UNIVERSITI SAINS MALAYSIA

APEX

THE INTERNATIONAL CONFERENCE ON MATHEMATICAL SCIENCES AND TECHNOLOGY 2026

MaTech 2026

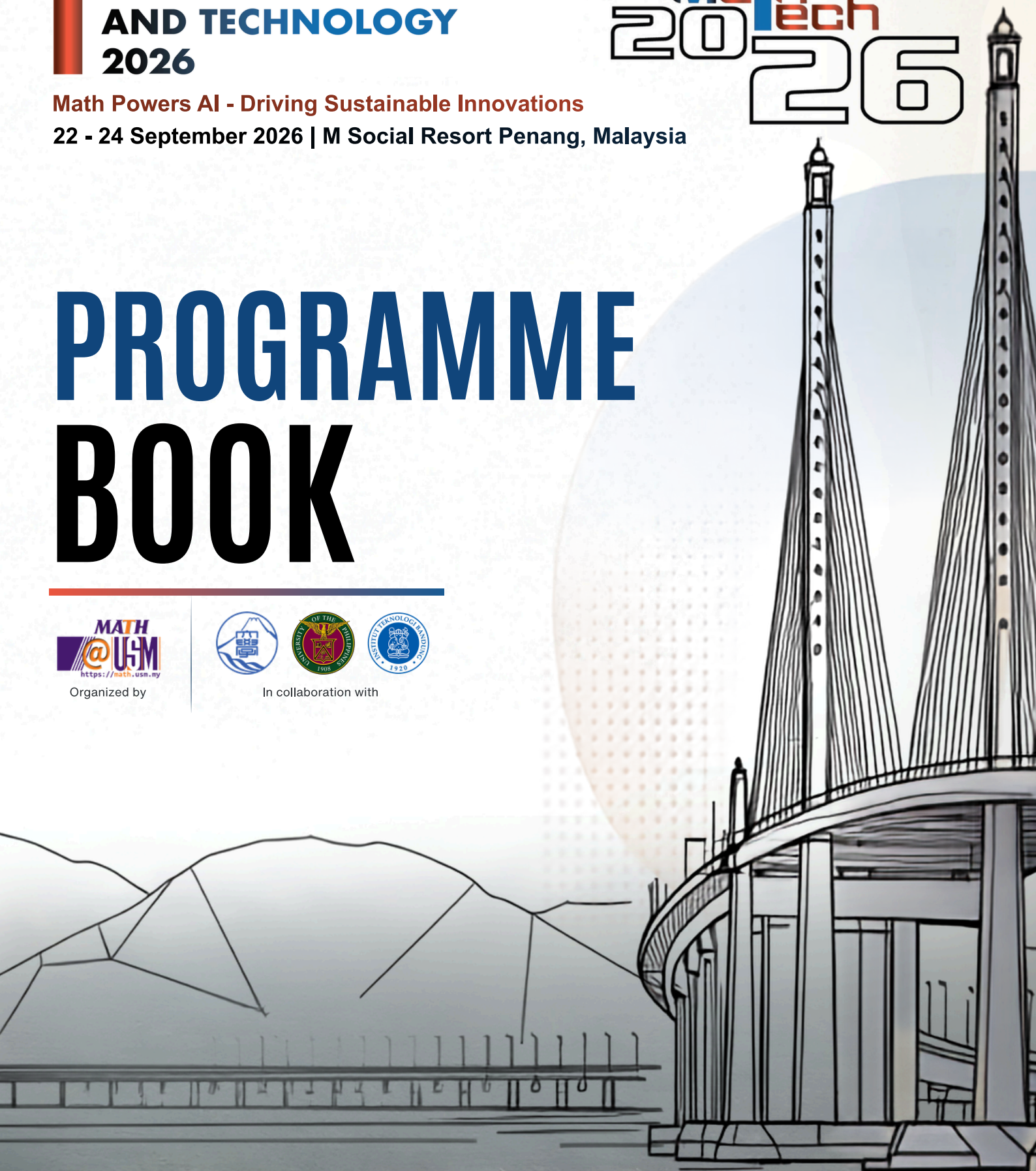
Math Powers AI - Driving Sustainable Innovations

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

PROGRAMME BOOK

Organized by

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Forewords



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 1: 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 – 12:00	Pavilion Ballroom	PT **Plenary Talk 2: Prof. Emeritus Dr. Kenjiro T. Miura** Aesthetic Curves and Interpolating Splines Chairperson: Assoc. Prof. Dr. Gobithaasan Rudrusamy
12:00 – 13:00	Pavilion Ballroom	PT **Plenary Talk 3: Prof. Dr. Hailiza Kamarulhaili** From Ancient Ciphers to Post-Quantum Cryptography: Advancing Cryptographic Resilience in the Era of Emerging Technologies Chairperson: Assoc. Prof. Dr. Lee See Keong
13:00 – 14:30	Beast & Butterflies	**Lunch Break**
14:30 – 17:00	Pavilion 1	IT **Invited Talk 1: Prof. Dr. Rizavel C. Addawe** CT Parallel Session 1A
	Pavilion 2	IT **Invited Talk 2: Asst. Prof. Joseph Ludwin D. Marigmen** CT Parallel Session 1B
	Vista	IT **Invited Talk 3: Dr. RR. Kurnia Novita Sari** CT Parallel Session 1C
16:40 – 17:40	Pavilion Foyer	**Afternoon Tea Break**
20:00 – 22:00	Pavilion Ballroom	**Dinner**

PT - Plenary Talk IT - Invited Talk CT - Contributed Talk

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

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

08:30 – 10:30	Pavilion 1	CT Parallel Session 2A
	Pavilion 2	CT Parallel Session 2B
	Vista	CT Parallel Session 2C
	Pavilion 3	WS Workshop 1
		CT Virtual Presentation: https://mathtech.usm.my/programme/virtual-sessions
10:30 – 10:50	Pavilion Foyer	**Morning Tea Break**
10:50 – 12:50	Pavilion 1	CT Parallel Session 3A
	Pavilion 2	CT Parallel Session 3B
	Vista	IT **Invited Talk 4: Prof. Dr. Zabidin Salleh** CT Parallel Session 3C
	Pavilion 3	WS Workshop 2
		IT **Invited Talk 5: 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 4: 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 6: Prof. Dr. Darren Ong Chung Lee** CT Parallel Session 4B
	Vista	CT 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

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

Day 3 | 24 September 2026 (Malaysia Time / GMT+8)

08:30 – 10:30	Pavilion 1	CT Parallel Session 5A
	Pavilion 2	CT Parallel Session 5B
	Vista	CT Parallel Session 5C
	Pavilion 3	WS Workshop 4
10:30 – 10:50	Pavilion Foyer	**Morning Tea Break**
10:50 – 12:50	Pavilion 1	CT Parallel Session 6A
	Pavilion 2	IT **Invited Talk 7: Assoc. Prof. Dr. Ikha Magdalena** CT Parallel Session 6B
	Vista	CT Parallel Session 6C
	Pavilion 3	WS Workshop 5
12:50 – 13:10	Pavilion 1	**Closing Ceremony**
13:10 – 14:10	Beast & Butterflies	**Lunch Break**
14:10 – 17:00	Social Hub	Research Collaboration and Networking

