Muhammad Hashir Hassan Khan

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Summary

I am a physics and mathematics undergraduate applying for a **PhD in Applied Math and Physics**. I have research interests in chaotic dynamical systems, using tools from ergodic theory and numerical analysis. I do recreational math on the side.

Education

Lahore University of Management Sciences (LUMS) **Aug. 2020 – June 2024**
Bachelor of Science in Physics with a minor in Mathematics *Lahore, Pakistan*

cGPA: 3.95/4.0, **TOEFL IBT – 115/120**, **Physics GRE – 950/990 (90th percentile)**

Graduate Level Courses (Grade Recieved): Advanced Quantum Mechanics (A), Relativistic Electrodynamics (A+), General Relativity (A), Computational Physics (A+), Introduction to Quantum Field Theory (A), Differential Geometry [International Mathematics Master Variant] (B+), Qualitative Differential Equation [International Mathematics Master Variant] (A+)

Selected Projects & Presentations

Senior Thesis on Chaos in General Relativity **Fall 2023 – Spring 2024**
Report and **Presentation** (Supervisor: Dr. Syed Moeez Hassan)

- Worked through the exercises and proofs in Chapters 1–9 of Strogatz's *Nonlinear Dynamics and Chaos* and the last section of Hobill et. al.'s *Deterministic Chaos in General Relativity*
- Explored the merits and demerits of ways to quantify chaos in GR including discrete approximations, Painlevé analysis, fractals and Lyapunov exponents, employing techniques from ergodic theory, PDE theory and numerical analysis

Directed Research Project on Thermodynamic Formalism **Present**
Write-up in progress (Supervisor: Dr. Waqas Ali Azhar and Dr. Charlene Kalle)

- Reading "*Equilibrium States and the Ergodic Theory of Anosov Diffeomorphisms*" by Rufus Bowen
- Aim to explore Minkowski ?-type functions between dynamical systems using the thermodynamic formalism

Course Project on the Logistic Map **Fall 2023**
Report (MATH 4102 – Qualitative Differential Equation)

- Proved a topological conjugacy between the logistic map and the tent map and found fixed and periodic point measures as well as another ergodic and invariant measure and calculated the mean sojourn times for all of them

Course Project on the Causal Structure of Spacetime **Spring 2023**
Report and **Presentation** (PHY 442 – General Relativity)

- Worked through the proofs in Penrose's *Techniques of Differential Topology in Relativity*, Geroch's *Domain of Dependence*, Chapter 6 of Hawking and Ellis's *The Large Scale Structure of Spacetime* and Chapter 8 of Wald's *General Relativity*
- Constructed a hierarchical structure of increasingly causal spacetimes

Experimental Project on Chaos in Simple Electrical Circuits **Fall 2022**
Report

- Created **Proteus** simulations and phase portrait analyses of RLC and Chua's circuits, quantifying the period-doubling bifurcation route to chaos

Course Project on the Anomalous Magnetic Moments of Leptons **Spring 2023**
Report and **Presentation** (PHY 539 – Introduction to Quantum Field Theory)

- Derived the magnetic moments of the leptons via minimal coupling in the Dirac equation and a one-loop QED correction, filling in the missing steps from Chapter 6 of Peskin and Schroeder's *An Introduction to Quantum Field Theory*

Course Project on Constructible Numbers **Spring 2024**
Report (MATH 320 – Algebra I)

- Introduced the field of constructible numbers in Euclidean geometry

Course Project on Gait Cycle and Posture **Spring 2023**
Presentation and Jupyter Notebook (PHY 317 – Introduction to Human Biomechanics)

- Used **Kinovea** to find, and test at the 95% confidence level, differences in spinal, trunk and head angles, shoulder elevation and stride length and time among a representative sample of individuals with different backpack-wearing styles

Lecture Notes for Relativistic Electrodynamics **Fall 2023**

- Developed **lecture notes** as a TA for the (graduate cross-listed) course on Relativistic Electrodynamics at a level between Zangwill's *Modern Electrodynamics* and Jackson's *Classical Electrodynamics* while working in $c = 1$ units

