جامعة خليفة
Khalifa University

DEPARTMENT OF MATHEMATICS

5-YEAR STRATEGIC RESEARCH PLAN

2025-2030

Date:
16 December 2025

Department Chair:
Prof. Mohamed Khamsi

Vision and Strategic Context

The Department of Mathematics at Khalifa University is a core enabler of the UAE's shift to a knowledge-based, innovation-driven economy. Through excellence in fundamental and applied mathematics, the Department provides the analytical, computational, and modeling foundations that support national progress in energy, health, sustainability, advanced manufacturing, and digital technologies.

Vision

Establish the Department of Mathematics as a regional leader in theoretical and applied research, driving innovation across Khalifa University's institutes and advancing the UAE's strategic priorities in science, technology, and sustainable development.

Strategic Context

Mathematics forms the analytical infrastructure of Khalifa University's research ecosystem. The Department integrates theory with computation and modeling to enable rigorous inquiry, credible prediction, and decision support across science and engineering. Its mission reflects the UAE's emphasis on technological leadership, sustainability, and human-capital development, ensuring that mathematical insight informs national innovation and societal benefit.

UAE National Research Priorities

The Department's research agenda is guided by the UAE's national research and innovation priorities.

Renewable Energy and Sustainability
Solar, hydrogen, and clean energy systems.
01

Health and Biotechnology
Medical modeling, bioinformatics, and disease analytics.
02

Water and Food Security
Mathematical modeling for efficient water use and sustainable agriculture.
03

Advanced Technologies and AI
Machine learning, cybersecurity, and smart manufacturing.
04

Transportation and Smart Mobility
Modeling and optimization for energy-efficient infrastructure.
05

Space Exploration
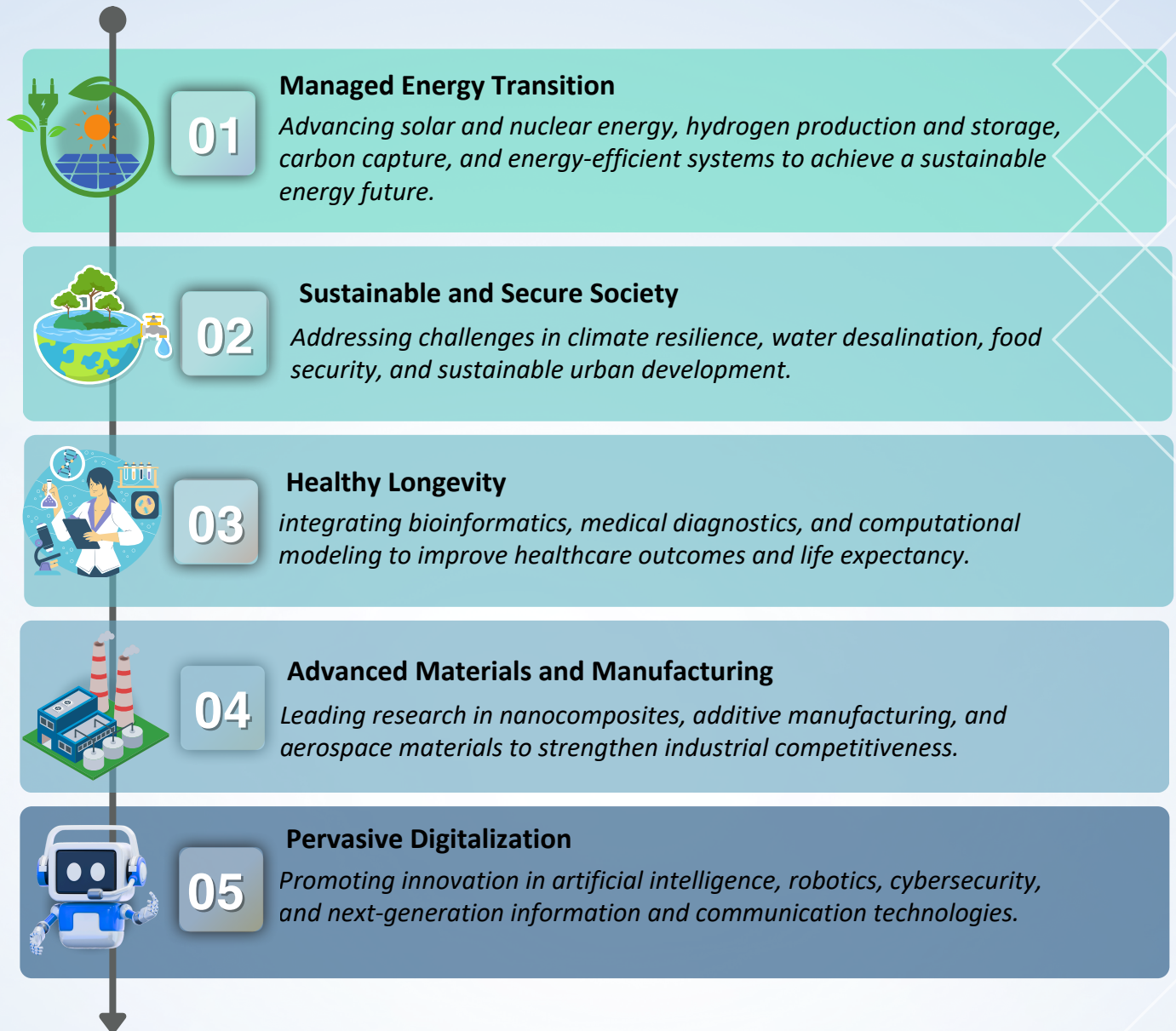Orbital mechanics, mission design, and data analysis.
06