CT - Contributed Talk IT - Invited Talk WS - Workshop

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

Parallel Sessions & Workshops

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

Parallel Session 1

Time	Pavilion 1 **Parallel Session 1A** Mathematical Modelling **Chairperson:** Dr. Yazariah Mohd Yatim	Pavilion 2 **Parallel Session 1B** Operations Research and Statistics **Chairperson:** Assoc. Prof. Dr. Mohd Tahir Ismail	Vista **Parallel Session 1C** Artificial Intelligence and Machine Learning **Chairperson:** Assoc. Prof. Dr. Mohd Shareduwan Mohd Kasihmuddin	Pavilion 3
14:30 – 15:00	**Invited Talk 1** **Prof. Dr. Rizavel C. Addawe** Towards "Zero By 30": Epidemiological, Temporal, And Spatial Modeling of Animal Bites and Rabies Risk In Baguio City, Philippines	**Invited Talk 2** **Asst. Prof. Joseph Ludwin D. Marigmen** Time Series Analysis of Animal Bites Cases In Baguio City, Philippines	**Invited Talk 3** **Dr. RR. Kurnia Novita Sari** Beyond Classical Geostatistics: Deep Neural Networks For Learning Complex Three-Dimensional Spatial Dependence	
15:00 – 15:20	**MathTech 2026-0034** **Aziz Takhirov** On a Steady Turbulent Kinetic Energy Navier-Stokes Model	**MathTech 2026-0018** **Cody Christopher Sy** Gotta Catch All Nodes: A Comparative Framework for Traveling Salesman Problem (TSP) Algorithms	**MathTech 2026-0212** **Mohd Shareduwan Mohd Kasihmuddin** Higher Order Satisfiability in Mutation Hopfield Neural Network	
15:20 – 15:40	**MathTech 2026-0196** **Benny Yong** How Well Can MCMC Samplers Recover Epidemic Parameters? Evidence from Indonesian COVID-19 Data	**MathTech 2026-0026** **Ratthapoom Phuemchai** Reducing Computational Cost in Two-Sample Permutation Tests via the Mean Value Theorem	**MathTech 2026-0024** **Sydney Xin Ni Lim** Graph Classification via Extended Persistence Using Heat Kernel Signature	
15:40 – 16:00	**MathTech 2026-0090** **Ahmad Khaled Abualigah** Blood-Based Williamson Ternary Hybrid Ferrofluid in Magneto-Radiative Hiemenz Flow Subject to Stretching/Shrinking Wall Motion	**MathTech 2026-0029** **Monchai Kooakachai** Estimating Comeback Probabilities from Half-Time Deficits in English Football	**MathTech 2026-0025** **Shakthi Aswin A. S.** The Stability and Expressiveness of Single-Parameter Filtration and Bifiltrations in Persistent Homology	
16:00 – 16:20	**MathTech 2026-0100** **Said Juma Khamis Al Uraimi** Numerical Analysis of Oldroyd-B Viscoelastic Channel Flow via a Quintic B-Spline Galerkin Method	**MathTech 2026-0208** **Siti Fatimah Ismail** Fiscal–Monetary Policy Coordination in Malaysia: Evidence from a Multi-Equation ARDL Analysis	**MathTech 2026-0040** **Chia Yi Gan** Comparative Analysis of Micro-Expression Datasets Using a Hierarchical Transformer Network	
16:20 – 16:40	**MathTech 2026-0104** **Mohammed Banikhalid** Travelling-Wave Solutions of Nonlinear Dispersive Equations: An Ansatz-Based Comparison of Parameter Constraints	**MathTech 2026-0135** **Osama Mohammad Mousa Yaghi** Minimax Quantile Tracking Under Kolmogorov Drift and Weak Dependence	**MathTech 2026-0053** **Sarvanan Muniandy** An Enhanced Quantile Regression Technique for An Efficient Moisture Ratio Removal in Seaweed	
16:40 – 17:00			**MathTech 2026-0106** **Faustine Kastory Nziku** Topology-Augmented Visual Representation for Interpretable and Efficient Crop Disease Classification	

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

Parallel Session 2 / Workshop 1

Time	Pavilion 1 **Parallel Session 2A** Mathematical Modelling **Chairperson:** Ts. Dr. Siti Ainor Mohd Yatim	Pavilion 2 **Parallel Session 2B** Operations Research and Statistics **Chairperson:** Dr. Zainudin Arsad	Vista **Parallel Session 2C** Artificial Intelligence and Machine Learning **Chairperson:** Dr. Foo Chuan Hui	Pavilion 3 **Workshop 1**
08:30 – 08:50	**MathTech 2026-0060** **Muhammad Afzal Saidi** Three-Sub-Step Composite Time Integration Method for Solving Electromagnetic Transients in Power Systems	**MathTech 2026-0081** **Mohsen Ayyash** A Mixed-Effects Support Vector Machine Approach to District-Level Poverty Mapping in Malaysia	**MathTech 2026-0082** **Gabriella Haumahu** Temporal Integrity in Gaussian Process Time Series: A Subsampling Framework for Sustainable Finance	
08:50 – 09:10	**MathTech 2026-0062** **Christian Russel Reyes** Dimension Reduction Framework and Modeling of Sparse High-Dimensional Censored Data	**MathTech 2026-0096** **Zainudin Arsad** Modelling and Forecasting Tourism Demand of Malaysia by European Countries using SARIMA and Transfer Function Models	**MathTech 2026-0111** **Shiyan Liu** Enhancing Transparency of CNN-Based EMC Analysis for Wire-Harness Defect Detection Using Score-CAM	
09:10 – 09:30	**MathTech 2026-0063** **Monalisa E. Rijoly** Linearized Dispersive Green-Naghdi Level-1 Model for Landslide-Generated Waves	**MathTech 2026-0097** **Zainudin Arsad** Mean and Volatility Spillovers from Foreign Stock Markets, Oil Prices and Exchange Rate on the Malaysian Stock Market	**MathTech 2026-0160** **Foo Chuan Hui** A Machine Learning Framework for Pancreatitis Classification Using Wrist Pulse Signal Morphology	**Ts. Puteri Anis Aneeza Zakaria** Empowering Future Innovators Through Mathematics, Technology and Robotics (08:30 – 10:30)
09:30 – 09:50	**MathTech 2026-0071** **Esther Yolandyne Bunga** Adaptive Intuitionistic Fuzzy Logic Control for Combination Therapy Dosing in an Immune-Cancer Model: A Dual-Modality Comparative Study	**MathTech 2026-0105** **Wang Luqi** Dividends or Burdens? Assessing the Trade-offs Between Low-Carbon Performance and Social Equity under Carbon Trading in China	**MathTech 2026-0163** **Cheng Eng Chong** Epileptic Seizure Detection in Electroencephalogram Signal with Convolutional Neural Networks Enhanced with Incremental Learning and Rehearsal Data	
09:50 – 10:10	**MathTech 2026-0080** **Norhidayah Zolbahar** Mathematical Analysis of Delayed Typhoid Fever Transmission Model with Control Strategies	**MathTech 2026-0117** **Ruzanna Mat Jusoh** A Network-Theoretic Approach for Assessing Road Traffic Volume Malaysia (RTVM) Census Stations in an Urban Traffic Monitoring System		
10:10 – 10:30	**MathTech 2026-0102** **Akaninyene Okon Ekong** Modeling Drivers of Carbon Emissions in Nigeria using Bayesian Quantile Regression			

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 MRSM: A Regression Analysis	**Invited Talk 4** **Prof. Dr. Zabidin Salleh** Best Proximity Points Analysis for Fuzzy Graphical Proximal Contractions in Graphical Fuzzy Metric Spaces	
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 MRSM 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 MRSM	**MathTech 2026-0049** **Mark Anthony C. Tolentino** Multiset Resolving Sets in Strong Products of Paths	**Prof. Dr. Rizavel C. Addawe & Asst. Prof. Joseph Ludwin D. Marigmen** Univariate and Multivariate Time Series Analysis using Animal Bites Cases (10:50 – 12:50)
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 6** **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	
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	**Dr. Kong Voon Pang** Introduction to Curve Fitting (15:10 – 17:10)
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
08:30 – 08:50	**MathTech 2026-0002 Norazuwin Najihah Mat Tahir** Modulated Gravity Effects on Double-Diffusive Lorentz-Like Magneto Convection in Viscoelastic Nanofluid Layer
08:50 – 09:10	**MathTech 2026-0115 Maharani A. Ummi** Extracting Long-Term Mortality Improvement Trajectories Using Wavelet Denoising
09:10 – 09:30	**MathTech 2026-0198 Renier G. Mendoza** Predicting Calf Production Outcomes in Artificially-Inseminated Philippine Carabaos Using Machine Learning
09:30 – 09:50	**MathTech 2026-0201 Nur Adilah Abd Jalil** MHD Squeeze Radiative Flow of Ternary Casson Nanofluid with Chemical Reaction Effect
09:50 – 10:10	**MathTech 2026-0157 Muhammad Nor Adam Ziqril Bah Rasad** Heat Transfer of Unsteady Micropolar Hybrid Nanofluid Flow Over a Permeable Vertical Stretching and Shrinking Surface
10:10 – 10:30	**MathTech 2026-0046 Michelle R. Montilla** The Stable Marriage Problem with Suggested Pairs
10:30 – 10:50	Morning Tea Break
10:50 – 11:20	**Invited Talk 5** **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

Day 3 | 24 September 2026 (Malaysia Time / GMT+8)

