



UNIVERSITI
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MALAYSIA



THE INTERNATIONAL CONFERENCE ON MATHEMATICAL SCIENCES AND TECHNOLOGY 2026



Math Powers AI - Driving Sustainable Innovations

22 - 24 September 2026 | M Social Resort Penang, Malaysia

PROGRAMME BOOK



**SPECIAL SESSION
FOR TEACHERS**



Organized by



In collaboration with

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Assoc. Prof. Dr. Ahmad Lutfi Amri Ramli

Dean

School of Mathematical Sciences

Universiti Sains Malaysia

It is my great pleasure to welcome our plenary speakers, invited speakers, presenters, and participants from across the globe to MathTech 2026, themed “Math Powers AI – Driving Sustainable Innovations.” The conference provides an international platform for sharing knowledge, exchanging ideas, and fostering meaningful collaborations among mathematics and science educators, researchers, academics, and industry practitioners.

AI has proven to make our lives easier. We are able to expedite daily processes and enhance our research, whether by utilising it as part of a tool or method, or by helping us with writing. There is so much more potential in utilising AI to create innovations. There is also a huge opportunity to go back to the basics of Mathematics and see or research how it can shape AI. As AI data centres use a lot of resources, there are basic questions of sustainability that can be addressed through numerical approaches or the fundamentals of Mathematics, with an understanding of Science itself. Various research opportunities are created in this AI area.

The theme reflects the fundamental role of mathematics in the development of artificial intelligence and emerging technologies. Mathematics provides the foundation for artificial intelligence, data science, machine learning, optimisation, modelling, and many other innovations that are transforming our society. At the same time, these mathematical and technological advancements offer new opportunities to address complex challenges and support sustainable development.

I am proud to see that MathTech 2026 has become a consistent conference brand by the School of Mathematical Sciences that brings together researchers, educators, students, policymakers, and industry practitioners to share the latest developments and research findings in various disciplines.

The conference has also strengthened connections between academia, industry, and education at the secondary and pre-university levels, while supporting the Science, Technology, Engineering and Mathematics (STEM) agenda locally and globally. Together, let us explore how mathematics can power AI and drive sustainable innovations for the benefit of society, both locally and globally. Finally, I would like to express my sincere appreciation to our plenary and invited speakers, presenters, participants, organising committee, and everyone who has contributed to the organisation of MathTech 2026. Your continued support and tremendous efforts are greatly valued and appreciated.

I wish everyone a fruitful, inspiring, and rewarding MathTech 2026.

Thank you.



Assoc. Prof. Dr. Gobithaasan Rudrusamy

Chair

MathTech 2026

It is my great pleasure, on behalf of the organising committee, to welcome all distinguished speakers, researchers, educators, co-hosts, industry practitioners, students, and participants to the **International Conference on Mathematical Sciences and Technology 2026 (MathTech 2026)**.

This year, MathTech 2026 embraces the theme **“Math Powers AI – Driving Sustainable Innovations,”** highlighting the essential role of mathematics in shaping the future of artificial intelligence and technological innovation. As AI continues to transform our world, mathematical knowledge remains at the heart of its development, providing the foundations for modelling, optimisation, statistics, data science, machine learning, and intelligent decision-making. More importantly, the integration of mathematics and AI opens new possibilities for developing innovative and sustainable solutions to the complex challenges faced by society.

The conference offers an opportunity for participants to engage with current developments and emerging ideas across a broad spectrum of mathematical sciences and technology. Through plenary lectures, invited talks, workshops, and technical sessions, we hope to create an environment that encourages meaningful dialogue, knowledge sharing, and the exchange of diverse perspectives. The programme brings together contributions from various areas, including pure and applied mathematics, mathematics education, statistics, financial mathematics, operations research, data science, artificial intelligence, and other related fields.

MathTech 2026 also seeks to strengthen connections between researchers, educators, students, and industry practitioners. We believe that meaningful collaboration across disciplines is essential to advancing mathematics and technology and to translating knowledge into impactful innovations. In particular, we hope this conference will inspire new collaborations and encourage the development of ideas that contribute to sustainable development and the well-being of society.

I would like to extend my sincere appreciation to all those who have contributed to making MathTech 2026 possible. My heartfelt thanks go to our distinguished speakers, presenters, reviewers, organising and programme committee members, supporting institutions, sponsors, and all participants for their valuable contributions, dedication, and support. I would also like to express our sincere gratitude to our co-hosts: Shizuoka University, University of the Philippines and Institut Teknologi Bandung, for their invaluable partnership, commitment, and support in making MathTech 2026 a success.

I am confident that MathTech 2026 will be an enriching and inspiring experience for everyone. May the conference provide opportunities to learn, connect, collaborate, and explore how the power of mathematics and AI can drive meaningful and sustainable innovations for the future.

I wish you all a productive, enjoyable, and memorable **MathTech 2026**.

Thank you, and welcome to MathTech 2026!

Conference Programme



Day 1 | 22 September 2026 (Malaysia Time / GMT+8)

08:00 – 08:45	Pavilion Foyer	Registration
09:00 – 09:40	Pavilion Ballroom	Opening Ceremony
09:40 – 10:40	Pavilion Ballroom	PT Plenary Talk: Dr. Chuah Kee Man Proof, Plausibility and Pedagogy: Rethinking Mathematical Thinking with Generative AI Chairperson: Assoc. Prof. Dr. Mohd Hafiz Mohd
10:40 – 11:00	Pavilion Foyer	Morning Tea Break
11:00 – 13:00	Pavilion 3	ST Session for Teachers 1: Dr. Yazariah Mohd Yatim Visualising Mathematics
13:00 – 14:00	Beast & Butterflies	Lunch Break
14:00 – 15:30	Pavilion 3	ST Session for Teachers 2: Assoc. Prof. Dr. Ahmad Lutfi Amri Ramli Gamifying Mathematics Classrooms through Digital Tools
15:30 – 17:00	Pavilion 3	ST Session for Teachers 3: Dr. Norazrizal Aswad Abdul Rahman Practical Strategies to Re-Engage Students in Mathematics
17:00 – 17:40	Pavilion Foyer	Afternoon Tea Break
20:00 – 22:00	Pavilion Ballroom	Dinner*

PT - Plenary Talk **ST** - Session for Teachers

Pavilion Ballroom, Pavilion 3, Pavilion Foyer, Beast & Butterflies : Level 8n

* Please note that the dinner applies to participants who have registered and paid for the dinner option.

Day 2 | 23 September 2026 (Malaysia Time / GMT+8)

08:30 – 10:30	Pavilion 3	ST Workshop 1: Ts. Puteri Anis Aneeza Zakaria Empowering Future Innovators Through Mathematics, Technology and Robotics
10:30 – 10:50	Pavilion Foyer	Morning Tea Break
10:50 – 12:50	Pavilion 1	CT Parallel Session 3A
	Pavilion 2	ST Parallel Session 3B
	Vista	IT Invited Talk: Prof. Dr. Zabidin Salleh CT Parallel Session 3C
	Pavilion 3	WS Workshop 2
		IT Invited Talk: Assoc. Prof. Dr. Hanni Garminia CT Virtual Presentation: https://mathtech.usm.my/programme/virtual-sessions
12:50 – 14:00	Beast & Butterflies	Lunch Break
14:00 – 15:00	Pavilion 1	PT Plenary Talk: Dr. Ahmad Fairudz Jamaluddin Climate Projection Until 2100 in Malaysia and Objective Analysis Techniques Chairperson: Assoc. Prof. Dr. Mohd Tahir Ismail
15:10 – 17:20	Pavilion 1	CT Parallel Session 4A
	Pavilion 2	IT Invited Talk: Prof. Dr. Darren Ong Chung Lee CT Parallel Session 4B
	Vista	ST Parallel Session 4C
	Pavilion 3	WS Workshop 3
		CT Virtual Presentation: https://mathtech.usm.my/programme/virtual-sessions
16:40 – 17:40	Pavilion Foyer	Afternoon Tea Break

PT - Plenary Talk **IT** - Invited Talk **CT** - Contributed Talk **WS** - Workshop
ST - Session for Teachers

Pavilion 1, Pavilion 2, Pavilion 3, Pavilion Foyer, Beast & Butterflies : Level 8
 Vista : Level 7

Parallel Sessions & Workshops

Day 2 | 23 September 2026 (Malaysia Time / GMT+8)

Parallel Session 3 / Workshop 2

Time	Pavilion 1 Parallel 3A Financial Mathematics Chairperson: Dr. Shamsul Rijal Muhammad Sabri	Pavilion 2 Parallel 3B Mathematics Education Chairperson: Dr. Siti Amirah Abd Rahman	Vista Parallel 3C Pure Mathematics Chairperson: Dr. Norazrizal Aswad Abdul Rahman	Pavilion 3 Workshop 2
10:50 – 11:20	MathTech 2026-0141 Marcellino Wijaya Dynamic Prediction of Insurance Premiums and Reserves During Outbreaks: COVID-19 in Indonesia as a Case Study	MathTech 2026-0301 Ahmad Yuszaidi Zulkifli Predicting SPM Outcomes from Continuous Assessments in MRSN: A Regression Analysis	Invited Talk Prof. Dr. Zabidin Salleh Best Proximity Points Analysis for Fuzzy Graphical Proximal Contractions in Graphical Fuzzy Metric Spaces	Prof. Dr. Rizavel C. Addawe & Assist. Prof. Joseph Ludwin D. Marigmen Univariate and Multivariate Time Series Analysis using Animal Bites Cases (10:50 – 12:50)
11:20 – 11:40	MathTech 2026-0144 Andi Fitriawati Implementation of Differential Evolution Algorithm for Solving ESG Portfolio Optimization with Buy-In Threshold Constraints	MathTech 2026-0302 Irma Rohaiza Ibrahim Predictive Validity of Internal Assessments on National Secondary School Mathematics Examination (SPM) Achievement Across MRSN Programs: An Educational Data Analytics Study	MathTech 2026-0011 Kevin Fung Steinerberger Curvature on Digraphs: Discrete Bonnet-Myers and Lichnerowicz Theorems	
11:40 – 12:00	MathTech 2026-0172 Ala Alrawajfi Long Term Insurance Data Prediction Using MODWT and ARIMA Model	MathTech 2026-0303 Mohd Amir Yuzaini Mohd Yusof Data-Driven SPM Mathematics Intervention Design: Evidence from Internal Assessment Patterns in Selected Premier Program MRSN	MathTech 2026-0049 Mark Anthony C. Tolentino Multiset Resolving Sets in Strong Products of Paths	
12:00 – 12:20	MathTech 2026-0175 Saleh Atiewi AI-Based Predictive Analytics for Financial Time Series Using Hybrid Deep Learning Models	MathTech 2026-0304 Noorwahida Daud @ Arifin Prediction of SPM Mathematics Achievement using Multiple Regression Analysis in Microsoft Excel: A School-Based Educational Data Analytics Study	MathTech 2026-0050 Timothy Robin Y. Teng Twin Intersection Edge Colorings of Grids and Prisms	
12:20 – 12:40	MathTech 2026-0209 Tan Shay Kee Bridging Mathematical Coherence and Machine Learning: The HEG-CARR Framework for Volatility Forecasting	MathTech 2026-0305 Norlina Hamidon Predicting SPM Mathematics Achievement Using Internal Examination Results	MathTech 2026-0067 K. A. Azizu The Locating Proper Rainbow Edge Connection Numbers of Several Graphs with Diameter Two	

