John McGuigan

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Education

- **University of Tennessee, Knoxville** — Knoxville, TN
  B.S. Mathematics & Physics — GPA (Math & Physics only): ***3.57/4.00*** — *Aug 2023 – Present*

Skills Summary

- **Programming/ML**: Python; PyTorch; JAX; scikit-learn; XGBoost; LightGBM; Random Forests; MLPs; multi-task learning; LaTeX; Java; Julia
- **Scientific**: Mathematica; MATLAB
- **Systems**: Linux servers; HPC GPU training workflows

Research Experience

- **Machine Learning Astrophysics** — Knoxville, TN
  Undergraduate Researcher, Neutrino Fast Flavor Instabilities (FFI) — *Mar 2025 – Present*
  - **Neural modeling**: Develop ML pipelines for detecting and characterizing fast flavor instabilities in dense neutrino environments; primary models: MLPs and Random Forests.
  - **Training**: Build training and evaluation in PyTorch and JAX; use scikit-learn; test XGBoost/LightGBM for baselines and feature studies.
  - **Compute**: Train on Linux HPC GPU nodes; manage data ingestion, batching, and profiling for large simulation-derived datasets.
  - **Current direction**: Design multi-task networks for joint inference across core-collapse supernova (CCSN) and neutron-star-merger (NSM) simulations.

Teaching & Tutoring

- **The Math Place, University of Tennessee** — Knoxville, TN
  Math Tutor — *Aug 2025 – Present*
  - **Student-centered support**: Provide drop-in tutoring for Calculus I–III, Linear Algebra, and Differential Equations with an emphasis on intuition before algebra.
  - **Plain-language explanations**: Translate notation into everyday language; normalize mistakes to dial down math anxiety and keep sessions low-stress.

Presentations & Awards

- **APS Division of Nuclear Physics (DNP) — CEU** — Chicago, IL
  Undergraduate Poster Presenter — *Oct 2025*
  - **Machine Learning Flags Fast-Neutrino Flavor Instabilities**: Presented Summer MLP results along with cpu/gpu model inference time latency
- **Summer Research Scholars Symposium** — Knoxville, TN
  Undergraduate Presenter — *Jul 2025*
  - **Machine Learning for Neutrino Fast Flavor Instabilities**: Discussed MLP baseline results in PyTorch; trained on HPC GPUs; highlighted dispersion-relation-informed features from an analytic LSA effort; discussed preliminary generalization across CCSN/NSM-derived datasets.
- **Allen Medal Mathematics Competition** — Knoxville, TN
  Winner — *Mar 2024*
  - **Recognition**: Received a scholarship award.

Independent Projects

- **Analytic Neutrino Linear Stability Analysis (LSA)**: Derived analytic/semi-analytic LSA for flavor-mixing instabilities; used orthogonal polynomials to obtain inhomogeneous recursion relations; derived continuants via discrete Green's functions.

Independent Study

- **Physics**: Classical Mechanics; Quantum Kinetics (Neutrinos); General Relativity
- **Mathematics**: Applied differential geometry; exterior calculus; discrete exterior calculus; complex analysis; analytic combinatorics (incl. Mellin transforms & orthogonal polynomials).
- **Machine Learning**: CNNs, DNNs, optimization methods (gradient descent variants); theory-to-practice for scientific ML.
- **Problem Solving**: Putnam training (MATH 309 Putnam Preparation Seminar): intensive problem solving in number theory, inequalities, combinatorics, asymptotics, and proof-writing under time constraints.

Selected Coursework

- **Mathematics**: Honors Calculus III; Differential Equations I & II; Intro to Analysis; Combinatorics.
- **Physics**: Waves, Optics & Relativity; Quantum Physics and Applications; Thermal Physics; Electronics Laboratory.