Parallel Session 5 / Workshop 4

Time	Pavilion 1 **Parallel 5A** Financial Mathematics **Chairperson:** Dr. Teng Mei Tuan	Pavilion 2 **Parallel 5B** Operations Research and Statistics **Chairperson:** Dr. Nuzlinda Abdul Rahman	Vista **Parallel 5C** Artificial Intelligence and Machine Learning & Interdisciplinary Mathematics **Chairperson:** Dr. Fariha Syaqina Zulkepli	Pavilion 3 **Workshop 4**
08:30 – 08:50				
08:50 – 09:10	**MathTech 2026-0013** **Jeric Briones** Mining Actionable Serial Correlations in the Philippine Stock Market Using Spatio-Temporal Sequences	**MathTech 2026-0147** **Ng Peh Sang** An Enhanced Double Exponentially Weighted Moving Average Chart in Short Production Runs	**MathTech 2026-0021** **Brian Godwin Lim** Benchmarking Econometric and Deep Learning Models for Forecasting Philippine Electricity Spot Prices	
09:10 – 09:30	**MathTech 2026-0027** **Jiro Ashkelon Tanyag** On Hybrid Time Series and Deep Learning Models for the Prediction of Stock Index Trade Volume	**MathTech 2026-0159** **Hongxiang Li** Parametric Bootstrap Goodness-of-Fit Tests for the Skew- normal Distribution with Estimated Parameters	**MathTech 2026-0023** **Kah Fai Liew** Prediction of the Malaysia Financial Sector Index Using a Neural Network	
09:30 – 09:50	**MathTech 2026-0122** **Jana Meril Rocimo** An Analysis of Time-Series Predictability in Sector Investing within the Philippine Stock Exchange	**MathTech 2026-0166** **Mohd Azri Pawan Teh** Modified Group Chain Sampling Plans (MGChSP-1) for Gamma Distribution	**MathTech 2026-0008** **Petarpa Boonserm** Transmission and Reflection Resonances from the Superposition of Various Potentials Using the Quasilinearization Method	**Dr. Shamani Supramaniam** Introduction to LaTeX (08:30 – 10:30)
09:50 – 10:10	**MathTech 2026-0123** **Werry Febrianti** Solving ESG Portfolio Optimization with Buy-In Threshold Constraints Using Spiral Optimization Algorithm	**MathTech 2026-0205** **Wei Lun Tan** Multivariate Analysis of ENSO-Related Atmospheric Circulation Variability over Malaysia using ERA5 Reanalysis	**MathTech 2026-0044** **Zurita Ismail** Mapping Interconnectedness in Malaysia's Technology Sector: An MST Analysis of the COVID-19 Period	
10:10 – 10:30	**MathTech 2026-0133** **Mohd Tahir Ismail** Time-Varying Dynamics and Volatility Spillovers between VIX and S&P 500: Evidence from TVP-VAR and BEKK-GARCH Models	**MathTech 2026-0075** **Rizavel C. Addawe** Cointegration Analysis of Animal Bites with Precipitation, Temperature and Humidity in Baguio City, Philippines	**MathTech 2026-0052** **Linyuan Tay** A Comprehensive Empirical Evaluation of Disaster Preparedness Behaviour Using Structural Equation Modelling: A Case Study in Penang Island	

Parallel Session 6 / Workshop 5

Time	Pavilion 1 **Parallel 6A** Mathematical Modelling **Chairperson:** Dr. Syakila Ahmad	Pavilion 2 **Parallel 6B** Pure Mathematics **Chairperson:** Dr. Shamani Supramaniam	Vista **Parallel 6C** Operations Research and Statistics **Chairperson:** Dr. Siti Amirah Abd Rahman	Pavilion 3 **Workshop 5**
10:50 – 11:20	**MathTech 2026-0125** **Jose Carlos Bungabong Bacatan** A Pareto-Efficient Second-Best Congestion Pricing Model for McKinley Road: Integrating Nested Logit Estimation and Nonlinear Least Squares Optimization	**Invited Talk 7** **Assoc. Prof. Dr. Ikha Magdalena** Generalized Fisher-Type Model for Coastal Green Infrastructure Dynamics	**MathTech 2026-0121** **Kevin Kam Fung Yuen** POO-LPSP: Parallel Osprey Optimized Least Penalty-Squared Prioritization Methods for Priority Derivation in the Analytic Hierarchy Process	
11:20 – 11:40	**MathTech 2026-0142** **Nurul Izzatie Najwa Kamarul Bahrim** Bernstein Operational Matrix of Derivative Approach for Nonlinear Lane-Emden Equation	**MathTech 2026-0129** **Lawrence M. Viesca** Palindromic Complexity in SFT Random Substitution Subshifts	**MathTech 2026-0137** **Nur Amalina Shafie** Time Series Forecasting of Red Chilli Prices in Negeri Sembilan: A Box-Jenkin Application	
11:40 – 12:00	**MathTech 2026-0149** **Iskandar Shah Mohd Zawawi** A Composite TR-BDF2 for the Numerical Integration of Stiff Differential Equations	**MathTech 2026-0130** **Kurt Anthony C. de los Santos** On Some Families of Substitutions over Infinite Alphabets	**MathTech 2026-0143** **Sani Rabiu** Stochastic Sustainable EPQ Model with Carbon Tax, Emission Cap, and Endogenous Green Investment under Demand and Defect-Rate Uncertainty: Theory and Application to Semiconductor Manufacturing	**Assoc. Prof. Ts. Dr. Saratha Sathasivam** Inside the Machine Mind: Neural Networks and Intelligent Optimization (10:50 – 12:50)
12:00 – 12:20	**MathTech 2026-0150** **Yopi Andry Lesnussa** Migration Regulation and Conservation Harvesting Control on a Two-Habitat Single-Species Model	**MathTech 2026-0131** **Azizi Rosli** Dynamical System of a Lotka-Volterra Operator with Non-Isolated Fixed Points		
12:20 – 12:40		**MathTech 2026-0128** **Aquinnah Gay C. Balistoy** Diffraction of a Rectangular Random Block Substitution		

List of Abstracts – Plenary Talks

PT Plenary Talk 1



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.

PT Plenary Talk 2



Prof. Emeritus Dr. Kenjiro T. Miura
Department of Information Science and Technology
Graduate School of Science and Technology
Shizuoka University
Japan

Prof. Emeritus Dr. Kenjiro T. Miura was born in Yokohama, Japan. Obtained Bachelor's and Master's Degrees from the University of Tokyo in 1982 and 1984, respectively. After graduation he joined Canon Inc., Japan. By the support of his company, he successfully obtained a Ph.D. from Cornell University in 1991. In 1993, he got an associate professor position at the University of Aizu and spent for four years there. Then he moved to Shizuoka University in 1997 and promoted to a full professor in 2004. He has almost 40-year teaching and research experiences at a Japanese company and universities and now continue his teaching and research services at Shizuoka University. Currently he is Professor Emeritus at Shizuoka University. Prof. Miura has published 18 books and more than 300 paper publications. Out of them, over 120 reputed international journals that includes the top journals such as computer aided geometric design and computer-aided design and his h-index is 21. He has supervised 4 Ph.D. students and 2 post-doctoral students. He personally has collaborated with more than 10 researchers from Malaysia and around the world. Along his carrier as academician, he personally has received awards and recognition among them are Yamashita Memorial Award from information processing society of Japan, Frontier research award from Japan Society of Mechanical Engineering in 2009, Takagi award from Japan society of precision engineering in 2012, the best paper award at the CAD conference in 2013, Contributor award from Japan Society of Mechanical Engineering in 2017, visiting researcher at Tsinghua University in 2000, visiting researcher at Carnegie Mellon University in 2015, and visiting researcher at Seoul National University 2016. He has been a group leader of CREST project named Evolving Design and Discrete Differential GEometry: ED3GE. He visited more than 10 countries on visiting assignments or for delivering invited talks.

Aesthetic Curves and Interpolating Splines

Aesthetic shapes are usually actualized as 3D objects represented by free-form surfaces. The main components used to achieve aesthetic surfaces are 2D and 3D curves, which are the elements most basic for determining the shapes and silhouettes of industrial products. Bezier, B-Spline and NURBS are types of flexible curves developed for various design intents. These curves, however produce complex curvature functions that may undermine the formulation of shape aesthetics. A viable solution to this problem is to formulate aesthetic curves from well-defined curvatures to improve aesthetic design quality. This presentaion advocates formalizing aesthetic curve theories to fill the gap mentioned above, which has existed since the 1970s. This presentation begins by reviewing on fair curves and surfaces. It then extensively discusses on the technicalities of Log-Aesthetic (LA) curves and touches on industrial design applications. These emerging LA curves have a high potential for being used as standards to generate, evaluate and reshape aesthetic curves and surfaces, thus revolutionizing efficiency in developing curve and shape aesthetics. We will also discuss about interpolating splines, wich is one of the hottest topics on curve research.

PT Plenary Talk 3



Prof. Dr. Hailiza Kamarulhaili
Malaysia Cryptology Technology and Management Center
Universiti Putra Malaysia
Malaysia
School of Mathematical Sciences
Universiti Sains Malaysia
Malaysia

Prof. Dr. Hailiza Kamarulhaili earned her BSc from Universiti Sains Malaysia (USM) and her MSc and PhD in Pure Mathematics from the University of Liverpool, UK. She joined the School of Mathematical Sciences, USM, in 2000, where she served as Deputy Dean (2010–2015) and Dean (2016–2024). A prominent figure in Malaysia's cryptology landscape, Prof. Hailiza held key leadership roles in the Malaysian Society for Cryptology Research (MSCR), serving as Secretary, Vice President, and President (2016–2018). Since 2010, she has served on CyberSecurity Malaysia's National Trusted Cryptography Expert Panel, evaluating national algorithms (MySEAL) and contributing to the Cabinet-approved National Cryptography Policy (2013). She is a Fellow of the Malaysian Scientific Association (MSA) and an active member of PERSAMA, ISAAC, and IACR. She currently serves as Deputy Director I at the Malaysia Cryptology Technology and Management Centre (PTPKM), focusing on national cryptographic readiness and post-quantum security challenges.