Day 2 | 23 September 2026 (Malaysia Time / GMT+8)

Parallel Session 4 / Workshop 3

Time	Pavilion 1 Parallel 4A Mathematical Modelling Chairperson: Dr. Yazariah Mohd Yatim	Pavilion 2 Parallel 4B Pure Mathematics Chairperson: Dr. Azhana Ahmad	Vista Parallel 4C Mathematics Education Chairperson: Dr. Rosmanjawati Abdul Rahman	Pavilion 3 Workshop 3
15:10 – 15:40	MathTech 2026-0148 Syazreen Niza Shair Modelling Poverty Transitions among Asnaf Households in Selangor: A Three-State Markov Chain Analysis	Invited Talk Prof. Dr. Darren Ong Chung Lee Average Degree of Graphs Derived From the Ammann A2 Aperiodic Tiling	MathTech 2026-0039 Muhammad Azrin Ahmad Technology-Enhanced Classroom: Using Chromecast and AirPlay Proprietary Screen Sharing Protocol via Google TV and Apple TV, Respectively for Effective Teaching at the University Level	Dr. Kong Voon Pang Introduction to Curve Fitting (15:10 – 17:10)
15:40 – 16:00	MathTech 2026-0152 Khairunnisa Mokhtar Forecasting Disability-Free Life Expectancy Using an Extended Sullivan Model and Functional Lee-Carter Approach	MathTech 2026-0068 Mukayis The Locating Proper Rainbow Vertex Connection Numbers of Some Operations of Complete Graphs	MathTech 2026-0085 Jeanelle R. Ibañez Redesigned Frayer Model Graphic Organizer in Statistics and Probability: Its Effect on the Academic Performance, Attitude, and Motivation of Academic Track Senior High School Students	
16:00 – 16:20	MathTech 2026-0153 Natita Wangsoh Optimization-Based PM2.5 Forecasting and Mitigation in Chiang Mai, Thailand	MathTech 2026-0072 Muhammad Ahnaf Yusuf The Locating Rainbow Edge Connection Numbers for Several Variations of Squid Graphs	MathTech 2026-0093 Zean Exel C. Damaso Attitude towards Problem-Based Learning as Predictor of Problem-Solving Skills among Preservice Mathematics Teachers	
16:20 – 16:40	MathTech 2026-0154 Johnfel Mike V. Rivera Stability Results for a Compartmental Disease Model with Quarantine and General Force of Infection	MathTech 2026-0099 Eduard C. Taganap Perfect Precise Colorings of Euclidean Tile-Transitive Isogonal Tilings	MathTech 2026-0204 Foo Chuan Hui Development and Validation of an Interactive Digital Learning Module for Additional Mathematics	
16:40 – 17:00	MathTech 2026-0056 Nurraihan Muhammad Haznol AI-Assisted for Convergence and Stability Analysis of the Fractional Composite Trapezoidal-Backward Differentiation Formulas	MathTech 2026-0192 Jorem Jordan M. Cawagas Which Polyhedra Admit Plain Weavings?		
17:00 – 17:20	MathTech 2026-0211 Titus Okello Orwa Optimal Control Analysis of Malaria Transmission in the Presence of Insecticide Resistance and Climate Variability in Kenya	MathTech 2026-0120 Chandrashekar Ramasamy Sufficient Conditions for Analytic Functions to be Janowski Starlike		

Day 2 | 23 September 2026 (Malaysia Time / GMT+8)

Virtual Presentations

Time	Webex: https://mathtech.usm.my/programme/virtual-sessions Chairperson: Dr Ong Wen Eng
10:50 – 11:20	Invited Talk Assoc. Prof. Dr. Hanni Garminia Schanuel's Lemma in a Localization Framework: The S -Injective Case
11:20 – 11:40	MathTech 2026-0058 Annie Lyn O. Yusiong Adaptive Bracket Search with Newton-Regula Falsi Hybrid for Non-Linear Equations
11:40 – 12:00	MathTech 2026-0202 Douglas Frederick S. Guangco On the Nonnegative Integer Solutions of the Diophantine Equation $F_n^x + L_n^x = y^2$
12:00 – 12:20	MathTech 2026-0030 Marie Cris B. Mahinay On the Nilpotent Graph of the Ring of Integers Modulo n
12:20 – 12:40	MathTech 2026-0076 Destiny S. Lutero Topological Analysis of Metropolitan COVID-19 Epidemic Trajectories in the Philippines Using Persistent Homology
12:40 – 13:00	MathTech 2026-0197 Nurulhuda A. Manaf Optimizing Medication Pathways for Diabetes with Cardiovascular Patients: A Decision Analysis Approach
13:00 – 13:20	MathTech 2026-0170 Clarenz B. Magsakay Dengue Forecasting and Climate Attribution in the Philippines: A Comparative Study using Statistical, Machine Learning, and Deep Learning Models
13:20 – 15:10	Lunch Break
15:10 – 15:30	MathTech 2026-0051 Saiful Azril Ishak Coherent Cause-Specific Mortality Forecasting with Redistribution Using Compositional Data Analysis
15:30 – 15:50	MathTech 2026-0109 Wang Zihong A Comparative Study of Hybrid Models Integrating Principal Component Analysis with Regression Techniques in the Drying Process of Black Pepper
15:50 – 16:10	MathTech 2026-0167 Ali Kole Does the Belt and Road Initiative Accelerate System Performance, Transition Readiness, and Energy Transition Index? Evidence from a Residualized Quantile Regression Approach
16:10 – 16:30	MathTech 2026-0047 Sted Micah T. Cheng Examining the Role of Color in Predicting Fruit Freshness Using Convolutional Neural Networks
16:30 – 16:50	MathTech 2026-0048 Richell Isaiah S. Flores Progressive Pooling and Deep Convolutional Networks for Street Number Digit Recognition
16:50 – 17:10	MathTech 2026-0207 Lee Zi Cheng Dynamic and Fixed Rebalancing Strategies in Factor-Based Index Tracking: Evidence from the S&P 100

List of Abstracts – Plenary Talks

PT Plenary Talk



Dr. Chuah Kee Man
Faculty of Education, Language and Communication
Universiti Malaysia Sarawak
Malaysia

Dr. Chuah Kee Man is a senior lecturer at the Faculty of Education, Language and Communication, Universiti Malaysia Sarawak who has more than 15 years of experience in teaching and research. He holds a PhD in Educational Technology from Universiti Sains Malaysia. His expertise is within the areas of educational technology, learning sciences, instructional design, computational linguistics and AI in education. He is recognised for his innovative approaches to teaching and learning and has published extensively on topics related to e-learning, learning technology, and linguistic analysis. He has also received numerous awards for his contributions to the field and is committed to empowering students through equitable quality education.

Proof, Plausibility and Pedagogy: Rethinking Mathematical Thinking with Generative AI

Generative AI can produce fluent solutions and mimic mathematical argument, which forces mathematics education to confront a new boundary between doing mathematics and delegating it. This talk examines how AI shifts the centre of gravity from producing answers towards judging validity and making informed choices about methods and tools. It covers how classroom tasks can treat AI output as a stimulus for critique and refinement so that students practise verification and sense making rather than copying polished responses. The talk connects these task designs to assessment by highlighting approaches that capture reasoning and responsiveness to feedback even when AI is available. The session also includes practical workflows for teachers and lecturers, including prompt literacy for mathematics and ways to build student agency when mathematical work is increasingly co-produced with AI.



Dr. Ahmad Fairudz Jamaluddin
National Climate Centre
Malaysia Meteorological Department
Malaysia

Dr. Ahmad Fairudz Jamaluddin is a Senior Meteorologist with more than 25 years of professional experience at the Malaysian Meteorological Department. He has been serving as the Director of the National Climate Center Division since December 2024. He is responsible for the operation of national climate monitoring, including the operation of the early warning system for drought, heatwave and fire danger rating system (FDRS), national climate change monitoring and the National Climate Database Center. Dr. Ahmad obtained his PhD from the National University of Malaysia majoring in climate change variability especially over the Southeast Asia region. He is actively involved in national climate change agenda such as Co-Chair for the technical working group of research and systematic observations, UNFCCC National Communication (NC) 4.

Climate Projection Until 2100 in Malaysia and Objective Analysis Techniques

The ability to transform complex atmospheric dynamics into accurate, localized climate projections and actionable climate-based solutions represents a critical measure of Malaysia's climate resilience. Recent climate observations indicate a significant shift in climate patterns, characterized by an increasing frequency and intensity of extreme weather events across Malaysia. Concurrently, the country has experienced a steady rise in greenhouse gas (GHG) concentrations, including carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O), which are the primary drivers of rising temperature anomalies. Additionally, to assess the impact of these greenhouse gases (GHGs) on future climate conditions, experiments using Global Climate Models (GCMs), dynamically downscaled through Regional Climate Models (RCMs), were conducted for Malaysia. Objective analysis techniques were applied to select suitable GCMs and to validate the performance of the RCM simulations. Under the high-emission SSP5-8.5 scenario (2080–2099), Malaysia is projected to experience a substantial increase in temperature relative to the baseline period. Projections indicate that mean daily maximum temperatures will increase by approximately +4.1°C in Peninsular Malaysia and up to +4.5°C in Sarawak. In addition, rising temperatures are the primary drivers of heatwave-related health risks, which are further intensified by the Urban Heat Island (UHI) effect in areas such as Greater Kuala Lumpur (GKL), where heat intensity is most pronounced at night but reaches its peak during the day. During heatwave events, the maximum heat load in GKL at noon can be up to 2.3°C higher than on non-heatwave days. Moreover, because a warmer atmosphere can hold approximately 7% more moisture per degree Celsius, Malaysia is projected to experience up to a 40% increase in daily rainfall extremes by the end of the century. This intensified precipitation, coupled with urbanization and land-use changes that reduce ground absorption, substantially elevates the risk of flash floods in major urban centres.

