Thesis Project Portfolio

Head to Ground Test Device

(Technical Report)

A Virtue Ethics Approach to Exoskeleton Research and Development

(STS Research Paper)

An Undergraduate Thesis

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Max Wooten

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Sociotechnical Synthesis

In the modern era of sport and biomedical innovation, the convergence of engineering and ethics is critical in improving athlete safety. My thesis portfolio investigates the complex challenge of head-to-ground (H2G) concussions in American football—an issue that has often been overlooked in both helmet design and broader safety standards. My work spans two domains: the technical challenge of designing a repeatable H2G test device for helmet evaluation, and the ethical critique of how exoskeletons—another form of human protection—are shaped by differing institutional priorities. Together, these projects explore how technologies intended to protect and model the body must also be situated within value-driven contexts.

My technical capstone project, *Football Helmet: Head to Ground Test Device*, addresses a limitation in current helmet testing protocols. While head-to-head collisions have received ample attention, nearly 20% of concussions in the NFL stem from H2G impacts, particularly the rotational "whipping" motion that occurs during contact with the turf. To address this, our team designed a scalable, adjustable device that replicates the linear and angular velocities found in real-world impacts. By combining gravity and spring-based forces, and validating the device through field testing and SolidWorks simulations, we developed a prototype that can consistently recreate realistic impact conditions. The final model offers a low-cost, accessible tool for helmet manufacturers to study rotational trauma—a significant step toward improving protective headgear.

My STS research project, *Virtue Ethics and the Development of Exoskeleton Technologies*, explores how the design and deployment of protective systems are influenced by

institutional intent. I compared medical and military exoskeletons, showing that technologies can embody vastly different moral commitments depending on their context. Whereas medical devices aim to promote patient flourishing, military models often reflect objectives tied to efficiency and combat readiness. By applying virtue ethics, I argue that protective technologies should not just perform technically, but support the well-being of their users—an insight directly applicable to helmet design.

Through these paired investigations, I came to understand how technical precision must be accompanied by ethical clarity. Whether developing a test device or critiquing the goals of wearable technology, the common thread is this: protective design is not neutral. It carries the weight of assumptions about whose safety matters, what performance means, and what values are prioritized. This sociotechnical lens has deepened my view of engineering not just as problem solving, but as responsibility taking.