From Ancient Ciphers to Post-Quantum Cryptography: Advancing Cryptographic Resilience in the Era of Emerging Technologies

Cryptography has always evolved in response to changing technologies, capabilities, and threats. From the earliest substitution ciphers used to conceal messages in ancient civilizations to the mathematically grounded systems that secure today's digital infrastructure, cryptography reflects humanity's enduring need for trust in communication. Early cryptographic methods relied largely on manual techniques, offering limited protection. As analytical skills and tools advanced, the twentieth century marked a decisive turning point, with the emergence of modern cryptography founded on information theory, computational hardness, and rigorous security definitions. Breakthroughs such as in symmetric and public-key cryptosystem, as well as in digital signatures enabled secure communication over open networks and became essential to the growth of the internet, electronic commerce, and digital governance. Today, cryptography stands as a pillar to secure communication. The anticipated arrival of large-scale quantum computers threatens to undermine widely deployed public-key cryptosystem, such as RSA (Rivest-Shamir-Adleman) and ECC (Elliptic Curve Cryptosystem), and raising concerns over long-term data confidentiality and system resilience. In response, the cryptographic community is developing quantum-safe, or post-quantum cryptographic solutions, designed to withstand both classical and quantum attacks, due to Shor's algorithm. This transition is not merely a technical upgrade, but a strategic shift that demands foresight, crypto-agility, and coordinated global action. By viewing cryptography as an evolving discipline, this talk traces the long curve of cryptographic evolution, highlighting key transitions that reshaped how secrecy, authentication, and trust are achieved. This talk also emphasizes the importance of adaptability in securing the digital future, from the ancient cryptographic techniques to modern cryptographic solutions resilience against AI-enabled (Artificial Intelligence) technology. With the advent of quantum computing coupled with artificial intelligence technology, the need for resilience has never been greater, and post quantum cryptography (PQC) represents the next frontier in protecting information against quantum threats. In addition to quantum threats, the increasing use of AI-assisted approaches in cryptanalysis introduces new and evolving challenges. By charting this evolutionary path of innovation, this talk also addresses why advancing cryptographic resilience is essential to securing the digital future. Ensuring long-term cryptographic resilience reminds us that digital trust depends on our ability to anticipate and adapt to emerging threats, ultimately enabling crypto-agile infrastructures.

PT Plenary Talk 4



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 (CO_2), methane (CH_4), and nitrous oxide (N_2O), 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 1



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

Prof. Dr. Rizavel C. Addawe is a Professor at the Department of Mathematics and Computer Science, University of the Philippines Baguio. Her expertise spans statistics, mathematical modeling, optimization, machine learning, data science, and public health analytics. Her research focuses on optimization algorithms, Bayesian methods, spatiotemporal disease modeling, artificial intelligence, epidemiology, and statistical computing. She has led numerous interdisciplinary research projects funded by the University of the Philippines, government agencies, and research institutions. She has published more than thirty peer-reviewed papers in reputable international journals and conference proceedings and actively mentors graduate students in statistics, mathematics, and computational modeling. Prof. Addawe currently serves as a member of the Baguio General Hospital and Medical Center Research Ethics Committee and has extensive experience as a statistical consultant and research reviewer. She is a UP Scientist I, One UP Professorial Chair Awardee, and recipient of the University of the Philippines Gawad Pangulo Award for Excellence in Public Service.

Towards "Zero By 30": Epidemiological, Temporal, and Spatial Modeling of Animal Bites and Rabies Risk in Baguio City, Philippines

Animal bites and rabies remain major global health threats, predominantly affecting children and low-income communities, and causing an estimated 59,000 deaths annually in Asia. Despite clear WHO guidance and national efforts, local implementation still depends on timely and reliable data analysis. Baguio City exemplifies this challenge: animal bite cases have significantly risen over the past decade despite ABTC efforts in mass dog vaccination. Existing local surveillance captures case counts; however, provides limited insights into species involved, high-risk demographic groups, spatial clustering, seasonality, and the influence of weather. Without this information, resource allocation, risk communication, and vaccination campaigns cannot be fully optimized. This presentation will therefore showcase a comprehensive analytical framework that combines: (1) descriptive epidemiology of bite cases from 2018–2024; (2) advanced time series modeling, such as SARIMA and cointegration, to characterize trends, cycles, and relationships with environmental variables such as temperature and precipitation; and (3) GIS-based spatial and spatio-temporal analysis, including Moran's I and hotspot mapping, to identify high-risk barangays. The motivation is to move beyond routine reporting toward predictive, spatially explicit, and policy-relevant analytics. This work is relevant as a transferable model for other cities aiming for "Zero by 30." This will illustrate how routinely collected bite-case data, when rigorously cleaned, modeled, and mapped, can inform targeted vaccination, community education, insurance utilization, and integrated One Health action. The session will highlight both methodological approaches and practical lessons for building data-driven, collaborative rabies control strategies in resource-constrained settings.

Invited Talk 2



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

Joseph Ludwin D. Marigmen is an Assistant Professor of Mathematics at the University of the Philippines Baguio. He received his Master of Science degree in Mathematics from the same university in 2024. His research topics deal with Mathematical Statistics, Regression Analysis, and Time Series Analysis, with a focus on statistical modeling of notifiable infectious diseases such as dengue fever, COVID-19, and influenza-like illness (ILI). He is also an active member of the Statistics Research Group at the university. Asst. Prof. Marigmen has published nine Scopus-indexed research articles and one non-refereed article. He recently presented his new research on the cointegration between ILI and meteorological factors at an international conference in June 2026.

Time Series Analysis of Animal Bites Cases in Baguio City, Philippines

In this paper, we aim to construct a time series model to forecast the animal bites cases reported in Baguio City in the 52-week period of 2025 using the historical weekly data from 2023 to 2024. Utilizing the Autoregressive Integrated Moving Average (ARIMA) and the Seasonal ARIMA (SARIMA) models, we acquire ARIMA(3,1,3)(0,0,1)[52] as the best-performing time series model, where it forecasts to report around 4,100 additional cases for the last 22 weeks of the year. This hinted a possibility that the annual animal bites cases in Baguio City may increase by around 6.8% compared to the same period in 2024. Proper anti-rabies vaccinations and care for animal pets are advised to avoid possible surge of recorded animal bites cases in the city. Furthermore, city government officials need to review policies and activities in controlling and preventing the spread of the disease.

Invited Talk 3



Dr. RR. Kurnia Novita Sari
Faculty of Mathematics and Natural Sciences
Institut Teknologi Bandung (ITB)
Indonesia

Dr. RR. Kurnia Novita Sari is a lecturer in the Mathematics and Actuarial Science Study Programs at the Faculty of Mathematics and Natural Sciences, Institut Teknologi Bandung (ITB), Indonesia. She earned her Bachelor's, Master's, and Doctoral degrees in Mathematics from ITB in 2004, 2009, and 2016, respectively. Her research interests include spatial statistics and geostatistics, particularly semivariogram and kriging modeling, as well as actuarial science, with a focus on mortality and morbidity modeling. Her research has been applied to various fields, including agriculture, mining, education, and life insurance. She has contributed to research on 3D anisotropic semivariogram modeling, multiple-life and multiple-decrement models, and the development of Indonesian mortality and morbidity tables. Kurnia is also actively involved in academic seminars, workshops, and research collaborations at national and international levels. Her recent activities include presenting research on 3D anisotropic semivariogram modeling and morbidity tables, as well as delivering workshops on geostatistics and morbidity tables in Indonesia and Ghana.

Beyond Classical Geostatistics: Deep Neural Networks for Learning Complex Three-Dimensional Spatial Dependence

Understanding complex spatial dependencies remains a fundamental challenge in geostatistics, particularly when dealing with three-dimensional anisotropic phenomena characterized by heterogeneous spatial structures. The classical semivariogram model has long been used to quantify spatial dependencies by measuring the variance of differences between observed values at different locations. This semivariogram is expressed as a lag function of distance that also includes the angle between locations, which exhibits anisotropic phenomena. The increasing complexity of geospatial datasets, including the large number of distance pairs between these 3D locations, has motivated the exploration of data-driven approaches capable of capturing complex spatial patterns beyond the assumptions of conventional parametric models. This study investigates the integration of Deep Neural Networks (DNNs) into semivariogram modeling, specifically in estimating the nugget effect, sill, and range parameters as semivariogram model parameters. Interpretation of this semivariogram-DNN model allows for a more flexible characterization of anisotropic spatial structures. This methodology is applied to megathrust earthquake data in Java, Indonesia, a region characterized by highly complex tectonic interactions resulting from the convergence of the Indo-Australian and Eurasian plates. Several theoretical semivariogram models are compared and then improved through DNN-based learning. The results show that the spherical semivariogram DNN can provide the most accurate and consistent representation capturing the complex three-dimensional anisotropic spatial variability of earthquakes compared to conventional approaches. These findings highlight the potential of deep learning to extend classical geostatistics and provide a robust framework for advanced spatial modeling in geophysical and seismic applications.