Education and Human Capital Development
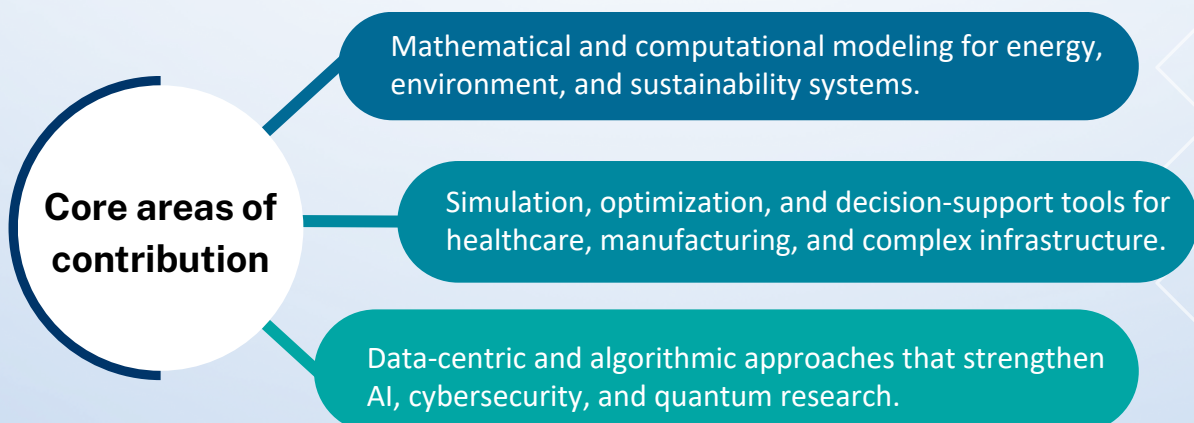Mathematics education innovation and STEM workforce advancement.
07

Khalifa University Research Themes

Khalifa University operationalizes national priorities through five institutional research themes that organize multidisciplinary collaboration and scientific investment.

01 Managed Energy Transition

Advancing solar and nuclear energy, hydrogen production and storage, carbon capture, and energy-efficient systems to achieve a sustainable energy future.

02 Sustainable and Secure Society

Addressing challenges in climate resilience, water desalination, food security, and sustainable urban development.

