Announcing the Final Examination of Jared M. Long-Fox for the degree of Doctor of Philosophy in Physics

Date: March 10, 2026

Time: 10:00 A.M.

Room: PSB 160/161 (https://teams.microsoft.com/meet/28343890931225?p=7ZMPolq3l2ZVtx1QnL)

Dissertation title: Computational Regolith Mechanics and Instrumentation Development for Lunar Exploration and Resource Utilization

Abstract:

Sustained exploration of the Moon requires quantitative understanding of lunar regolith properties to support scientific investigation, in situ resource utilization, excavation, and infrastructure development. This dissertation examines the mechanical interaction between robotic excavation systems and lunar regolith, emphasizing how regolith behavior both enables and constrains exploration-focused and exploration-enabled science. Computational excavation models were compared to laboratory data to evaluate prediction of excavation forces and to develop metrics of excavation efficiency. Laboratory experiments using high-fidelity lunar regolith simulants were conducted to characterize pressure-sinkage behavior, shear strength, and angle of repose across a range of material states. Common analytical excavation and terramechanics models were assessed and shown to be inadequate for uniquely or reliably predicting regolith mechanical properties from excavation data, highlighting limitations of terrestrial soil models when applied to granular, angular, low-gravity materials. New quantitative efficiency metrics reveal predictable relationships between actuation parameters, excavation depth, and force reduction, as well as diminishing returns at higher percussive frequencies. Robotic arm-based experiments demonstrate that pressure-sinkage and angle of repose measurements can be used to infer relative regolith density and near-surface mechanical behavior, while shear strength measurements require specialized tool geometries and boundary conditions to produce interpretable results. Collectively, the findings demonstrate that excavation and surface operations are not only engineering activities but also powerful scientific tools that provide insight into subsurface structure, stratigraphy, and regolith formation processes. This work supports an integrated approach to lunar surface exploration in which excavation and surface operations are leveraged as primary tools for exploration-focused and exploration-enabled science, enabling sustained robotic and human exploration of the Moon and other planetary bodies.

Outline of Studies:

Major: Physics, Planetary Sciences Track

Educational Career:

B.S. Geology (Mathematics and Geospatial Technology Minors), South Dakota School of Mines and Technology
M.S. Geology and Geological Engineering, South Dakota School of Mines and Technology

Committee in Charge:
Dr. Daniel Britt (Chair)
Dr. Joshua Colwell
Dr. Kerri Donaldson Hanna
Dr. Robert Anderson (External Committee Member, NASA/Caltech JPL)

Approved for distribution by Dr. Daniel Britt, Committee Chair, on February 23, 2026.

The public is welcome to attend.