List of Abstracts – Invited Talks

IT Invited Talk

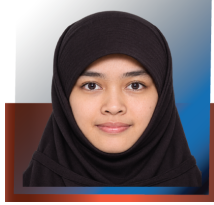


Prof. Dr. Zabidin Salleh
Faculty of Computer Science and Mathematics
Universiti Malaysia Terengganu
Malaysia

Prof. Dr. Zabidin Salleh received his BSc degree in Mathematics in 1992 and his Dip. Ed. in Mathematics and Physics Methods in 1995 from Universiti Malaya, Malaysia, and his MSc degree in Univalent Function Theory in 2002 from Universiti Sains Malaysia, and his PhD in Topology in 2008 from Universiti Putra Malaysia. Currently, he is a Professor in Pure Mathematics at the Faculty of Computer Science and Mathematics, Universiti Malaysia Terengganu. He has published several articles in high impact factor scientific journals. His research interests are in the field of topology, fuzzy topology, fixed point theory, univalent function theory, fluid dynamics and unconstrained optimization.

Best Proximity Points Analysis for Fuzzy Graphical Proximal Contractions In Graphical Fuzzy Metric Spaces

In this paper, we initiate the analysis of best proximity point theory in the framework of graphical fuzzy metric spaces, thereby addressing gaps in the existing literature. All results are established under the assumptions of M -Cauchyness and M -completeness. For non-self mappings, the notions of fuzzy proximal edge-preserving mappings and (G, G') -fuzzy graphical proximal contractions are introduced. Best proximity point results for this class of contractions are established, and examples are presented to illustrate the validity of the obtained results.



Assoc. Prof. Dr. Hanni Garminia
Faculty of Mathematics and Natural Sciences
Institut Teknologi Bandung (ITB)
Indonesia

Assoc. Prof. Dr. Hanni Garminia is an Associate Professor in the Algebra Research Group at the Faculty of Mathematics and Natural Sciences, Institut Teknologi Bandung (ITB), Indonesia. She completed all her tertiary education at ITB, earning her PhD in Mathematics in 2008. Her research expertise encompasses abstract algebra, ring and module theory, ideal theory, and the application of algebraic structures to cryptosystems.

Schanuel's Lemma in a Localization Framework: The S -Injective Case

Let R be a commutative ring and S a multiplicative subset of R . The classical Schanuel Lemma for injective modules is a fundamental result in homological algebra: whenever two short exact sequences of R -modules share a common left term and both middle terms are injective, the two right terms are isomorphic up to a direct sum with the respective opposite middle terms. This reflects a deep structural symmetry that injective resolutions of a fixed module share at their initial stage. Motivated by the notion of S -injective modules recently introduced by Bennis and Bouziri, which weakens classical injectivity by requiring the extension property only after passing to the localization R_S , we examine how far this structural symmetry persists when the middle terms are merely S -injective rather than injective. We present two analogues of Schanuel's Lemma in this setting. The first works directly within the category of R -modules and recovers the isomorphism between the right terms under mild additional conditions relating the modules to the set S . The second approach localizes both sequences at S , where S -injectivity becomes classical injectivity over R_S and the conclusion then follows from the original lemma applied in the localized category. As an immediate consequence, a localized form of the isomorphism holds between the right terms for any two such sequences, without further hypotheses. Taken together, these results show that the comparison principle at the heart of Schanuel's Lemma remains intact within the broader framework of S -relative homological algebra.



Prof. Dr. Darren Ong Chung Lee
Department of Mathematics
Xiamen University Malaysia
Malaysia

Prof. Dr. Darren Ong Chung Lee is a Professor of Mathematics at Xiamen University Malaysia. He has a PhD in Mathematics from Rice University in the United States. His research focuses on spectral theory and mathematical physics, with a particular interest in unitary operators, quantum walks and aperiodic order.

Average Degree of Graphs Derived From The Ammann A2 Aperiodic Tiling

The Ammann A2 tiling is a simple aperiodically ordered tiling of the plane. We consider the graph derived from this tiling by treating each corner of each tile as a vertex and each side of each tile as an edge. We present a closed-form formula for the average degree of the graph corresponding to this Ammann A2 tiling. More precisely, we derive explicit formulas for the number of vertices and the sum of all vertex degrees in each finite generation of the tiling, which then yield the average degree. Our method is based on the recursive structure of the Ammann A2 substitution tiling and a detailed analysis of how vertices on the intersection line change from one generation to the next. We also show that the average degree converges to a limiting value and support the theoretical result with numerical computations. This provides, to our knowledge, the first explicit average-degree formula for the graph associated with the Ammann A2 tiling.

List of Sessions for Teachers

ST Session for Teachers 1



Dr. Yazariah Mohd Yatim
School of Mathematical Sciences
Universiti Sains Malaysia
Malaysia

Visualising Mathematics

Exploring dynamic visual tools, simulations, and technology platforms to enhance conceptual understanding in mathematics.

ST Session for Teachers 2



Assoc. Prof. Dr. Ahmad Lutfi Amri Ramli
School of Mathematical Sciences
Universiti Sains Malaysia
Malaysia

Gamifying Mathematics Classrooms through Digital Tools

Integrating game-based learning, digital platforms, and AI-powered engagement strategies in mathematics teaching.

Benefit for Teachers:

1. Hands-on training with digital mathematics tools
2. Classroom-ready strategies
3. Professional networking
4. Innovative STEM teaching approaches

ST Session for Teachers 3



Dr. Norazrizal Aswad Abdul Rahman
School of Mathematical Sciences
Universiti Sains Malaysia
Malaysia

Practical Strategies to Re-Engage Students in Mathematics

Evidence-based approaches to improve motivation, participation, and mathematical confidence.

Area of Focus:

1. Digital Tools for Mathematical Visualisation
2. Gamification & Interactive Learning
3. Technology-Enhanced Assessment & Analytics

List of Workshops

Workshop 1



Ts. Puteri Anis Aneeza Zakaria
Statworks (M) Sdn Bhd
Malaysia

Empowering Future Innovators Through Mathematics, Technology and Robotics

Workshop Synopsis:

This interactive workshop aims to equip participants with future-ready STEM competencies by integrating mathematics, coding, robotics, and problem-solving through engaging hands-on activities. Participants will explore the applications of robotics, automation, artificial intelligence (AI), and computational thinking using Texas Instruments (TI) technology and Leanbot. The session is designed to bridge classroom learning with real-world industry applications, inspiring participants to develop innovative thinking, creativity, and digital skills essential for the future workforce.

Objectives:

1. Empower participants with future-ready STEM skills by integrating mathematics, coding, and robotics through hands-on learning experiences using Texas Instruments technology and Leanbot.
2. Increase awareness of STEM technologies, robotics, automation, and AI while providing practical experience with industry-relevant tools and technologies.

Who should attend:

1. STEM educators and teachers.
2. Anyone interested in interactive learning, coding, robotics and emerging technologies.
3. Beginners are welcome; no prior programming or robotics experience is required.

Requirements:

1. All Texas Instruments technology, robotics equipment and workshop materials will be provided by the organizer.
2. A notebook and pen for note-taking (optional)

Agenda:

1. Introduction to Texas Instruments technology and Leanbot robotics platform.
2. Graphing calculator and robotics activities.
3. STEM challenges: applying mathematics and programming to solve real-world problems.
4. Showcase, discussion, Q&A, and closing remarks.

WS Workshop 2



Prof. Dr. Rizavel C. Addawe
Department of Mathematics and Computer Science
University of the Philippines Baguio
Philippines



Asst. Prof. Joseph Ludwin Marigmen
Department of Mathematics and Computer Science
University of the Philippines Baguio
Philippines

A Workshop on Univariate and Multivariate Time Series Analysis using Animal Bites Cases

Workshop Synopsis:

This workshop offers a practical introduction to univariate and multivariate time series analysis using RStudio using examples drawn from health data. The speakers will guide participants through key concepts and methods along with hands-on activities. This session will help participants understand how time series techniques can be applied and interpreted to real-world health problems. Participants will gain experience working with R or RStudio during the workshop.

Objectives:

1. Introduce univariate and multivariate time series analysis.
2. Provide applications to health data.

Requirements:

Participants must bring their own laptops and must have R or RStudio installed.

Agenda:

1. Introduction.
2. Univariate Time Series Analysis.
3. Multivariate Time Series Analysis.
4. Closing Remarks.

WS Workshop 3



Dr. Kong Voon Pang
School of Mathematical Sciences
Universiti Sains Malaysia
Malaysia

Introduction to Curve Fitting

Workshop Synopsis:

This workshop introduces fundamental concepts and techniques for finding curves that best fit your data. Participants will learn to model relationships between variables, smooth out noisy data, and make inferences using linear and non-linear curve approximation and interpolation. Through practical examples, participants will develop skills to successfully capture underlying trends.

Objectives:

1. Introduce fundamental concepts and techniques for finding curves that best fit your data.
2. Participants will learn to model relationships between variables, smooth out noisy data, and make inferences using linear and non-linear curve approximation and interpolation.
3. Participants will develop skills to successfully capture underlying trends through practical examples.

Who should attend:

1. Students, researchers and academicians in mathematics, statistics, engineering, computer science and related fields.
2. Industry professionals involved in data analysis, modelling and scientific computing.
3. Educators interested in integrating curve fitting and interpolation techniques into teaching and research.
4. Anyone seeking practical experience with curve fitting techniques using MATLAB.

Requirements:

1. Participants must bring their own laptops.
2. MATLAB software.
3. Sample datasets for practical exercises will be provided.

Agenda:

1. Introduction to Curve Fitting.
2. Fundamentals of Linear Curve Fitting.
3. Non-linear Curve Fitting Techniques.
4. Curve Approximation and Interpolation.
5. Practical Demonstration and Hands-on Exercises.
6. Discussion, Questions and Closing.