IT Invited Talk 4



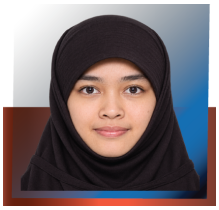
Prof. Dr. Zabidin Salleh
Faculty of Computer Science and Mathematics
Universiti Malaysia Terengganu
Malaysia

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.

Invited Talk 5



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.

Invited Talk 6



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.

Invited Talk 7



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

Assoc. Prof. Dr. Ikha Magdalena is an Associate Professor of Mathematics at Institut Teknologi Bandung (ITB), Indonesia, where she currently serves as Head of the Graduate Program in Mathematics. Her research lies at the intersection of applied mathematics, scientific computing, and coastal engineering, with particular emphasis on the mathematical modeling and numerical simulation of water waves, tsunami propagation, wave–structure interactions, coastal protection, and nature-based solutions. She has published extensively in reputable international journals, with more than 100 Scopus-indexed publications, and actively collaborates with researchers and institutions worldwide. Beyond her research, Dr. Magdalena is actively engaged in regional and international mathematical communities. She serves as Secretary of the Southeast Asian Mathematical Society (SEAMS), is a member of the Executive Committee of the East Asia SIAM Section (EASIAM), and is an Associate Member of CIMPA. She is also strongly committed to translating research into societal impact through community-based coastal protection initiatives, including mangrove and coastal tree planting, rehabilitation of vulnerable shorelines, and the promotion of nature-based and hybrid engineering solutions for coastal resilience. Through her research, teaching, international collaboration, and community engagement, she seeks to bridge applied mathematics with real-world coastal challenges and to strengthen the societal impact of the mathematical sciences.

Generalized Fisher-Type Model for Coastal Green Infrastructure Dynamics

Here, we present a generalized Fisher-type reaction–diffusion model to characterize the spatio-temporal dynamics of the density of coastal green infrastructures (particularly coastal vegetation, such as mangrove and seagrass) that accounts for interactions with hydrodynamic conditions. It means that the model has a nonlinear growth term, whose exponent can be modulated in order to describe some class of density dependent ecological processes that are defined in a more general form than the classic logistic one. These mechanisms enable the model to reproduce threshold-mediated growth behavior characteristic of coastal environments subject to diverse hydrodynamic and sedimentary regimes. We develop a high-order numerical scheme numerical scheme, which discretizes the governing equation in space using the fourth-order accurate finite difference method and time using an explicit solver. This method offers significantly better accuracy at narrower vegetation fronts than any other methods available, while maintaining computational efficiency. Homogeneous Neumann boundary conditions are used (at the open side) to simulate isolated coastal domains and no vegetation flux. The interaction between diffusion and nonlinear growth generates traveling-wave-like fronts, which is the natural inclination of plant life moving into unplanted territory according to numerical simulations. A systematic parametric study reveals that local density is highly sensitive to a nonlinear growth exponent, while the rate of spatial distribution is controlled by diffusion. These findings show a strong connectivity between model parameters and ecological interpretations, e.g. dispersal mechanisms and environmental gradients resistance. This generic framework provides a robust and tractable modelling tool for coastal systems vegetation dynamics. It also opens opportunities for future coupling to hydrodynamic models, such as the Shallow Water Equations (SWE), in order to explore wave–vegetation interactions, including wave attenuation induced by the vegetation, and provide further support towards designing nature-based solutions for coastal protection.

List of Abstracts – Workshops

WS 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.

WS Workshop 4



Dr. Shamani Supramaniam
School of Mathematical Sciences
Universiti Sains Malaysia
Malaysia

Introduction to LaTeX

Workshop Synopsis:
This workshop provides a basic introduction to LaTeX, a document preparation system widely used for academic and mathematical writing. Participants will learn how to create a simple document and include mathematical elements such as equations, symbols, and formulas. The workshop will use MiKTeX and WinEdt or the Overleaf online platform for practical hands-on exercises.

Objectives:

1. Provide an introduction to the word processor LaTeX.
2. Demonstrate how a simple document with mathematical elements can be constructed using LaTeX.

Requirements:

1. Laptop
2. Option 1: Installation
   - MiKTeX
   - WinEdt
3. Option 2: Online Platform
   - Overleaf (No installation required; only an internet connection and browser are needed)

Agenda:

1. Introduction to LaTeX.
2. Structure of the document.
3. Figures & tables.
4. Wrap-up and Q&A.

WS Workshop 5



Assoc. Prof. Ts. Dr. Saratha Sathasivam
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Inside the Machine Mind: Neural Networks and Intelligent Optimization

Workshop synopsis:
Inside the Machine Mind: Neural Networks and Intelligent Optimization offers participants an engaging introduction to the core concepts of Artificial Intelligence (AI), Neural Networks, and intelligent optimization. The workshop explores various Neural Network models, including Hopfield, Radial Basis Function, and Kohonen Networks, together with their applications in solving real-world problems. Participants will also be introduced to advanced metaheuristic optimization techniques, including Artificial Bee Colony (ABC), Particle Swarm Optimization (PSO), and Hybrid Blue Whale Optimization (HBWO). Through practical and hands-on activities using MATLAB R12, participants will develop a better understanding of how these computational intelligence techniques can be applied to enhance AI systems and address complex optimization problems.

Objectives:

1. Understand the fundamentals and structure of Artificial Intelligence (AI) and Neural Networks.
2. Explore different types of Neural Networks, including Hopfield, Radial Basis Function, and Kohonen Networks.
3. Learn the applications of intelligent optimization techniques in AI systems.
4. Gain exposure to metaheuristic algorithms such as Artificial Bee Colony (ABC), Particle Swarm Optimization (PSO), and Hybrid Blue Whale Optimization (HBWO).

Requirements: Laptop and MATLAB R12

For USM staff and students, the following preparations are required before attending the workshop:

1. MATLAB Software Download and Installation
   Participants are required to log in using their official USM email address and password to access and download the software through the USM MATLAB portal: https://en.digital.usm.my/muat-turun/perisian
2. Access to MATLAB Online
   Participants may also use MATLAB Online by signing in with their USM email account and password via the MathWorks platform: https://www.mathworks.com/products/matlab-online.html

Participants from outside USM may also join, provided that their institution holds a valid MATLAB campus-wide or institutional subscription that supports workshop participation.

Please ensure that the software installation or online access setup is completed prior to the workshop to facilitate smooth participation during the hands-on sessions.

Agenda:

1. Introduction and Workshop Overview.
2. Fundamentals of Artificial Intelligence and Neural Networks.
3. Structure and Types of Neural Networks.
4. Hopfield, Radial Basis Function, and Kohonen Networks.
5. Metaheuristic Algorithms in Neural Networks.
6. Artificial Bee Colony (ABC) & Particle Swarm Optimization (PSO).
7. Hybrid Blue Whale Optimization (HBWO) Algorithm.
8. Future of AI, Conclusion, and Q&A Session.

List of Abstracts – Contributed Talks

Artifical Intelligence & Machine Learning

CT MathTech 2026-0021 Benchmarking Econometric and Deep Learning Models for Forecasting Philippine Electricity Spot Prices

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The Wholesale Electricity Spot Market (WESM) in the Philippines operates as a bid-based, energy-only pool and, alongside bilateral agree- ments, supplies the electricity demand of the nation. This deregulated dual system facilitates electricity trading but also introduces significant price volatility, driven by economic competition, socio-economic dynamics, and weather conditions. In fact, a wide disparity in WESM price changes has recently been observed across the different regions of the country. While electricity price forecasting (EPF) is crucial for risk minimization and effective bidding strategies, its application in the Philippine context remains limited in the literature, largely due to data scarcity. In response, this study benchmarked classical econometric and modern deep learning models for forecasting the daily generation and load-weighted average prices (GWAP, LWAP) across the three major island groups of the Philippines—Luzon, Visayas, and Mindanao. Specifically, the predictive performance of the Long Short-Term Memory (LSTM) was compared against the Seasonal Autoregressive Integrated Moving Average with eXogenous variables (SARIMAX), along with its volatility-tracking variants—Generalized Autoregressive Conditional Heteroskedasticity (GARCH) and Exponential GARCH (EGARCH). Moreover, the period from January 1, 2022 to December 31, 2023 with a 60-20-20 split for training, validation, and testing periods was considered, and system-, weather-, and demand-based indicators were included as additional covariates. Interestingly, evaluation based on root mean squared error (RMSE) and mean absolute error (MAE) on the testing period revealed a divergence in predictive accuracy—LSTM outperformed SARIMAX, SARIMAX-GARCH, and SARIMAX-EGARCH in Visayas and Mindanao, while SARIMAX outperformed SARIMAX-GARCH, SARIMAX-EGARCH, and LSTM in Luzon. Nevertheless, Diebold-Mariano (DM) tests, along with the mean absolute percentage error (MAPE), highlighted that these performance differences are statistically insignificant. Overall, while these findings largely agree with existing EPF literature on the potential of deep learning models, they also underscore how traditional econometric models remain highly competitive in volatile, data-scarce regions like the Philippines.