03 Healthy Longevity

integrating bioinformatics, medical diagnostics, and computational modeling to improve healthcare outcomes and life expectancy.

04 Advanced Materials and Manufacturing

Leading research in nanocomposites, additive manufacturing, and aerospace materials to strengthen industrial competitiveness.

05 Pervasive Digitalization

Promoting innovation in artificial intelligence, robotics, cybersecurity, and next-generation information and communication technologies.

Department of Mathematics: Integrative Role

Within this framework, the Department serves as a cross-cutting research partner that underpins every theme with quantitative methods and computation.

Core areas of contribution

- Mathematical and computational modeling for energy, environment, and sustainability systems.
- Simulation, optimization, and decision-support tools for healthcare, manufacturing, and complex infrastructure.
- Data-centric and algorithmic approaches that strengthen AI, cybersecurity, and quantum research.
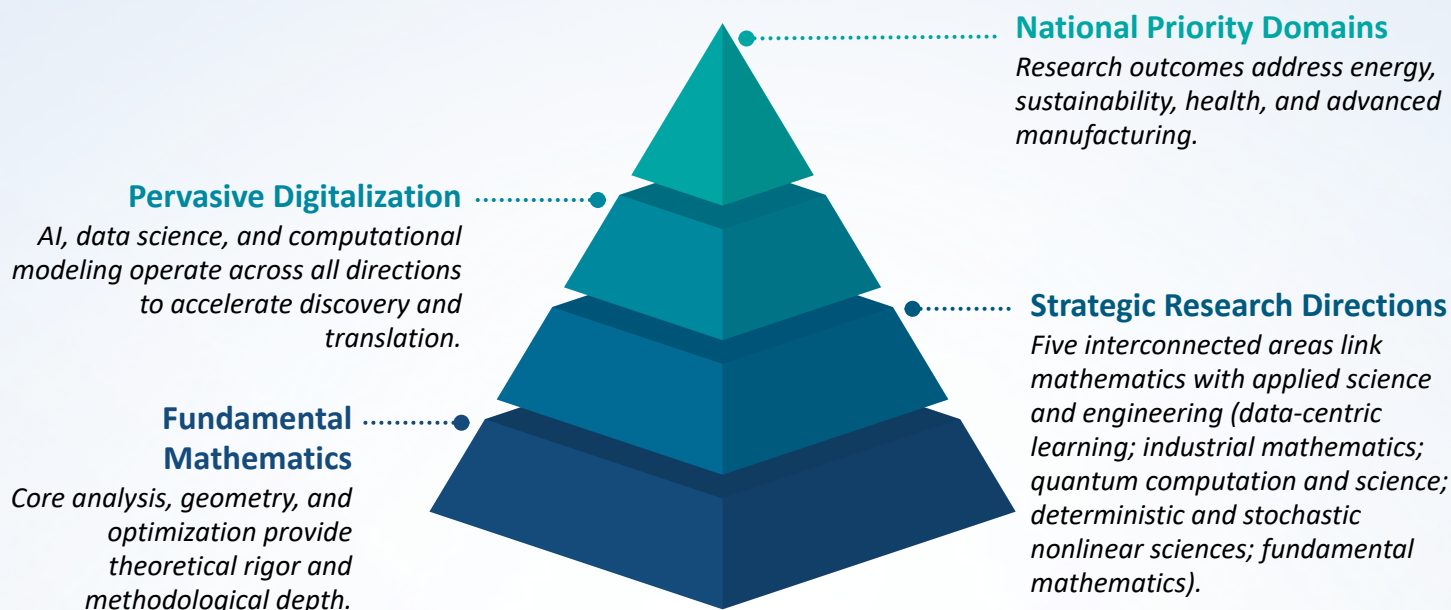
Current State and Departmental Role

The Department combines rigorous theoretical scholarship with computational and applied expertise. Faculty lead research across analysis, scientific computing, data science, and applied probability, with active collaboration across KU institutes and national partners.