List of Abstracts – Contributed Talks

Artificial Intelligence & Machine Learning

CT MathTech 2026-0047 Examining the Role of Color in Predicting Fruit Freshness Using Convolutional Neural Networks

Sted Micah T. Cheng^{1,2}, Annika Nicole F. Montemayor^{1,2}, Richell Isaiah S. Flores¹ and Christian Paul O. Chan Shio^{1,*}

¹Department of Information Systems and Computer Science, Ateneo de Manila University, Katipunan Ave., Loyola Heights, 1108 Quezon City, Philippines

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Color is a commonly used visual cue for assessing fruit freshness, which is a concern that remains critical in food supply chain management. Computer vision techniques offer a way to reduce the subjectivity and improve the consistency of freshness evaluation. This study uses an image dataset containing eight fruit types, with balanced samples of fresh and rotten images, to investigate how different color transformations influence the behavior of a convolutional neural network. To examine how color information affects classification performance, the model is trained on the original images and on five color-based variants, namely grayscale, red-blue channel swap, and isolated red-only, green-only, and blue-only channels. By altering color channels, the model was effectively constrained to rely on structural, textural, and luminance-based cues rather than full-spectrum color information. The model trained on the original images has training and validation accuracies of 91% and 81%, respectively, only exceeded by the swap variant with training and validation accuracy of 93% and 78%, respectively. Confusion matrix analyses were primarily utilized to identify performance differences across the variants and highlight fruit-specific trends. This revealed that the swapped variant outperforms the original variant for apples, bananas, guavas, and pomegranates; the red variant beats the original for grapes and oranges; the blue variant surpasses the original for jujubes, while the grayscale variant is an equally-performing alternative for strawberries. Overall, while full-color imaging has been shown to contain pertinent indicators of fruit freshness, color-based transformations may be viable for specific fruits, such as grapes and jujubes, especially in environments with limited imaging capabilities.

CT MathTech 2026-0048 Progressive Pooling and Deep Convolutional Networks for Street Number Digit Recognition

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With the rise of online retail and door-to-door deliveries, automated address recognition systems become increasingly critical for logistics optimization. While computer vision applications commonly include the classification of texts and objects in images, real-world address and landmark indicators such as street numbers pose a problem as these exhibit greater variability in font styles, lighting conditions, viewing angles, and background clutter. Thus, the goal of this paper is to build on convolutional neural network (CNN) models from previous implementations of classifying digits from the Street View House Numbers (SVHN) dataset to achieve higher efficiency and accuracy. Starting from a baseline accuracy of 87.01%, the methods modified three previously established implementations by changing max pooling sizes and quantities, using average pooling, adjusting unit sizes, and applying progressive downsampling. The best-performing CNN used a deeper three-block architecture ($32 \rightarrow 64 \rightarrow 128$ filters) with 6 convolution layers, where each block consisted of two convolutions followed by 2×2 pooling and dropout, progressively reducing spatial dimensions from 32×32 to 64×64 . Results showed that replacing a single max pooling layer of size 8×8 with two smaller ones of sizes 2×2 and 4×4 improved the baseline model's accuracy by 1.34 percentage points, while the final architecture yielded an overall improvement of 6.42 points, achieving 93.43% test accuracy with convergence at epoch 12 compared to epoch 30 for baseline models. This increase in performance could be attributed to progressive pooling as it preserves spatial hierarchies and prevents abrupt information loss while it maintains translation invariance at multiple scales. The modified architecture proved to be more robust than the previous implementations as analysis of the misclassified instances showed that misclassification occurs due to extreme numerical visual similarity or ambiguity that even the human eye cannot read.

CT MathTech 2026-0170 Dengue Forecasting and Climate Attribution in the Philippines: A Comparative Study using Statistical, Machine Learning, and Deep Learning Models

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Regional dengue forecasting and climate attribution are both essential for evidence-based vector control planning in the Philippines, where climate variability influences seasonal transmission dynamics. This study applies seventeen forecasting models such as SARIMA-family models (SARIMA, SARIMAX, Negative Binomial GLM), tree-based machine learning regressors (Random Forest, XGBoost), Attention-LSTM deep learning architectures, and two hybrid approaches using monthly dengue surveillance data from all 17 Philippine regions from 2016 to 2025, augmented with reanalysis and satellite climate covariates from NASA (MERRA-2, GPM IMERG, MODIS LST) and the NOAA Oceanic Niño Index. On the forecasting comparison, SARIMAX with a COVID-19 regime indicator achieved the lowest absolute error (RMSE: 1,625.3 cases/month), while a weighted ensemble of SARIMAX and an Attention-LSTM with one-hot region encoding achieved the lowest proportional error (MAPE- τ : 59.04%; where τ denotes a 100-case threshold applied per region-month to avoid low-count inflation). On climate attribution, SHAP analysis of SARIMA forecast residuals identifies temperature and precipitation variables as the primary climate signals beyond seasonal autoregressive structure (67.4% of marginal attribution combined), with ENSO-related indices contributing an additional 21.4% through ONI at one-to-three-month lags. Elevated temperatures shorten the dengue virus extrinsic incubation period, while precipitation reductions in the Visayas and Mindanao due to El Niño promote drought-induced water storage practices that create *Aedes aegypti* breeding sites and amplify transmission risk. With the latest NOAA CPC ENSO Diagnostic Discussion confirming that El Niño conditions are present, the lagged climate signals identified in this study provide quantitative evidence for pre-emptive dengue preparedness, particularly in the Visayas and Mindanao region.

Financial Mathematics

CT MathTech 2026-0141 Dynamic Prediction of Insurance Premiums and Reserves During Outbreaks: COVID-19 in Indonesia as a Case Study

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Calculating insurance premiums and reserves during an epidemic poses a significant challenge for insurers seeking to mitigate financial risks. Outbreaks, particularly unprecedented events such as the Covid-19 pandemic, are characterized by rapid transmission, high severity, and high mortality rates. While numerous models have been developed to capture the dynamics of Covid-19, they often struggle to accommodate the sharp fluctuations in infection rates during rapid surges and declines. To address this, we employ a multiple logistic approach to estimate the transmission rate of the virus. This framework yields simulation results that dynamically track temporal data trends, allowing the transmission model to serve as an early warning system for case fluctuations. Furthermore, we integrate historical case data and transmission rates into a predictive analysis, demonstrating robust performance in capturing actual data trends. These predictions are subsequently used to calculate premiums and reserves. Additionally, we incorporate a loading factor adjustment to correct the predicted premiums, thereby ensuring pricing accuracy and financial stability.

CT MathTech 2026-0144 Implementation of Differential Evolution Algorithm for Solving ESG Portfolio Optimization with Buy-In Threshold Constraints

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We investigate an ESG portfolio optimization problem aimed at minimizing portfolio risk under buy-in threshold constraints. The proposed model is solved using the Differential Evolution (DE) algorithm, chosen for its strong convergence performance and effectiveness in handling nonlinear optimization problems. Constraint handling is implemented through a penalty function approach. Numerical experiments are conducted using data from five selected stocks to evaluate portfolio performance under continuous buy-in threshold constraints. The results show that DE can find the best proportion of this ESG portfolio with minimum risk is equal to 0.8827.

CT MathTech 2026-0172 Long Term Insurance Data Prediction Using MODWT and ARIMA Model

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Forecasting financial data is critical for stockholders, investors and policymakers. The main objective of this paper is to decomposing the Jordanian Insurance Financial data using Maximum over lapping Discrete Wavelet Transform then using Autoregressive Integrated Moving Average (ARIMA) method for predicting the future values. The datasets are from the Amman Stock Exchange (ASE) January 2022 to end of May 2026, the investigation offers appreciated visions for long-term forecasts. The results highlight the efficiency of the ARIMA (p, d, q) method, the results have compared based on Mean Square error (MSE). The finding highlights the ARIMA method's utility in guiding investment decisions and shaping future trading strategies for insurance stocks in the Amman Stock Market.

CT MathTech 2026-0175 AI-Based Predictive Analytics for Financial Time Series Using Hybrid Deep Learning Models

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Financial time-series forecasting is a challenging predictive analytics task because financial markets are noisy, nonlinear, non-stationary, and highly volatile. Traditional statistical models such as ARIMA and moving-average-based approaches provide useful linear modelling capabilities, but they often struggle to capture complex temporal dependencies and nonlinear market behaviour. Recent advances in artificial intelligence, particularly deep learning, have created new opportunities for modelling financial sequences using architectures capable of learning both short-term fluctuations and long-term dependencies. This paper proposes a hybrid deep learning framework for financial time-series forecasting that integrates one-dimensional convolutional neural networks, bidirectional long short-term memory, gated recurrent units, and an attention mechanism. The proposed model is designed to extract local temporal features, capture sequential dependencies in both forward and backward directions, reduce computational complexity through gated units, and assign greater importance to the most informative historical time steps. The framework includes data preprocessing, feature engineering, sliding-window transformation, normalization, model training, and evaluation using standard forecasting metrics including MAE, RMSE, MAPE, R^2 , and directional accuracy. The proposed approach is compared with baseline statistical, machine learning, and deep learning models. The expected contribution of this study is a robust and interpretable hybrid predictive analytics framework that improves financial forecasting performance while supporting data-driven decision-making in investment analysis, risk management, and financial planning.

CT **MathTech 2026-0207** Dynamic and Fixed Rebalancing Strategies in Factor-Based Index Tracking: Evidence from the S&P 100

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Passive asset management requires balancing two competing operational priorities: replicating the performance of a target benchmark index and minimizing transaction costs. While portfolio construction methods define the initial asset selection, the choice of out-of-sample rebalancing frequency represents the primary operational lever for managing tracking error and trading turnover. This study conducts a comprehensive comparative evaluation of four distinct rebalancing strategies: rigid, fixed-interval rebalancing at 20-day (monthly), 60-day (quarterly), and 120-day (semi-annual) frequencies, versus a dynamic, state-dependent Statistical Process Control (SPC) engine based on dual-band Exponentially Weighted Moving Average (EWMA) control charts. To evaluate these strategies under different market conditions, we construct four distinct, style-tilted asset replication environments using S&P 100 index components from 2009 to 2025: Low Beta, High Beta, Minimum Tracking Error (MinTE), and Maximum Sharpe Ratio (Max Sharpe). Each portfolio is restricted to exactly 30 stocks, with weights mathematically optimized using quadratic programming to minimize tracking error relative to the S&P 100 index. The empirical results show that the optimal rebalancing frequency is depends on the underlying market environment, with no single strategy consistently outperforming the others. In the defensive and low-volatility tracking environments (Low Beta), the SPC framework effectively limits unnecessary trading, achieving a monthly turnover of only 5.68% while maintaining a low tracking error. Notably, it outperforms the Fixed 120 strategy despite rebalancing nearly three times more frequently. Conversely, under the Minimum Tracking Error (MinTE) portfolio, the SPC framework experiences a boundary collapse, resulting in turnover and rebalancing frequency comparable to the Fixed 20 strategy. In the return-oriented Maximum Sharpe (Max Sharpe) portfolio, frequent SPC-triggered rebalancing interrupts momentum, reducing the benefits of return compounding. We interpret these findings from both statistical process control and financial market perspectives to develop a structured framework for selecting an appropriate rebalancing strategy.