CT MathTech 2026-0023 Prediction of the Malaysia Financial Sector Index Using a Neural Network

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Accurate prediction of stock market indices is important for investors, policymakers, and financial analysts in making informed decisions. This study aims to forecast the Malaysia financial sector index using a neural network model. Daily historical data, including closing prices, high prices, low prices, opening prices, and transaction volumes, are collected for the period from January 2019 to December 2025. The Multilayer Perceptron (MLP) model is developed to capture nonlinear relationships and complex patterns in financial time series data. The standard error metrics such as Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE) are utilized to measure the model's performance. The results are expected to exhibit the capability of the MLP model in providing accurate predictions of the financial sector index. This study contributes to the artificial intelligence techniques' application in financial forecasting, particularly in the Malaysian market context. The findings may assist investors and financial analysts in understanding market trends and improving decision-making strategies. Future work may consider incorporation of additional macroeconomic indicators to further enhance prediction accuracy.

CT MathTech 2026-0024 Graph Classification via Extended Persistence Using Heat Kernel Signature

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Persistent Homology (PH), a main methodology in Topological Data Analysis (TDA) quantifies the shape and structure of complex datasets by representing the topological and geometrical information of data in the form of a persistence diagram, $\mathcal{D}_k(X)$. $\mathcal{D}_k(X)$ can be converted into vector spaces that can be directly used as features for machine learning (ML) input. Graph classification is an essential task within ML that has applications in various fields, including bioinformatics and molecular chemistry. It requires descriptors that capture both global topological shapes and local structural connectivity. Moreover, there is a lack of comparative research demonstrating whether a fixed- parameter topological pipeline, when enriched with local structural kernels such as the Weisfeiler-Lehman (WL) kernel, can match or exceed the performance of these complex neural layers. This work presents a handcrafted pipeline leveraging heat kernel signatures (HKS) for ordinary and extended PH. By hybridizing these topological signatures with WL features, we demonstrate a significant increase in classification performance on the MUTAG and PROTEINS datasets. Utilizing a stratified cross-validation framework with SVM and RF classifiers, our results show that this approach yields strong discriminative power, exceeding the performance of specialized neural network baselines like PersLay on MUTAG and remaining highly competitive on PROTEINS. Our best-performing pipelines, WL+PH(PI) and WL+EPH(PI) with RF, achieve mean weighted F_1-scores of 0.8986 ± 0.0625 on MUTAG and 0.7541 ± 0.0300 on PROTEINS, respectively, outperforming the neural baseline PersLay (0.8245 ± 0.0836 and 0.7459 ± 0.0373). A timescale sensitivity analysis further identifies $t = 8$ and $t = 3$ as the empirically optimal HKS diffusion scales for MUTAG and PROTEINS, pushing peak performance to 0.9088 and 0.7622, respectively.

CT MathTech 2026-0025 The Stability and Expressiveness of Single-Parameter Filtration and Bifiltrations in Persistent Homology

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Persistent homology, a principal tool in Topological Data Analysis, encodes topological structure as birth–death pairs (b_i, d_i) in persistence diagrams $D_k(X)$, with long-lived pairs capturing global structure and short-lived pairs reflecting local geometric variation. A fundamental property of topological signature is stability: small perturbations in the underlying data induce controlled changes in the persistence signatures, ensuring robustness to noisy data. This stability persists under vectorizations such as Persistence Landscapes, Persistence Images, and Euler Characteristic Curves, which make persistent homology amenable to machine learning. However, single-parameter filtrations capture feature evolution at only one geometric scale, limiting their expressiveness. This study formally defines expressiveness and systematically examines the stability–expressiveness trade-off by comparing single-parameter filtration and bifiltration-based feature representations on classification and regression tasks. Alpha filtration serves as the single-parameter baseline, while, bifiltrations combine alpha filtration with secondary scalar functions, including Gaussian kernel density, codensity, and three newly proposed Curvature-Sensitive Scores (Types I–III), which quantify local curvature sensitivity via eigenvalue decomposition of neighborhood covariance matrices. Features derived from bifiltrations are summarized through Euler Characteristic Surfaces. The framework is evaluated on four settings: synthetic two-circle point clouds under controlled perturbation, two synthetic 2D planar-shape datasets for multi-class classification (SVM, XGBoost Classifier); and point clouds sampled from hyperbolic, planar, and spherical surfaces for curvature regression (SVM regressor). Results show that while single-parameter filtrations effectively capture global topology, covariance-based bifiltrations markedly improve fine-grained geometric discrimination. In particular, raw local normal spread (CSS_1) and its bounded, stability-controlled counterpart (CSS_3) show high expressiveness in both shape classification and curvature regression, whereas scale-normalized anisotropy (CSS_2) distinguishes structural classes but poorly tracks continuous curvature. These results position curvature-sensitive scores as a means of treating feature extraction as a controllable stability–expressiveness design problem, tailoring topological signatures to application demands.

CT MathTech 2026-0040 Comparative Analysis of Micro-Expression Datasets Using a Hierarchical Transformer Network

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Micro-expressions are the true emotion of people that only occur fractions of a second, the subtle change of micro-expression is hard to detect by human eyes, therefore micro-expression recognition is a challenging problem. SAMM, CASME II, and SMIC are the three widely used benchmark datasets in micro-expression recognition. These datasets differ in the aspects of frame rate and image resolution. In this study, we present a comparative analysis of the pairwise combinations datasets to investigate their performance on classifying micro-expression by employing a Hierarchical Transformer Network. The results will be evaluated using unweighted average recall and unweighted F1-score under the Leave-One-Subject-Out Cross-Validation scheme. Furthermore, an ablation study on the impact of the number of attention heads, the number of hierarchies and the number of transformer layers will also be reported.

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

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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 ($32 \to 64 \to 128$ 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 2026-0053 An Enhanced Quantile Regression Technique for An Efficient Moisture Ratio Removal in Seaweed

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Solar drying is widely employed for seaweed preservation because of its low operating cost and environmental sustainability; however, drying efficiency is strongly influenced by complex environmental and operational factors whose effects may vary across different moisture conditions. Conventional Ordinary Least Squares (OLS) regression estimates only the conditional mean of the response variable and therefore provides limited insight into heterogeneous drying behaviour. This study proposes an enhanced quantile regression framework integrating Ordinary Least Squares (OLS) as a benchmark model, Standard Quantile Regression ($\tau = 0.25, 0.50$ and 0.75), Extended Quantile Regression ($\tau = 0.10 - 0.90$), penalized regression techniques, and coefficient heatmap visualization to investigate the factors influencing moisture content during solar drying of seaweed. Model performance was evaluated using the Residual Sum of Squares (RSS), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Absolute Scaled Error (MASE), Mean Absolute Percentage Error (MAPE), and coefficient of determination (R^2). While OLS served as the benchmark model, the enhanced quantile regression framework provided substantially richer insights into distribution- dependent drying behaviour by revealing variations in predictor effects across the conditional moisture distribution. To mitigate multicollinearity, improve variable selection, and evaluate predictor robustness, Ridge, LASSO, Elastic Net, Adaptive LASSO, and SCAD regression were subsequently employed. Using a dual selection criterion based on statistical significance ($p < 0.01$), coefficient stability across quantiles visualized through heatmaps, and confirmation by penalized regression, T2 (solar collector inlet temperature), T12 (drying chamber rear temperature), and T17 (drying chamber front temperature) consistently emerged as the most influential drying predictors across all modelling frameworks, whereas T13 and T25 exhibited quantile-dependent behaviour. The proposed integrated framework provides a comprehensive and distribution-sensitive approach for identifying robust drying factors, offering practical guidance for optimizing solar drying operations and improving seaweed production in Semporna, Sabah.