Mathematics Department Key Dimensions of Impact

01 Core Academic Foundations

Provides the theoretical and methodological base that underpins advanced research across the university. Faculty expertise includes:

- *Analysis, (partial) differential equations.*
- *Probability, statistics, and stochastic processes.*
- *Optimization and control theory*
- *Scientific & Quantum computing.*
- *Nonlinear dynamics and complex systems.*

This core foundation ensures that mathematics continues to serve as a disciplinary anchor for innovation across KU's research institutes.

02 Interdisciplinary Applications

*Transforms mathematical theory into powerful tools and methodologies that enable cutting-edge scientific and technological advancements.
Its research supports:*

- High-performance simulations and computational modeling.
- Decision-making under uncertainty in energy, finance, and public policy.
- Modeling of complex biological and physical systems.

Applied areas such as Mathematical Biology and Mathematical Finance exemplify how theoretical principles translate into applied research and education.

03 Cross-Sector Integration

*Bridges mathematics with diverse disciplines to address complex, real-world challenges.
It advances research in:*

- Life sciences, through modeling biological systems and high-fidelity medical processes.
- Energy and sustainability, through optimization and predictive simulation.
- Engineering and space research, through modeling, and control.

By integrating theory, computation, and application, the Department supports collaboration with all five of KU's strategic research institutes, enhancing both institutional capacity and national impact.

Horizontal-Vertical Framework

The Department organizes its research so that foundational mathematics provides the theoretical and analytical base for interdisciplinary research directions, enabling coherent advancement across core areas. This structure ensures that mathematical discovery supports applied research and contributes to nationally relevant scientific and technological applications.

Framework Overview

National Priority Domains
Research outcomes address energy, sustainability, health, and advanced manufacturing.

Pervasive Digitalization
AI, data science, and computational modeling operate across all directions to accelerate discovery and translation.

Strategic Research Directions
Five interconnected areas link mathematics with applied science and engineering (data-centric learning; industrial mathematics; quantum computation and science; deterministic and stochastic nonlinear sciences; fundamental mathematics).

Fundamental Mathematics
Core analysis, geometry, and optimization provide theoretical rigor and methodological depth.

Horizontal Integration

The Horizontal–Vertical Framework provides a unified view of how mathematical research is structured within the Department to ensure coherence across theory, application, and impact. It highlights how foundational research enables advanced inquiry while maintaining clear pathways toward interdisciplinary collaboration and national relevance.

Vertical Progression

Vertically, the framework illustrates how research progresses from fundamental mathematical theory to applied innovation. Foundational Mathematics supports Strategic Research Directions, which collectively enable digital technologies and contribute to national priority outcomes. This progression ensures that mathematical discovery is continuously translated into real-world scientific and technological impact.

## Strategic Research Directions (2025–2030)

Building on the Department's Horizontal–Vertical Framework, five strategic research directions guide its scientific development for 2025–2030.

Each connects fundamental mathematics to applied innovation in line with Khalifa University's institutional themes and the UAE's national research priorities

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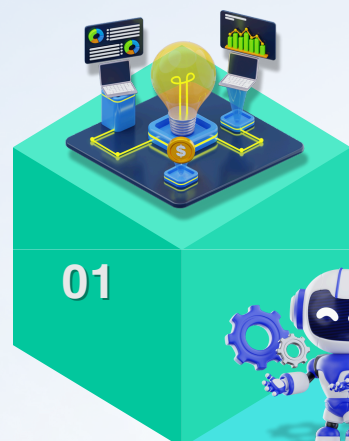
Mathematical Foundations of Data-Centric Learning

Develops rigorous mathematical frameworks for AI, physics-informed learning, operator theory, and uncertainty quantification. Strengthens decision-making and reliability in digital twins and intelligent systems across healthcare, energy, and sustainability.