CT **MathTech 2026-0209** Bridging Mathematical Coherence and Machine Learning: The HEG-CARR Framework for Volatility Forecasting

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Traditional range-based volatility models enforce mathematical coherence (positivity and nesting) but struggle with complex nonlinear dynamics, whereas pure machine learning approaches capture nonlinearity yet often sacrifice stability and auditability. This study introduces the Hierarchical Evidence-Gated Conditional Autoregressive Range (HEG-CARR) framework, which reconciles these tensions by anchoring forecasts on the CARR conditional mean and modelling corrections through log-ratio residuals. The architecture enforces forecast positivity, bounded corrections, and chronological information admissibility via four integrated mechanisms: validation-driven evidence gates, quantile residual bounds, evidence-class fusion, and recursive aggregation layer. These constraints ensure that machine learning adjustments are applied only when supported by out-of-sample evidence. We evaluate HEG-CARR across a broad universe of cryptocurrencies, foreign exchange rates, equities, and indices, employing four range estimators and fourteen base learners. Using fixed chronological splits and 7,195 rolling-window forecasts, we benchmark performance via statistical loss tests, ablation studies, and interpretability diagnostics. In the final holdout period, HEG-CARR reduces the equal-weight QLIKE loss by 5.14% relative to CARR, while maintaining a pooled 95% tail-risk exception rate of 4.99%, nearly matching the nominal level. However, several simpler ensemble rules achieve marginally lower average point losses; because the 95% risk mapping was applied only to HEG-CARR and CARR, these rules cannot be claimed to offer superior tail-risk calibration. The class-level geometric forecast emerges as the most parsimonious strong candidate, and the final recursion as the principal aggregation bottleneck. Mathematical structure and evidence-based gating can thus co-exist with machine learning to produce transparent, reproducible forecasts, while optimal aggregation remains an open design problem.

Interdisciplinary Mathematics

CT **MathTech 2026-0076** Topological Analysis of Metropolitan COVID-19 Epidemic Trajectories in the Philippines Using Persistent Homology

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The first year of the COVID-19 pandemic was a very critical phase worldwide, especially in the Philippines. It was characterized by waves of infection and evolving transmission patterns. This study examines reported COVID-19 cases in the country in 2020 using Topological Data Analysis (TDA) to investigate the underlying geometric properties of the data. Rather than focusing solely on peak counts or growth rates, the study analyzes the geometric structure of case trajectories over time. The time series data were transformed into a geometric point-cloud representation that captures the evolution of case counts across consecutive periods. Persistent homology was then applied to extract topological features. Quantitative descriptors derived from these features were used to characterize wave behavior and compare different phases of the pandemic. By examining the topological structure of COVID-19 case trajectories during the peak pandemic years, this study provides a different framework to analyze outbreak dynamics. The results indicate that the topological descriptors capture structural patterns in the progression of the disease that may not be fully reflected in other approaches. This approach contributes an additional quantitative perspective to understanding the spread of the disease and informing public health assessment.

CT **MathTech 2026-0197** Optimizing Medication Pathways for Diabetes with Cardiovascular Patients: A Decision Analysis Approach

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Diabetes and cardiovascular disease (CVD) are two severe health conditions. The presence of both diseases simultaneously is highly critical and increases the risk of death. Furthermore, the practice of taking multiple medicines (polypharmacy) increases the risk of medication errors. In Malaysia, prescription errors alone account for 24% to 76% of all drug errors, which can lead to dangerous drug-to-drug interactions (DDIs) for high-risk patients. Therefore, the objective of this study is to predict the safest and most optimal medication pathway for Type 2 Diabetes Mellitus (T2DM) patients with CVD while minimizing DDI risks. In this study, a Decision Analysis (DA) approach was applied. Relevant drug data and treatment procedures were collected from the Malaysian Clinical Practice Guidelines (CPG) and drug performance ratings were obtained from the Drugs.com website. The medication combinations were evaluated using decision trees and Expected Value (EV) mathematical calculations. The findings indicate that the most effective treatment option is the pathway with the highest EV reflecting the optimal treatment with the lowest interaction risk. This study provides a significant real-world impact on the medical industry. This prediction can assist pharmacists and doctors in identifying the best medications for T2DM with high-risk CVD patients, making it easier to select safe, personalized prescribing pathways and reduce critical medication errors.

Mathematical Modelling

CT MathTech 2026-0056 AI-Assisted for Convergence and Stability Analysis of the Fractional Composite Trapezoidal-Backward Differentiation Formulas

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Solving fractional differential equations might be challenging because of their non-local nature, where the solution is affected by the previous step. Consequently, the numerical error between previous solution and the current solution will be carried into the future solution, resulting in error accumulation. Therefore, performing stability analysis is crucial to ensure the error remains bounded and does not diverge significantly from the exact solution over the time. This study presents a stability analysis of fractional TR-BDF2, specifically the zero-stability and A-stability. To visualize the stability region, Maple software with artificial intelligence (AI)-assisted tools is utilized for handling Caputo derivatives, which involve complex structures such as the Gamma function and the Mittag-Leffler function. This approach significantly enhances standard Maple simulation algorithm by simplifying the symbolic coding process compared to manual computation in previous studies, thereby improving the procedure for proving the convergence and stability of the numerical method.

CT MathTech 2026-0148 Modelling Poverty Transitions among Asnaf Households in Selangor: A Three-State Markov Chain Analysis

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Poverty alleviation remains a primary goal of the Malaysian government, particularly since most of the poor are Bumiputera, for whom zakat institutions play a vital role in social safety nets. Current poverty identification relies on static measures such as Had al-Kifayah, however, these metrics are unable to capture the dynamic nature of socioeconomic mobility. This study aims to address this gap by developing a three-state Markov chain model to stochastically measure poverty transitions among Asnaf households in Selangor. Using longitudinal data from Lembaga Zakat Selangor, transition matrices were constructed to estimate transitions among three distinct states, including fakir, miskin, and non-poor. Results show that many households remain in the same poverty condition, while some are at risk of falling into a worse state. Analysis across years revealed a marked increase in upward mobility among Asnaf households after 2023, suggesting the positive impact of the proactive intervention programs implemented by LZS. The rural-urban comparison reveals significant disparities, with individuals in urban areas demonstrating a higher likelihood of transitioning out of poverty but simultaneously facing a greater risk of reverting to poverty compared to those in rural areas. The model further provides long-run equilibrium distributions, offering insights into the steady-state composition of poverty among the Asnaf population. The proposed poverty transition model provides an evidence-based framework for monitoring and improving socioeconomic mobility among Asnaf communities.

CT MathTech 2026-0152 Forecasting Disability-Free Life Expectancy Using an Extended Sullivan Model and Functional Lee-Carter Approach

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Disability-Free Life Expectancy (DFLE) provides a more comprehensive measure of population health than conventional life expectancy because it captures both survival and disability status. This study develops an integrated mathematical framework for projecting DFLE in Malaysia by combining mortality forecasting with projected disability prevalence using an extended Sullivan life table approach. Age- and sex-specific Malaysian mortality data from 1970 to 2019 were modelled using the Lee-Carter and Functional Lee-Carter approaches, and forecasting performance was evaluated using Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE). Disability prevalence data were obtained from the 2015 and 2019 National Health and Morbidity Surveys and were subsequently projected to 2030 using a reduction-based prevalence model. The better-performing mortality model was then integrated with projected disability prevalence to estimate future Life Expectancy (LE), DFLE, and Disability Life Expectancy (DLE) by age and sex. The results show that the Functional Lee-Carter model produced lower forecast errors than the original Lee-Carter model for both males and females. Historical Sullivan estimates indicate disability compression among males, but signs of disability expansion among females between 2015 and 2019. The 2030 projections suggest improvements in DFLE for both sexes, although disability remains concentrated at older ages, highlighting the importance of incorporating both mortality and disability in projecting DFLE. The proposed framework offers a robust approach for projecting DFLE and provides useful evidence to support healthy ageing policies, healthcare planning, and long-term care preparedness in Malaysia.

CT MathTech 2026-0153 Optimization-Based PM2.5 Forecasting and Mitigation in Chiang Mai, Thailand

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PM2.5 has become a major environmental and public health issue in Chiang Mai, Thailand, especially during period of biomass burning. This study aims to forecast PM2.5 and to find the optimal hotspot in Chiang Mai, Thailand. Two techniques between Ensemble regression model and nonlinear univariate optimization are combined. There are three datasets used in this study, including daily PM2.5 concentration data, satellite-based hotspot data, and weather data. Daily PM2.5 concentration data are collected from Air4Thai. The satellite-based hotspot data are from the Visible Infrared Imaging Radiometer Suite (VIIRS) and the weather variables, including average temperature and precipitation are obtained from the National Oceanic and Atmospheric Administration (NOAA). At the first step, daily pm2.5 is forecasted by ensemble regression model. The model performance achieved an RMSE of $17.36 \mu\text{g}/\text{m}^3$, an MAE of $9.96 \mu\text{g}/\text{m}^3$, and an R^2 of 0.506, indicating moderate predictive performance under highly nonlinear air pollution conditions. To support policy-based decision making, an optimization model called nonlinear univariate optimization was constructed to identify how much hotspots need to be reduced that minimizes PM2.5 concentration while simultaneously weighing costs of intervention. The proposed optimization framework lowered average PM2.5 concentration to $21.89 \mu\text{g}/\text{m}^3$ from an initial concentration of $24.66 \mu\text{g}/\text{m}^3$. The PM2.5 exceedance days also dropped from 64 days to 41 days, resulting in about a 35.9% decrease in unhealthy days from air pollution. An average hotspot reduction of around 19.8% was recommended by the optimization model in order to reach the lowered PM2.5 concentration. The results indicated that hotspot control measures can decrease unhealthy PM2.5 episodes significantly and that the proposed forecasting-optimization framework can provide a practical decision-support tool for biomass burning management and air quality policy implementation in Thailand.