CT MathTech 2026-0082 Temporal Integrity in Gaussian Process Time Series: A Subsampling Framework for Sustainable Finance

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Gaussian Processes (GPs) are widely adopted in financial forecasting for their principled uncertainty quantification, yet their $\mathcal{O}(n^3)$ computational complexity restricts scalability to large datasets. While subsampling offers a practical mitigation strategy, conventional techniques typically disregard the chronological ordering of time-series data, inducing time leakage and distorting volatility structures. In this study, we propose a time-aware subsampling framework that explicitly preserves temporal dependencies through block-partitioned stratification. To rigorously evaluate subsampled datasets, we introduce the Temporal Integrity Score (TIS), a composite metric quantifying the retention of autocorrelation patterns, volatility dynamics, distributional similarity, and regime persistence. Empirical evaluations across synthetic and real-world financial datasets, including the iShares ESG Aware MSCI USA ETF (ESGU), reveal a critical blind spot in conventional assessment: while the Root Mean Square Error (RMSE) remains invariant across subsampling strategies, TIS effectively discriminates methodological performance. Stratified sampling consistently maintains high temporal integrity (TIS > 0.85 on real-world data), whereas value-based approaches such as Latin Hypercube Sampling exhibit significant degradation. Notably, extreme-value sampling methods yield negative TIS values, indicating catastrophic temporal destruction. We conclude that for complex, non-stationary financial time series, time-aware stratification is not merely an optimization but a fundamental requirement for valid probabilistic forecasting and responsible decision- making in sustainable finance.

CT MathTech 2026-0106 Topology-Augmented Visual Representation for Interpretable and Efficient Crop Disease Classification

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Crop disease diagnosis requires methods that balance predictive performance, interpretability, and computational efficiency. This study investigates whether persistent homology-based topological descriptors provide complementary information beyond conventional colour and texture features for crop disease classification. A topology-augmented visual representation framework was developed by integrating persistence image descriptors with visual features through three multi-modal fusion strategies, Direct Concatenation (Concat), Complementary Residual Fusion (CRF), and Relief Attention Fusion (RAF). To provide an interpretable and computationally efficient evaluation, experiments were conducted using Support Vector Machines (SVM), Random Forests (RF), and k-Nearest Neighbours (KNN) across nine PlantVillage datasets comprising 39,925 images and 33 disease classes. Multimodal representations consistently outperformed single-modality approaches, confirming that visual and topological descriptors capture complementary aspects of disease morphology. The best-performing configuration, combining SVM and RAF, achieved a mean macro F1 score of 0.969, a balanced accuracy of 0.979, and a Cohen's Kappa of 0.929. The low average correlation between visual and topological features (0.177) indicates low redundancy between modalities. Dimensionality-control experiments, Wilcoxon tests, and feature-importance analyses confirmed that the observed gains originated from meaningful topological information rather than from increased feature dimensionality. Compared with a lightweight deep learning model (MobileNetV3-S), our best configuration achieved competitive performance while requiring 112 times less training time, 17 times lower inference latency, and 227 times fewer parameters. These findings demonstrate that topology-augmented visual representations provide an interpretable, computationally efficient, and competitive alternative to deep learning for crop disease diagnosis in resource-constrained agricultural environments.

CT MathTech 2026-0111 Enhancing Transparency of CNN-Based EMC Analysis for Wire-Harness Defect Detection Using Score-CAM

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Interpretability is an important requirement for machine-learning- based electromagnetic compatibility (EMC) judgment of automotive wire harnesses, especially when convolutional neural network (CNN) models are used to identify defective and non-defective samples from geometric images. Previous studies have shown the potential of CNN-based approaches for wire-harness EMC classification, but their applicability remains limited when the decision basis of the model is unclear. To address this issue, this study extends the analysis to wire-harness cross sections with different conductor counts and investigates the visual interpretability of CNN-based EMC judgment. Random cross-sectional datasets containing 6 to 10 conductors are generated, and the corresponding common-mode-current-related (CMC-related) response and crosstalk- voltage-related (XTV-related) response are calculated using a multiconductor transmission line (MTL) model. A Spatial-ResNet classifier is trained to classify each sample as defective or non-defective according to predefined EMC judgment criteria. The classification results show that the proposed model achieves accuracies higher than 96% and defective-class F1-scores close to 0.95 across the examined conductor counts and EMC targets. To further analyze the decision basis of the trained CNN, Score-weighted Class Activation Mapping (Score-CAM) is applied to visualize the spatial regions contributing to the classification results. In addition, conductor-level occlusion sensitivity is used as a complementary verification method. The visualization results show that the model mainly focuses on conductor regions and local conductor groups rather than irrelevant background areas. For the CMC task, the activated regions tend to be distributed over multiple conductor neighbourhoods, while for the XTV task they are more localized around dominant coupling regions. These results indicate that Score-CAM, supported by occlusion sensitivity, can provide physically plausible explanations for CNN-based wire-harness EMC judgment. The proposed approach improves the transparency of machine-learning-based EMC analysis and provides a useful basis for AI-assisted wire-harness screening and future extension to more realistic three-dimensional harness models.

CT MathTech 2026-0160 A Machine Learning Framework for Pancreatitis Classification Using Wrist Pulse Signal Morphology

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Wrist pulse signals (WPS) contain important information related to cardiovascular dynamics and organ health, providing potential support for non-invasive disease assessment. This study investigates the classification of pancreatitis using long quasi- periodic wrist pulse recordings. Unlike many existing approaches that rely on direct signal alignment or conventional waveform descriptors, the proposed framework trans- forms each signal into a compact set of phase-invariant cycle-morphology features. These include peak amplitude statistics, inter-peak intervals, width measures, and derivative- based shape descriptors extracted through automated peak detection. The extracted features are used to train a random forest classifier, with model tuning performed using 10-fold cross-validation on the training set and final evaluation conducted on a held-out test set. Experimental results demonstrate strong classification performance with high sensitivity and specificity (both above 93%, compared to approximately 91% - 92% from previous studies) in distinguishing pancreatitis patients from healthy subjects. The findings suggest that morphology-based representations of wrist pulse signals may provide an alternative, robust, and interpretable approach for non-invasive pancreatitis detection.

CT MathTech 2026-0163 Epileptic Seizure Detection in Electroencephalogram Signal with Convolutional Neural Networks Enhanced with Incremental Learning and Rehearsal Data

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Epilepsy is a neurological disorder that substantially impairs patients' daily functioning with the unpredictable seizure occurrence. Epilepsy is characterized by the recurrent unprovoked seizures, with definition heavily relies upon the capturing of epileptic seizure occurrence. However, due to the poor pathological understanding behind the triggering of epileptic seizure, models such as convolutional neural networks (CNNs) and recurrent neural networks have been widely utilized to assist the highly time-consuming and ineffective tasks of epileptic seizure detection and labelling. In the literature, a multitude of studies have been conducted with the use of CNNs and achieved significant progress and satisfactory accuracy in epileptic seizure detection. However, limited studies have been conducted with the focus of addressing the applicability issue of a frozen model resulting from offline learning. This study aims to demonstrate the use of incremental learning to train a CNN model for epileptic seizure detection, allowing for future training epoch to update the model with newly available recordings from new patients. The dataset provided by the Children's Hospital Boston and Massachusetts Institute of Technology is used in this study. The data is first pre-processed through segmentation and =iltering. Each patient's data is added incrementally to train a CNN model, and the =inal model is used to detect epileptic seizure in random samples selected from each patient. Another model is trained with a similar =low, appended with the introduction of rehearsal data. Both models are evaluated with suitable performance metrics. The baseline model obtained the highest accuracy of 63% and the highest loss metric of 4.3881, while experience replay enhanced model showed consistent accuracy of 95% or higher in detection. These findings present a scalable and sustainable pipeline to constantly enhance the CNN model, to achieve cross-patient generalized epileptic seizure detection.

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.

CT MathTech 2026-0212 Higher Order Satisfiability in Mutation Hopfield Neural Network

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The capability of a Discrete Hopfield Neural Network (DHNN) to represent complex logical relationship and retrieve optimal neuron states depends critically on its logical structure and retrieval mechanism. Conventional DHNN may repeatedly converge to a limited set of attractor form which restricts exploration of alternative global solutions. This study proposes a higher-order logical rule in a Mutation Hopfield Neural Network to improve the quality and diversity of the final neuron state. Higher-order clauses are represented through third order synaptic weight interactions in DHNN. During retrieval phase, a mutation search supported by an estimation of distribution strategy is employed to generate alternative neuron states from identified optimal solutions. Theoretical analysis is established through the derivation of the cost function, synaptic weights, local field and Lyapunov energy function. The proposed model is evaluated using simulated datasets. This experimental results demonstrate that the proposed model could potentially outperform conventional DHNN in terms of solution diversity as well as global minimum energy attainment.