02
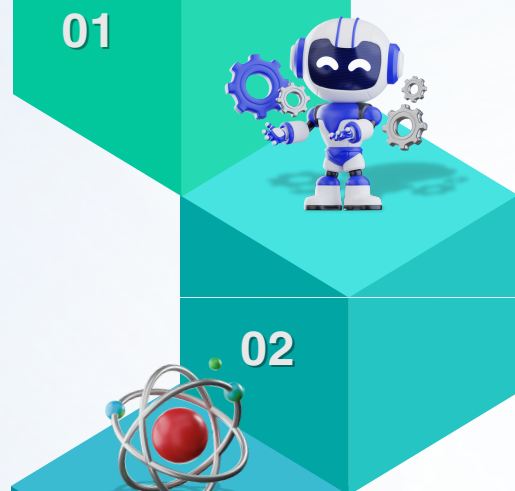
Industrial Mathematics (Scientific Computing and Computational Physics)

Advances high-performance computing, multi-physics simulations, and structure-preserving discretization for credible predictions in engineering, materials, and energy systems.

03
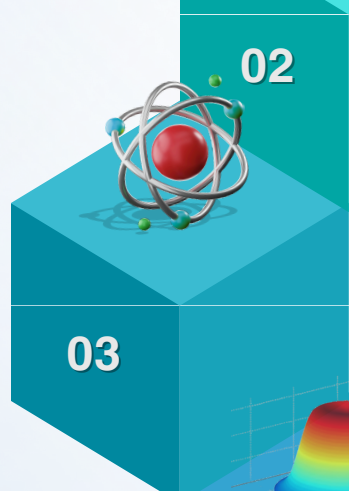
Quantum Computation and Quantum Science

Explores quantum algorithms, hybrid computing workflows, and quantum-safe cryptography, complementing classical HPC and supporting UAE's national quantum initiatives.

04
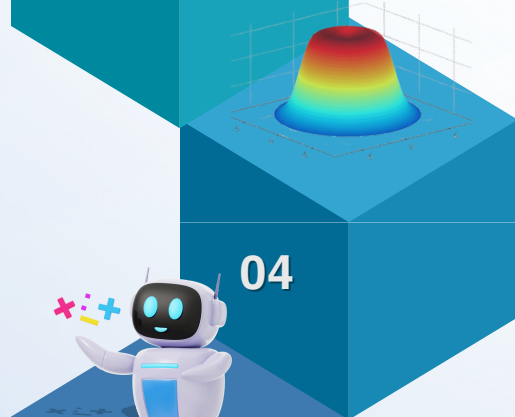
Deterministic and Stochastic Nonlinear Sciences

Investigates nonlinear dynamics, stochastic modeling, and control under uncertainty to support climate resilience, finance, and infrastructure optimization.

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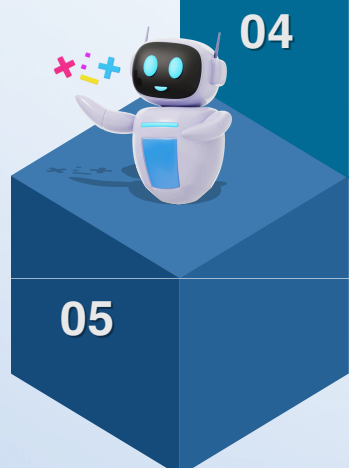
Fundamental Mathematics

Provides theoretical innovation through functional analysis, spectral theory, and approximation methods, ensuring academic excellence that sustains international recognition.

Strategic Objectives (2025–2030)

The Department of Mathematics aims to strengthen Khalifa University's research and educational ecosystem by advancing excellence in mathematical research, developing future-ready talent, and translating mathematical innovation into national impact. These objectives define what the Department seeks to achieve over the 2025–2030 period and provide a clear strategic focus for research growth, academic development, and interdisciplinary engagement.

Together, the objectives reflect the Department's dual role as both a core academic unit and a cross-cutting enabler of research across the University. They are designed to reinforce one another, ensuring that progress in research excellence, human capital, and applied impact is achieved in a coordinated and sustainable manner.