CT MathTech 2026-0154 Stability Results for a Compartmental Disease Model with Quarantine and General Force of Infection

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In compartmental models of infectious diseases, it is common to use a bilinear incidence term involving the susceptible and infectious compartments. Recently, researchers have started to investigate SIR and SEIR models in which this bilinear term is replaced by a general functional form $F(S, I)$. Motivations for such studies include the limitations of the bilinear term in capturing saturation effects at high infection levels, and the desire for results that apply uniformly across many specific incidence functions. In this work, we continue these recent developments by studying an SEIQR model with a general force of infection, where quarantined individuals are assumed to be fully isolated, thereby not contributing to disease transmission. Under standard assumptions on the general functional form $F(S, I)$ for the force of infection, we establish well-posedness of the model by proving existence and uniqueness of solutions and positive invariance of the feasible region. The basic reproduction number $\mathcal{R}_0$ is then derived via the next-generation matrix method. Equilibria of the system are then fully characterized through some scalar function, whose zeros correspond exactly to steady states of the system. The structure of equilibria is further analyzed via a strictly decreasing function whose fixed points identify endemic steady states. We then prove that when $\mathcal{R}_0 < 1$, the disease-free equilibrium is the unique equilibrium in the feasible region, while when $\mathcal{R}_0 > 1$, a unique endemic equilibrium exists. Asymptotic stability of the disease-free equilibrium when $\mathcal{R}_0 < 1$ and instability when $\mathcal{R}_0 > 1$, are established via linearization. Asymptotic stability of the endemic equilibrium when $\mathcal{R}_0 > 1$, is proved via Routh-Hurwitz analysis of the cubic characteristic polynomial of the linearization. Global asymptotic stability results for the disease-free equilibrium are also obtained using a Lyapunov function together with LaSalle's invariance principle. Finally, we present some simulations to illustrate our results.

CT MathTech 2026-0211 Optimal Control Analysis of Malaria Transmission in the Presence of Insecticide Resistance and Climate Variability in Kenya

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Malaria remains a major public health concern in Kenya, where changing climatic conditions, insecticide resistance, and mosquito behavioral adaptations continue to challenge control efforts. This study developed and analyzed a climate sensitive malaria transmission model that incorporates mosquito behavior, insecticide resistance and vector-human ecological dynamics to identify optimal control strategies for the Kenyan context. The model's well-posedness was established, the basic reproduction number was computed using the next generation matrix method, and the stability of the equilibrium points assessed. Spatial analysis of the reproduction number was performed using temperature and rainfall raster data to map transmission risk across Kenya under varying insecticide use scenarios. Results indicate that regions with climatic conditions favorable for vector survival, particularly parts of the Eastern and Western regions, experience higher transmission intensity. Simulations show that while insecticide use (deltamethrin or permethrin) substantially reduces malaria prevalence, resistance increases the value of the reproduction number and sustained transmission. An optimal control problem incorporating personal protection, antimalarial treatment and vaccination was formulated and solved using Pontryagin's Maximum Principle. The most effective reduction in malaria prevalence was achieved when all three interventions were applied simultaneously. These findings highlight the importance of integrating vector behavior, climate variability, and resistance dynamics into malaria models and support the use of combined intervention strategies to enhance control efforts in Kenya.

Mathematics Education

CT MathTech 2026-0039 Technology-Enhanced Classroom: Using Chromecast and AirPlay Proprietary Screen Sharing Protocol via Google TV and Apple TV, Respectively for Effective Teaching at the University Level

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This study investigates the undergraduate students' perception of wireless screen-sharing technologies, specifically Chromecast and AirPlay via Google TV and Apple TV respectively as tools to enhance classroom teaching and learning. Grounded by the TPACK framework, it examined how the technologies influence classroom interaction, engagement, and the teaching flexibility perceived by the students in the class. A mixed-method approach was used, combining pre-survey and post-survey answered by undergraduates from Universiti Malaysia Pahang Al-Sultan Abdullah in the period of April and June 2025. The questionnaire consisted of Likert-scale items and open-ended questions that examined students' views and perceived impact before and after using wireless screen-sharing technologies. The quantitative data were analysed using descriptive statistics, normality test, and inferential test including the paired t-test and Wilcoxon signed-rank test. Results showed no statistically significant difference between pre-survey and post-survey scores, which revealed by the qualitative findings that students already held very positive perceptions prior to classroom exposure. Our findings also showed that while students valued the technology's benefits such as efficiency, engagement, and mobility, they also addressed concerns such as connection stability and initial technical difficulties. The study concludes that while wireless screen-sharing technologies can enhance flexibility and collaboration in the classroom, its success depends heavily on the readiness of the infrastructure and institutional support to ensure a smooth classroom session.

CT MathTech 2026-0085 Redesigned Frayer Model Graphic Organizer in Statistics and Probability: Its Effect on the Academic Performance, Attitude, and Motivation of Academic Track Senior High School Students

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This study investigated the effectiveness of the Redesigned Frayer Model Graphic Organizer (RFM-GO) in improving the academic performance, attitude, and motivation of Academic Track Senior High School (AT-SHS) students in Statistics and Probability. The study employed a quasi-experimental multifaceted research design integrating descriptive, comparative, and correlational approaches. Forty-five AT-SHS students from San Jose City National High School–Senior High School during the School Year 2025–2026 participated in the study. The respondents were classified as low achievers, average achievers, and high achievers based on their academic standing. Data were gathered using a researcher-made pretest and post-test, a modified Students' Attitude toward Statistics and Probability questionnaire, and a Statistics and Probability Motivation Questionnaire. Descriptive statistics in the form of frequency, percentage, mean, and standard deviation were applied to analyze the data whereas inferential statistics comprising of Wilcoxon Signed-Rank Test and Spearman-rank correlation were applied to find any significant difference and relationship between the variables. The results showed that the post-test scores of the students had improved significantly after using the RFM-GO. In addition, there was also found to be decreased anxiety and test anxiety level of the students whereas confidence, enjoyment, benefits/value, intrinsic value, self-regulation, self-efficacy, and utility value increased after the intervention. It was also found that the utilization of the RFM-GO helped to improve academic performance and affective learning outcomes of the students. Thus, it can be concluded that Redesigned Frayer Model Graphic Organizer is a learner-centered instructional strategy which helps the students learn meaningfully and improve their performance and attitude towards Statistics and Probability.

CT **MathTech 2026-0093 Attitude towards Problem-Based Learning as Predictor of Problem-Solving Skills among Preservice Mathematics Teachers**

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Problem-solving skills involve analyzing complex issues, breaking them down, and finding effective solutions. Problem-Based Learning (PBL) was utilized to enhance the problem-solving skills of preservice mathematics teachers that are difficult to enhance using traditional approaches. However, attitude towards PBL has big effect on how effective it will improve problem-solving skills. Grounded by Theory of Planned Behavior, students who have a favorable attitude towards PBL are more likely to engage actively in problem-solving activities. Moreover, while constructivist methods were increasingly advocated, there is a dearth of empirical evidence linking preservice teachers' attitudes toward PBL with their level of problem-solving skills. Hence, this study seeks to determine whether the level of attitude towards PBL significantly predicts the problem-solving skills of preservice mathematics teachers. A total of 159 preservice mathematics teachers were selected from Central Luzon State University, Philippines. Furthermore, data were collected using Attitude Towards PBL Scale, consisting of affective, behavioral and cognitive components, and validated researchers-made non-routine problem-solving aligned with the Philippines' Mathematics Curriculum, and the answers were evaluated using Polya's Four-Step Problem-Solving Process. The descriptive analysis found that preservice mathematics teachers exhibited a positive attitude towards PBL and more than half had an average level of mathematical problem-solving skills. Additionally, multiple linear regression showed that cognitive component and affective component were significant predictors of problem-solving skills, while behavioral was not. These findings suggest that enhancing cognitive and affective attitude towards PBL may be more effective than concentrating on behavioral components for enhancing problem-solving skills in educational contexts.

CT **MathTech 2026-0204 Development and Validation of an Interactive Digital Learning Module for Additional Mathematics**

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This study aimed to develop and evaluate a digital-based learning module for the Form Four Additional Mathematics topics of Indices, Surds, and Logarithms. The module was developed based on the Sidek Module Development Model by incorporating constructivist and cognitive learning principles. Content validity was evaluated by three subject-matter experts using the Content Validity Index (CVI), whereas reliability was assessed using responses from 66 Mathematics trainee teachers. Descriptive statistics and Cronbach's alpha coefficient were employed to evaluate the validity and reliability of the developed module. The content validity analysis demonstrated perfect expert agreement, with both the item-level and scale-level Content Validity Index values of $I\text{-CVI} = 1.00$ and $S\text{-CVI} = 1.00$. The overall reliability coefficient was $\alpha = 0.794$, indicating satisfactory internal consistency. The mean scores for the seven evaluation constructs ranged from 3.18 to 3.64 on a four-point Likert scale, reflecting moderate to high levels of user acceptance. Among the evaluated constructs, module presentation obtained the highest mean score ($\bar{x} = 3.64$), whereas module flexibility recorded the lowest ($\bar{x} = 3.18$). These findings indicate that the proposed module demonstrates acceptable content validity and reliability and is suitable as a supplementary instructional resource for teaching Additional Mathematics. The study contributes an empirically evaluated digital learning module that supports technology-enhanced mathematics education and provides a practical framework for future educational module development.

CT MathTech 2026-0301 Predicting SPM Outcomes from Continuous Assessments in MRSM: A Regression Analysis

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The capacity to predict summative academic performance using formative, continuous assessment data is a foundational objective within Educational Data Mining (EDM) and learning analytics (Bakhshinategh et al., 2018; Papamitsiou & Economides, 2014). In the Malaysian educational context, the Sijil Pelajaran Malaysia (SPM) serves as the definitive high-stakes national examination, determining tertiary education pathways and labor market entry. Recent systemic reforms have increasingly prioritized continuous Classroom-Based Assessment (CBA) to foster holistic learning; however, the predictive validity of these internal school assessments relative to the standardized SPM remains an area requiring rigorous empirical validation. This study deploys a Multiple Linear Regression (MLR) framework to analyze a large-scale dataset comprising 1,949 Maktab Rendah Sains MARA (MRSM) students, evaluating the predictive power of sequential Form 4 and Form 5 internal examinations on the final SPM outcome. The empirical results demonstrate that the combination of continuous assessments is a highly significant predictor of SPM success ($R^2 = 0.5014$, $p < 0.001$). Sequential analysis reveals the principle of temporal proximity, with the final Form 5 trial examination exerting the strongest predictive influence ($\beta = 0.1481$). Conversely, the end-of-year Form 4 examination demonstrated no statistically significant predictive validity ($p = 0.325$). Furthermore, distributional analyses revealed severe variance compression in the SPM results (kurtosis = 5.57) compared to internal assessments, an expected phenomenon within the highly selective, high-performing MRSM demographic. These findings underscore the necessity of enhancing assessment literacy among educators and provide a statistical foundation for the development of localized Early Warning Systems (EWS) to identify and support academically at-risk students well before high-stakes evaluations occur.

