). *The Long Ride: The Record-Setting Journey by Horse Across the American Landscape*, Introduction, Chapters 1-2

Week 4: The Biomechanics of Horse Gaits

Summary: We'll focus on the mechanics of different horse gaits, including the walk, trot, canter, and gallop. We'll look at how horses' anatomy and muscle movement allow for efficient and graceful motion. We'll also consider how gaits are coupled to respiration and heart rate.

Readings:

- Harris, S. E. (2016). *Horse Gaits, Balance, and Movement: Revised Edition*, Chapters 4-6
- **Supplementary:** Bramble, D. M., & Carrier, D. R. (1983). *Running and Breathing in Mammals*, *Science*, 219(4582), 251-256.

Week 5: Modern Technologies for Understanding Horse Gaits

Summary: This week we explore the technology used to measure and analyze horse movement, from high-speed video to IMUs (inertial measurement units). These tools are helping us measure lameness, understand gaits, and improve training methods.

Readings:

- Bosch, S., Braganca, F., Marin-Perianu, M., Marin-Perianu, R., van der Zwaag, B. J., Voskamp, J., Back, W., van Weeren, P., & Havinga, P. (2018). *EquiMoves: A Wireless Networked Inertial Measurement System for Objective Examination of Horse Gait*. *Sensors*, 18(3), 850.
- **Supplementary:** *Hoof Beats* (Taylor), Chapter 7

Week 6: The Future of Equine Biomechanics, Robotics, and Horse-Human Interactions

Summary: Our final week will cover how insights from horse movement are informing the design of robots that are balanced, agile, and efficient. We'll also look into research on horse-human interactions to understand how these relationships can inform human-robot interactions, especially in developing trust and clear communication.

Readings:

- Taylor, W. T. (2023). *Hoof Beats*, Chapter 10
 - Jain, E., & Gardner-McCune, C. (2023). *Horse as Teacher: How Human-Horse Interaction Informs Human-Robot Interaction*. *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*. ACM.
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Required Reading List

- Taylor, W. T. (2023). *Hoof Beats: How Horses Shaped Human History*. University of California Press
- Harris, S. E. (2016). *Horse Gaits, Balance, and Movement: Revised Edition*. Turner Publishing Company
- Spataro, L. (2012). *The Long Ride: The Record-Setting Journey by Horse Across the American Landscape*. Skyhorse Publishing
- Open Access Articles
 - Barras, C. (2023, March 31). *When Did Humans Domesticate the Horse?* *Smithsonian Magazine*
 - Bramble, D. M., & Carrier, D. R. (1983). *Running and Breathing in Mammals*. *Science*, 219(4582), 251-256
 - Bosch, S., Braganca, F., Marin-Perianu, M., Marin-Perianu, R., van der Zwaag, B. J., Voskamp, J., Back, W., van Weeren, P., & Havinga, P. (2018). *EquiMoves: A Wireless Networked Inertial Measurement System for Objective Examination of Horse Gait*. *Sensors*, 18(3), 850
 - Jain, E., & Gardner-McCune, C. (2023). *Horse as Teacher: How Human-Horse Interaction Informs Human-Robot Interaction*. *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*.