01 Advance Research Excellence

02 Develop Human Capital

03 Translate Research into Impact

01
- Strengthen core research areas in fundamental and applied mathematics.
- Support interdisciplinary research aligned with data science, quantum science, and advanced computing.
- Enhance the Department's contribution to high-impact, collaborative research initiatives.

02
- Expand graduate and doctoral education in key mathematical and computational disciplines.
- Introduce targeted academic pathways that support emerging research and workforce needs.
- Prepare highly skilled graduates for leadership roles in academia, industry, and government.

03
- Foster applied research that addresses real-world scientific and technological challenges.
- Support innovation through partnerships, knowledge transfer, and applied mathematical solutions.
- Strengthen the role of mathematics as an enabling discipline across KU's research institutes.

Strategic Enablers for Achieving Departmental Objectives

The Department's strategic objectives require robust institutional mechanisms that support sustained research growth, effective collaboration, and long-term impact. The strategic enablers outlined below define how these objectives will be operationalized through capacity building, partnerships, and research translation.

These enablers establish the structures and processes needed to implement research, education, and innovation activities in a coordinated and sustainable manner.

01   **Capacity Building and Talent Development**

- Strategic hiring of new faculty in key research areas to strengthen the feasibility of the 5-year research plan.
- Launch new mathematics minors/majors, in coordination with the rest of the College of Computing and Mathematical Sciences (CCMS), to accommodate educational needs in key directions:

    Mathematical Data Science
    Quantum Science & Computing

- to prepare students for the digital and quantum economy.
- Launch Quantum Science & Computing division within the Mathematics department
- Strengthen PhD programs in applied mathematics, targeting KU's institute research needs.
- Develop an executive PhD program to foster relationships with local industry (e.g., ADNOC, Mubadalah, ADIA) to bridge research with industrial innovation.
- Offer professional certificates in quantitative finance, computational modeling, and applied machine learning for engineers and data scientists

01   **Partnerships and National Engagement**

- Collaborate with UAE ministries and government entities to support policy modeling and decision support.
- Establish a Mathematics for Industry and Society Hub linking KU with national industry and research partners.
- Contribute mathematical expertise to national initiatives, including space science and advanced engineering.
- Strengthen international collaborations with leading academic and research institutions.

Partnerships enable the Department to extend the reach and relevance of its research beyond disciplinary and institutional boundaries. Through sustained engagement with government, industry, and global academic partners, mathematics serves as a shared platform for interdisciplinary problem-solving and national innovation.

01   **Innovation and Research Translation**

- Support the development of applied research projects and spin-off initiatives.
- Enable patentable outcomes in optimization, machine learning, and computational mathematics.
- Provide advanced consultancy and training programs for government and industry stakeholders.

Research translation ensures that mathematical advances are transformed into practical tools, methodologies, and solutions. By strengthening pathways from theory to application, the Department enhances the societal and economic value of its research while reinforcing mathematics as an essential enabler of innovation.

Expected Outcomes

The implementation of the Department's strategic plan will strengthen the role of mathematics as a central contributor to Khalifa University's research mission and to the UAE's national innovation agenda. The outcomes outlined below represent the tangible academic, scientific, and societal value generated through the Department's research directions, strategic objectives, and enabling mechanisms.

By 2030, the Department of Mathematics is expected to achieve the following outcomes:

01 A mathematical backbone for all five KU institutes.

02 Strong contributions to the UAE's AI & Digital Economy, Health Innovation, Clean Energy, Sustainability, and Advanced Manufacturing priorities.

03 Enhanced international visibility through research excellence, student training and strategic partnerships.

04 Direct contributions to the UAE's strategic goals in Quantum Science, Energy Transition, AI, and Sustainability.

05 Establishment of a Quantum Mathematics and Computing Division within the proposed departmental research center.

06 Strengthened capacity to attract competitive funding, elevate academic reputation, and shape national research directions.