Honors & Awards

2025 McCall-MacBain Scholarship Semi-Finalist **August 2024**

- Selected among **80** international students for the regional interviews (ongoing) for McGill's McCall-MacBain Scholarship

2024 Rhodes Scholarship Finalist **October 2023**

- Selected among **10** students for the final interview for the Oxford Rhodes Scholarship 2024 (Pakistan)

NMF Gold Medal **June 2024**

- Awarded for securing **first position** in the BS Physics batch of 2024 at LUMS

Dean's Honor List Scholarship **Fall 2021 – Spring 2024**

- Awarded in **2021** for securing **first position** at the School of Science and Engineering and **first overall** in LUMS
- Awarded in **2022** for securing **second position** at the School of Science and Engineering
- Awarded in **2023** for securing **first position** at the School of Science and Engineering and **second overall** in LUMS

Abdul Razak Dawood Scholar **2020–21**

- Awarded for being academically the **best first year undergraduate student** across all schools at LUMS

Top 10 High School Mathematicians in Pakistan **August 2019 – March 2020**

- Selected as reserve for Team Pakistan at **International Mathematics Olympiad** 2020 (**7th** in IMO training camps)
- Selected among **10** students for Team Pakistan at **Asia Pacific Mathematics Olympiad** 2020
- Selected for Team Pakistan on a **Bronze Medal** at the **Iranian Geometry Olympiad** 2019
- Won a **Silver Honour** (**Top 7%** in the world) at **International Youth Math Challenge** 2019
- Placed **1st** out of 3000 students in the **National Mathematics Talent Contest** 2019

Outstanding Cambridge Learner Award **June 2018**

- Awarded for scoring the **highest marks in Punjab** in O Level Physics

Teaching Experience

Teaching Assistant at SSE **Fall 2022 – Fall 2024**

- Served as TA for **PHY 212: Quantum Mechanics I**, **PHY 104: Modern Physics**, **PHY 404/504: Relativistic Electrodynamics** and **MATH 344: Numerical Analysis** and Head TA for **MATH 101: Calculus I**
- Designed and graded assignments and quizzes and held weekly office hours and tutorials

Instructor at LUMS National Outreach Programme Summer Coaching Session **Summers 2022 – 2024**

- Taught **Physics** (in 2022 and 2024) and **Advanced Mathematics** (in 2023) to over **1100** students (in total) for **2** weeks each summer, curating the curriculum for use by other instructors

Math Circles Instructor at Gilgit-Baltistan Summer Fiesta **July 2023**

- Designed innovative game-centric math sessions (on **Fibonacci Nim** and **Constructible Numbers**) for **10 days** for over **200** students in remote area of Kharmang, Baltistan (see **news report**)

Tutor at Math Skills Centre **Spring 2024 – Summer 2024**

- Designed promotional material and implemented effective strategies to establish this pilot project (jointly started by Student Success and the School of Science and Engineering) to offer peer-centric math-related help at LUMS

Leadership & Extracurricular Activities

LUMS Students' Mathematics Society **September 2020 – June 2024**

- Led a society of **96** members as **President (2022–23)** and member of the **Advisory Council (2023–24)**
- Introduced the **LUMS Integration Bee** in 2021 and weekly **Math Clinics** (to help students with mathematical queries) and monthly **Fermat's Enigma** sessions (to develop an interest in collective problem-solving) in 2022
- Serving as **Director Events**, organized the society's annual flagship event, **SIGMA**, and held frequent **Salam Sessions** (in memory of Dr. Abdus Salam) with experts to discuss the applications of mathematics in their fields
- Created art on **Desmos** (**click here to view**), resulting in over **107,000** views across society's social media pages

Peer Ambassador at LUMS for Social Support (PALss) **Fall 2022 – Spring 2023**

- Supported a group of **14** students through their first year at the School of Science and Engineering as their mentor

Skills & Interests

Skills: C++, Python, MATLAB, LaTeX, Canva; **Interests:** Desmos, Recreational Math, Fantasy Premier League, Chess