CT MathTech 2026-0302 Predictive Validity of Internal Assessments on National Secondary School Mathematics Examination (SPM) Achievement Across MRSM Programs: An Educational Data Analytics Study

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This study aims to analyze the predictive validity of internal assessments on Mathematics achievement in the *Sijil Pelajaran Malaysia* (SPM) examination across multiple MRSM academic programs. Utilizing an educational data analytics approach, this quantitative study utilized secondary data harmonized from six MRSM program datasets: BITARA, IGCSE, Ulul Albab, Premier and Borneo. A total of 10,913 student records were analyzed. The predictor variables consisted of internal assessment scores from Form 4_1, Form 4_2, Form 5_1, and Form 5_2, while the criterion variable was SPM Mathematics achievement. Data analysis involved descriptive statistics, Pearson correlation, multiple linear regression, multicollinearity diagnostics, and decision tree modeling to develop academic support profiles. The findings indicate that all internal assessment points possess a positive relationship with SPM Mathematics achievement, with consistently higher correlations observed in Form 5 assessments. The overall regression model was statistically significant, $F(4, 10908) = 2135.49$, $p < .001$ accounting for 43.9% of the variance in SPM Mathematics achievement. When controlling for program differences, the explanatory power of the model increased to 46.8%. Form 5_2 emerged as the strongest predictor in the overall model ($\beta = .348$), followed by Form 5_1 ($\beta = .272$). Furthermore, the decision tree analysis generated five distinct academic support profiles: Intensive Support, Targeted Remediation, Core Reinforcement, Excellence Acceleration, and Enrichment. These findings demonstrate that internal assessment data are not only suitable for performance reporting but also hold significant potential to serve as the foundation for early warning dashboards and more systematic SPM Mathematics intervention planning at the Bahagian Pendidikan Menengah MARA (BPM) level.

CT MathTech 2026-0303 Data-Driven SPM Mathematics Intervention Design: Evidence from Internal Assessment Patterns in Selected Premier Program MRSM

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Internal assessment serves as an important source of academic data for monitoring students' learning progress continuously. However, its use in schools is often limited to achievement reporting rather than supporting targeted early intervention planning. Therefore, this study was conducted to identify internal assessment patterns that differentiate SPM Mathematics achievement and to develop data-driven academic support profiles among selected MRSM Premier Program students. The study employed a quantitative predictive analytics design using the CRT Decision Tree method through IBM SPSS Statistics. The dataset involved 2013 students, with 1448 students assigned to the training sample and 565 students to the testing sample. Predictor variables consisted of FORM4_1, FORM4_2, FORM5_1 and FORM5_2, while SPM Mathematics achievement served as the dependent variable. FORM5_1 emerged as the primary root node with a split point of 36.5, followed by FORM5_2 as the next significant splitting variable. The CRT model generated five academic support profiles namely Intensive Support, Targeted Remediation, Core Reinforcement, Excellence Acceleration, and Enrichment. The risk estimate values for the training and testing samples were 30.091 and 32.703, respectively, indicating relatively consistent model patterns across both samples. Overall, Decision Tree analysis has the potential to assist teachers in translating internal assessment data into earlier, targeted, and evidence-based SPM Mathematics interventions while complementing teachers' professional judgement in pedagogical practice.

CT MathTech 2026-0304 Prediction of SPM Mathematics Achievement using Multiple Regression Analysis in Microsoft Excel: A School-Based Educational Data Analytics Study

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This study investigates the extent to which prior and concurrent Mathematics achievement indicators predict performance in the Sijil Pelajaran Malaysia (SPM) Mathematics examination among students in MRSM BITARA institutions. A quantitative correlational design with a predictive approach was employed, using secondary academic data from a sample of 2,555 students. The dependent variable was SPM Mathematics achievement, while the independent variables included FORM 4_1, FORM 4_2, FORM 5_1, and FORM 5_2, representing continuous assessment indicators prior to the SPM examination across three MRSM BITARA colleges: MRSM Pengkalan Chepa, MRSM Taiping, and MRSM Tun Ghafar Baba. Data analysis was conducted using Microsoft Excel as the primary analytical platform, incorporating descriptive statistics, Pearson correlation analysis, scatterplot visualization, residual diagnostics, and multiple regression modelling via the Data Analysis ToolPak. The results revealed that all predictor variables were positively associated with SPM Mathematics achievement. The regression model was statistically significant, $F(4, 2550) = 342.00$, $p < 0.001$, accounting for 34.9% of the variance in SPM Mathematics scores ($R^2 = 0.349$). All predictors FORM 4_1, FORM 4_2, FORM 5_1, and FORM 5_2 contributed significantly to the model. However, the negative regression coefficient observed for FORM 4_2 indicates potential multicollinearity or shared variance among predictors. Notably, FORM 5_1 and FORM 5_2 emerged as the most robust predictors of SPM Mathematics performance. These findings underscore the practical utility of Microsoft Excel as an accessible and effective tool for educational data analytics in school settings. Nevertheless, careful attention should be given to diagnostic testing and multicollinearity issues to ensure the validity and robustness of predictive models.

CT MathTech 2026-0305 Predicting SPM Mathematics Achievement Using Internal Examination Results

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This study aims to analyse the relationship and identify the predictive factors of SPM Mathematics achievement based on internal examination performance among MRSM Ulul Albab students. The study employed a quantitative correlational and regression approach involving secondary data from 1357 MRSM Ulul Albab students who sat for the SPM examination from 2023 to 2025. The data analysed included Semester I Form 4, Semester II Form 4, Semester III Form 5, SPMRSM and actual SPM Mathematics results. Descriptive statistics, Pearson correlation and multiple linear regression analyses were conducted using Statistical Package for Social Sciences (SPSS). The findings revealed that all variables had significant relationships with SPM Mathematics achievement at $p < 0.001$. The strongest relationships were recorded between Semester III and SPM Mathematics ($r = 0.619$), followed by SPMRSM and SPM Mathematics ($r = 0.612$). Multiple regression analysis indicated that the regression model was significant, $F(4, 1352) = 234.126$, $p < 0.001$ with an R^2 value of 0.409. This indicates that 40.9% of the variance in SPM Mathematics achievement could be explained by the students' internal examination performance. Semester III ($\beta = 0.383$) and SPMRSM ($\beta = 0.366$) were identified as the strongest predictors of SPM Mathematics achievement. The study demonstrates that internal examination performance can be used as an early indicator to identify at-risk students and assist MRSM in planning more systematic and data-driven academic interventions.

CT MathTech 2026-0051 Coherent Cause-Specific Mortality Forecasting with Redistribution Using Compositional Data Analysis

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This study assesses the independent Lee-Carter and coherent Li-Lee models against a suggested Compositional Data Analysis (CoDA) framework in order to address the systemic flaws in multi-cause mortality forecasting. We address a widespread fitting problem in which short-term empirical flexibility is given up for long-term biometric feasibility in unconstrained models. Our findings from systematic cause removal studies show that the traditional Li-Lee model produces significant post-hoc closure scale distortions, projecting unregulated lifespan expansions across extended horizons, while the independent Lee-Carter model displays structural paralysis. We use isometric log-ratio (ilr) transformations to natively incorporate the Li-Lee architecture within a limited simplex in order to address these shortcomings. A mathematically stable lifetime trajectory is produced by the resultant CoDA framework, which ensures absolute sub-compositional invariance. This design effectively depicts genuine competing risk dynamics by demonstrating that circulatory cause can reallocate late-life exposure toward emerging other diseases.

CT MathTech 2026-0109 A Comparative Study of Hybrid Models Integrating Principal Component Analysis with Regression Techniques in the Drying Process of Black Pepper

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The drying process of black pepper (*Piper nigrum*) generates high dimensional, multicollinear, and noisy datasets, severely limiting the efficacy of conventional statistical modeling approaches. To address these challenges, this study proposes a hybrid data driven framework that sequentially integrates standard principal component analysis with regularized regression methods (Lasso, Ridge, and Elastic Net) and robust regression estimators (M, MM, LTS, and S estimators). In the first stage, standard principal component analysis is performed as a classical textbook approach to compress 28 highly correlated physical variables into 6 orthogonal principal components explaining approximately 95% of the cumulative variance. Furthermore, second order interaction terms among these retained principal components are explicitly introduced to model latent nonlinear relationships often overlooked by purely linear methods. To enhance model interpretability, a principal component traceback analysis maps influential components and their interactions back to the original physical variables, thereby identifying the key factors governing the drying process. The empirical results demonstrate that pairing these standard principal components and their interaction terms with robust regression, particularly the S estimator, yields superior predictive performance ($R^2 = 0.970$, $RSE = 3.790$), significantly outperforming traditional regularized and alternative robust frameworks. Ultimately, the proposed sequential framework successfully mitigates multicollinearity, captures nonlinear interactions, and provides a highly stable, interpretable, and scalable approach to support data driven decision making in sustainable precision agriculture.

CT MathTech 2026-0167 Does the Belt and Road Initiative Accelerate System Performance, Transition Readiness, and Energy Transition Index? Evidence from a Residualized Quantile Regression Approach

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The Belt and Road Initiative (BRI) has become a defining force in global infrastructure and energy development, yet its role in advancing sustainable energy transitions remains contested. This study examines whether BRI participation accelerates energy transition, system performance, and transition readiness across 87 member countries from 2018Q1–2025Q4. Using Residualized Quantile Regression (RQR), complemented by Unconditional Quantile Regression and Panel OLS, we uncover significant distributional heterogeneity. Results show that BRI participation improves energy-system performance, particularly in low-performing countries, but has weak and often insignificant effects on the Energy Transition Index. Transition readiness is negatively affected, highlighting that infrastructure investment alone does not strengthen institutional, technological, or regulatory capacity. Sub-sample analysis reveals that countries in the low segment of upper-middle transition level captures greater benefits, while those in the higher context of low-human development gain more in transition outcomes. These findings suggest that the BRI contributes more to operational energy outcomes than to long-term transition readiness. Policy implications emphasize the need to complement infrastructure financing with institutional reforms, technological innovation, and renewable energy development to ensure that BRI participation supports inclusive and sustainable energy transitions.

Pure Mathematics

CT MathTech 2026-0011 Steinerberger Curvature on Digraphs: Discrete Bonnet–Myers and Lichnerowicz Theorems

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Steinerberger curvature encodes the global distance geometry of a graph through an equilibrium measure. In this paper, we derive explicit curvature formulas for undirected Cayley graphs of dihedral groups D_n and generalized quaternion groups Q_{4m} . We then extend Steinerberger curvature to strongly connected simple digraphs by introducing in-curvature and out-curvature, reflecting the asymmetry of directed distances. For these directed curvatures, we establish structural properties, including negativity criteria and a permutation relation between in- and out-curvature. Our main results are directed analogues of the Bonnet–Myers, Cheng’s and Lichnerowicz theorems, together with reverse Bonnet–Myers inequalities for directed diameter and out-radius, and an upper bound for in-radius in terms of total curvature.

CT MathTech 2026-0030 On the Nilpotent Graph of the Ring of Integers Modulo n

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The nilpotent graph of the ring of integers modulo n , denoted $G(\mathbb{Z}_n)$, is defined on the vertex set $\mathbb{Z}_n \setminus \text{Nil}(\mathbb{Z}_n)$, where two distinct vertices x and y are adjacent if $x + y$ is nilpotent. An element $d \in \mathbb{Z}_n$ is nilpotent if $d^k = 0$ for some positive integer k . The structure of $G(\mathbb{Z}_n)$ has been studied for various values of n , showing decompositions into complete subgraphs, complete bipartite subgraphs, and regular subgraphs depending on the factorization of n . In this paper, we present an alternative approach that emphasizes the regularity of subgraphs. By partitioning n into equivalence classes, we describe the structural properties of $G(\mathbb{Z}_n)$ for all positive integers n . Specifically, when $n = p_1^{a_1} p_2^{a_2} \dots p_m^{a_m}$ with distinct odd primes $p_1, \dots, p_m$, the graph decomposes into multiple copies of k -regular subgraphs, where $k = p_1^{a_1-1} p_2^{a_2-1} \dots p_m^{a_m-1}$. If n includes 2 as a prime factor, $G(\mathbb{Z}_n)$ additionally contains a complete subgraph together with k -regular subgraphs, highlighting the regular structure of the graph.

CT MathTech 2026-0049 Multiset Resolving Sets in Strong Products of Paths

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The vertex identification problem has been studied both for its theoretical significance and potential applications. Given a graph G , one approach for the vertex identification problem is to identify a subset W of vertices of G and then assign to each vertex v a multiset code, which corresponds to the multiset of distances between v and each of the vertices in W . If the resulting multiset codes are pairwise distinct, then W allows for the identification of the vertices of G and is called a multiset resolving set of G . If G possesses at least one multiset resolving set, then G is said to have finite multiset dimension $md(G)$, given by the minimum possible cardinality of such a set. If no multiset resolving set exists in G , then G is said to have infinite multiset dimension. Researchers’ interest on this topic is partially motivated by a computational complexity result of Hakanen and Yero, who established that the multiset dimension problem is NP-complete. They also studied multiset resolving sets in king grids that are obtained by taking the strong product of two paths of the same order. In this paper, we extend their work by investigating multiset resolving sets in strong products of two paths with arbitrary orders. For $m, n \geq 2$, our results lead to a characterization of all strong products $P_m \boxtimes P_n$ that have finite multiset dimension.

CT MathTech 2026-0050 Twin Intersection Edge Colorings of Grids and Prisms

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Given an edge coloring f of a graph G in which the edge colors are nonempty subsets of the set $1, 2, \dots, k$ for some positive integer k , a vertex coloring f' can be induced by defining $f'(v)$, for each vertex v , to be the intersection of all edge colors incident with v . Previous literature has focused on the case when f' is required to be a proper vertex coloring while no other restriction is imposed on f . Recently, we have introduced the notion of twin intersection edge coloring, which refers to the case when both f and f' are proper edge and vertex colorings, respectively. The smallest value of k for which G has a twin intersection edge coloring is called the twin intersection chromatic index of G . Our first focus in this work is to discuss how technology, particularly computer programming, can be used to aid research on this new topic. In particular, we develop a recursive procedure that can search for twin intersection edge colorings of a given graph. The procedure is implemented in a publicly available Google Colab notebook, whose features are also presented in this work. Using this recursive procedure as one of our tools, we then proceed to determine the twin intersection chromatic indices of grids and prisms.

CT MathTech 2026-0058 Adaptive Bracket Search with Newton-Regula Falsi Hybrid for Non-Linear Equations

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We present a hybrid of Newton-Raphson (NR) and Regula Falsi (RF) methods integrated with an adaptive bracket search strategy for solving nonlinear equations without requiring a pre-identified bracketing interval. Most of the existing hybrid approaches typically assume an initial interval where the function changes sign. However, this interval may not be readily available in many practical problems wherein only a single initial estimate of the root is provided. To address this limitation, our proposed method employs an adaptive search approach to detect possible function sign change, which is made possible by dynamically adjusting step sizes according to local function behavior to reduce unnecessary function evaluations while increasing the likelihood of identifying a valid interval that contains the root. After establishing the search space, the method transitions into the NR-RF hybrid wherein the Regula Falsi method maintains guaranteed convergence within the interval while the Newton updates are selected to accelerate convergence near the root when the derivative is reliable. Numerical tests are conducted to demonstrate the effectiveness of our approach.

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Throughout this paper, only finite, simple, connected, undirected, and nontrivial graphs are considered. For any positive integer k , a proper rainbow k -coloring of a graph G is defined as a mapping $c : E(G) \rightarrow \{1, 2, \dots, k\}$ that constitutes a proper edge coloring and ensures that every pair of distinct vertices $u, v \in V(G)$ is connected by a $u - v$ path whose edges receive pairwise distinct colors. The distance between two edges $e_1 = u_1v_1$ and $e_2 = u_2v_2$ of G is specified as

$$d(e_1, e_2) = \begin{cases} \min\{d(u_1, u_2), d(u_1, v_2), d(v_1, u_2), d(v_1, v_2)\} + 1, & \text{if } e_1 \neq e_2, \\ 0, & \text{if } e_1 = e_2. \end{cases}$$

The ordered partition of $E(G)$ induced by the coloring is denoted by $\Pi = \{R_1, R_2, \dots, R_k\}$, where R_i contains the edges colored with i for each $i \in \{1, 2, \dots, k\}$. The rainbow code of an edge $e \in E(G)$ with respect to Π is expressed as

$$rc_{\Pi}(e) = (d(e, R_1), d(e, R_2), \dots, d(e, R_k)),$$

where $d(e, R_i) = \min\{d(e, f) | f \in R_i\}$. When pairwise distinct rainbow codes are produced for all edges, c is referred to as a locating proper rainbow edge k -coloring of G . The smallest integer k enabling the existence of such a coloring is called the locating proper rainbow edge connection number of G , denoted by $precl(G)$. In this work, this parameter is determined for various graph classes having diameter two.

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We introduce and study a new coloring parameter, called the locating proper rainbow vertex connection number, for complete graphs and for several operations on them. A proper rainbow vertex coloring is a vertex coloring such that neighboring vertices never share a color and such that between any two vertices there is a path whose internal vertices receive mutually different colors. Whenever all vertices also have distinct rainbow codes, the coloring is said to be a locating proper rainbow vertex coloring. Exact values of this parameter are established here for complete graphs as well as for their amalgamations, their comb products, and their shackle products.

CT MathTech 2026-0072 The Locating Rainbow Edge Connection Numbers for Several Variations of Squid Graphs

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An edge coloring of a connected graph is called a locating rainbow edge coloring when it fulfills two requirements which are between every pair of vertices there must exist a path whose edges have different colors, and each edge can be uniquely identified through its distances from the different edge-color classes. The smallest number of colors for which such a coloring exists is referred to as the locating rainbow edge connection number. This paper introduces three families of graphs built from squid graphs, namely odd squid graphs, even squid graphs, and long squid graphs. We establish exact formulas for the locating rainbow edge connection number of each family.

CT MathTech 2026-0099 Perfect Precise Colorings of Euclidean Tile-Transitive Isogonal Tilings

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This work catalogues the perfect precise colorings of tile-transitive isogonal tilings of the Euclidean plane. A perfect precise coloring is a coloring that is both perfect and precise. In a perfect coloring, every symmetry of the tiling induces a permutation of the colors. In a precise coloring, each color appears exactly once around every vertex of the tiling. A framework for obtaining perfect precise colorings of a tile-transitive isogonal tiling is also presented.

CT MathTech 2026-0120 Sufficient Conditions for Analytic Functions to be Janowski Starlike

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Let A, B, C, D, α and β be real numbers and let p be an analytic function defined on the open unit disk, $p(0) = 1$. Conditions on real parameters A, B, C, D, α and β are determined so that $(1 - \alpha)p(z) + \alpha p^2(z) + \beta zp'(z)$ being subordinated to $(1 + Cz)/(1 + Dz)$ to imply p is subordinated to $(1 + Az)/(1 + Bz)$. The result is applied to Bernardi's integral operator of a class of analytic functions. Similar results are also obtained by considering the expressions $p(z) + zp'(z)/p^2(z)$ and $p^2(z) + zp'(z)/p(z)$. These results are used to obtain sufficient conditions for normalized analytic functions to be Janowski starlike.

CT MathTech 2026-0192 Which Polyhedra Admit Plain Weavings?

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In a weaving on a polyhedron, a ring is a closed strip of constant width that may be viewed as a rectangular strip of paper with zero thickness joined end to end to form a cylinder. At each point Q on the polyhedron that does not lie on the boundaries of the rings, the rings containing Q are assigned a ranking, and this ranking remains consistent throughout the weaving. The ranking specifies which ring passes over or under another ring at a crossing. A plain weaving on a polyhedron is a two-fold weaving in which each ring alternately passes over and under at successive crossings. Such structures provide interesting connections between geometry, topology, and combinatorial design, particularly in the study of polyhedral constructions and symmetric weaving patterns. In this presentation, we establish a necessary condition for a polyhedron to admit a plain weaving and describe how the geometric arrangement of faces and edges influences the existence of admissible weaving configurations. In addition, we present a systematic construction method for obtaining polyhedra admissible to plain weavings from regular or semiregular polyhedra. The method involves replacing every face of the given polyhedron with a baseless pyramid whose faces are isosceles triangles, thereby creating a modified polyhedral structure suitable for weaving patterns. We also discuss examples arising from classical polyhedra and illustrate how plain diagrams derived from polyhedral nets can be used to determine the rankings of rings at crossings and visualize the resulting weaving structures.

CT MathTech 2026-0202 On the Nonnegative Integer Solutions of the Diophantine Equation $F_n^x + L_n^x = y^2$

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In this paper, we solve the Diophantine equation $F_n^x + L_n^x = y^2$, where F_n and L_n are the n th Fibonacci and Lucas numbers, respectively. By exploiting fundamental properties of Fibonacci and Lucas numbers, together with techniques involving Pell's equation, Matveev's theorem, Dujella-Pethő lemma, as well as several elementary number-theoretic arguments, we determine all nonnegative integer solutions to the equation. In particular, we show that the solutions are $(n, x, y) = (0, 2t, 2^t), (2, 1, 2), (5, 1, 4)$, where $t \geq 1$ is an integer. These results extend earlier studies on perfect powers involving Fibonacci and Lucas numbers and contribute to the growing literature of Diophantine equations generated by linear recurrence sequences.

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