Financial Mathematics

CT MathTech 2026-0013 Mining Actionable Serial Correlations in the Philippine Stock Market Using Spatio-Temporal Sequences

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Stock prices are inherently volatile, rendering the risk of loss inevitable in technical trading. This volatility, however, also presents opportunities for traders to exploit, particularly in markets with mixed efficiency, such as the Philippine stock market. Capitalizing on this idea, this paper presents a framework for generating potentially profitable trading strategies in the Philippine stock market. This framework is based on an existing procedure that uses spatio-temporal stock sequences to leverage not only temporal dependence, but also spatial cross-correlations across different stocks. This paper then extends the analysis by identifying market "leaders" and "followers" from the frequently occurring spatio-temporal stock sequences. Results showed that trading multiple statistically significant sequences per week has the potential to yield competitively high fractional returns relative to appropriate benchmarks, with relatively low levels of risk. Certain component stocks also emerged as market leaders and followers during market-wide bull runs. While these results are heavily data-dependent, this paper offers a promising approach for investors, who only need to provide a specific input of choice (i.e., stocks they ultimately intend to trade) to identify potentially profitable trading strategies.

CT MathTech 2026-0027 On Hybrid Time Series and Deep Learning Models for the Prediction of Stock Index Trade Volume

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Existing works on the application of time series and deep learning models on financial markets largely focus on the accurate prediction of future asset returns. Nevertheless, models tailored for the prediction of trade volume, defined as the total number of units bought or sold over a specified period, remain limited. Recognizing its value as a critical indicator of liquidity and momentum for a financial asset, this work explored the application of hybrid time series and deep learning models for predicting the trade volume of the Standard & Poor's 500 Exchange-Traded Fund (SPY). In particular, the Autoregressive Moving Average with eXogenous variables (ARMAX), Long Short-Term Memory (LSTM), and Multi-Head Attention (MHA) models, along with their hybrid variants, were considered to forecast the five-minute log-differenced SPY trade volume for the period from September 30, 2022 to September 30, 2023. Using a 60-20-20 data split for training, validation, and testing periods, respectively, the mean squared errors (MSEs) observed for ARMAX, LSTM, and MHA were 0.1660, 0.1196 ± 0.0012, and 0.1334 ± 0.0031, respectively. Interestingly, the hybrid models LSTM-ARMA, MHA-ARMA, LSTM-MHA, and LSTM-MHA-ARMA obtained MSE values of 0.0731 ± 0.0029, 0.0424 ± 0.0046, 0.1220 ± 0.0032, and 0.0594 ± 0.0010, respectively. These findings suggest that despite the high representational capacity of deep learning models, the LSTM and MHA alone cannot fully explain the temporal dynamics of SPY trade volume. However, prediction errors significantly reduced when these architectures are paired with the classical ARMA model, suggesting that while deep learning models may capture complex non-linear patterns, the linear nature of ARMA remains essential for accurate trade volume forecasting. Overall, this work highlights the necessity of integrating classical econometric theories with modern deep learning architectures for robust financial time series analysis.

CT MathTech 2026-0122 An Analysis of Time-Series Predictability in Sector Investing within the Philippine Stock Exchange

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Sector investing involves allocating assets to specific areas of the economy by investing in stocks within defined market sectors. A key factor in enhancing this strategy is time-series predictability. This refers to the extent to which future values of a time series can be accurately forecasted. While prior studies have focused on predictability and its associated indicators across sec- tor indices in developed markets, sector-level predictability, particularly in the Philippine context, remains unexplored. Thus, this study sought to explore the existence and implications of time-series predictability in sector investing within the Philippine Stock Exchange (PSE). Daily index returns for the six sectors of PSE were collected from January 2010 to June 2025. These sector-level returns were arranged into rolling windows and were used to analyze predictability over time. The forecast performance was summarized through the Predictability Score (PS), which compares the root mean square error of a higher-level forecasting model to that of the Naive model. The Diebold-Mariano Test indicated that approximately 11% of the rolling windows across the six sectors exhibited significant PS values. Moreover, sector-level characteristics significantly associated with predictability were identified using dynamic fixed effects (DFE) and dynamic common correlated effects (DCCE) regression models. The results showed that sector-level indicators varied in significance depending on the model utilized. Specifically, excess return, price-to-earnings (P/E) ratio, return on common equity (ROE), trading volume, and volatility were found to be significant under the DFE model, while all indicators were found to be insignificant under the DCCE model. Among the five indicators suggested by the DFE model, P/E ratio, ROE, and volatility, when used with the ARMA-based forecasting strategy, were the most consistent in selecting sectors that yielded higher returns. Overall, our study suggests that while time-series predictability is not pervasive, certain significant indicators may guide sector investing decisions.

CT MathTech 2026-0123 Solving ESG Portfolio Optimization with Buy-In Threshold Constraints Using Spiral Optimization Algorithm

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This paper solves an ESG-constrained portfolio optimization problem with buy-in threshold constraints within the classical mean–variance framework. We propose minimizing portfolio risk with budget, target return, minimum ESG score, and buy-in threshold constraints. The implementation of buy-in threshold constraints transforms the ESG portfolio optimization problem into a mixed-integer nonlinear programming (MINLP) problems, which is difficult to solve using conventional optimization methods. Then, we use a penalty function to change the constrained portfolio model into an unconstrained optimization problem. Afterwards, we solved it using Spiral Optimization Algorithm (SOA). We use an ESG-compliant stocks listed on the Indonesia Stock Exchange to solve these portfolios consisting of five and ten assets. We compare the performance of SOA with Particle Swarm Optimization (PSO) and Grey Wolf Optimizer (GWO). The results show that all algorithms produce identical solutions for the five-stock portfolio, indicating the presence of a well-defined global optimum. For the ten-stock portfolio, GWO achieves the lowest portfolio risk, whereas SOA generates the most diversified portfolio by allocating capital across all available assets. The efficient frontier analysis confirms the trade-off between portfolio risk and expected return under ESG requirements, while the convergence analysis demonstrates the effectiveness of the spiral search mechanism in locating high-quality solutions. These results indicate that SOA provides a reliable and competitive approach for solving ESG portfolio optimization problems with buy-in threshold constraints and offers a practical alternative for sustainable portfolio construction.

CT MathTech 2026-0133 Time-Varying Dynamics and Volatility Spillovers between VIX and S&P 500: Evidence from TVP-VAR and BEKK-GARCH Models

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Given the importance of the VIX index and its construction from S&P 500 volatility, this study examines the dynamic relationship between VIX returns and S&P 500 returns using a Time-Varying Parameter Vector Autoregression (TVP-VAR) model estimated via Bayesian MCMC methods. Compared with a standard VAR model, the TVP-VAR delivers lower forecasting errors (MSE, RMSE, and MAE) for both series, indicating superior predictive performance. Residuals from both models are further used to estimate a BEKK-GARCH model to analyze volatility spillovers. All parameters in the A and G matrices are statistically significant, confirming strong bidirectional shock transmission and volatility persistence. However, the BEKK results based on TVP-VAR residuals show systematic adjustments in several coefficients relative to the VAR-based results, particularly in cross- market spillover and persistence terms, suggesting that the TVP-VAR framework effectively filters time-varying mean dynamics and induces a parameter correction effect in the volatility model. Overall, TVP-VAR improves both forecasting accuracy and the reliability of subsequent BEKK-GARCH estimation.

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 2026-0008 Transmission and Reflection Resonances from the Superposition of Various Potentials Using the Quasilinearization Method

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Quantum tunneling is a phenomenon in which a quantum particle passes through a potential barrier even if the total energy of the quantum particle is less than the potential energy. To describe this phenomenon, researchers use the Schrödinger equation to find the transmission probability of quantum particles passing through potential barriers. If potentials are complicated, it is not always possible to solve the Schrödinger equation directly. In this paper, we will present an approximation method called "quasilinearization". We apply this method to find an approximation solution to the Schrödinger equation for the superposition of various potentials. Then, we compare the resulting transmission probability in the quantum tunneling phenomenon obtained from the quasilinearization method with that obtained from the standard WKB approximation method. In addition, we discuss a suitable scenario for the use of the quasilinearization method.

CT MathTech 2026-0044 Mapping Interconnectedness in Malaysia's Technology Sector: An MST Analysis of the COVID-19 Period

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The COVID-19 pandemic has significantly disrupted global economic systems, with Malaysia's technology sector experiencing distinct structural adjustments. This study examines the transformation of technology companies listed on Bursa Malaysia during the pandemic period from 2019 to 2021. Given the continuous fluctuations in stock prices during trading hours, identifying the firms that strongly influence overall sectoral performance is a considerable challenge. Using daily price data for 89 listed technology stocks obtained from Eikon Datastream, this research applies the Minimum Spanning Tree (MST) methodology to construct and visualise the firms' correlation network. The MST framework enables a clearer representation of the sector's structural interconnectedness and facilitates the identification of central nodes within the network. To further assess the relative importance of individual stocks, betweenness centrality is employed to determine which firms play pivotal roles in transmitting shocks and shaping network dynamics. The results show that several firms emerged as key connectors during the pandemic, significantly influencing sectoral behaviour. These findings provide empirical evidence of the resilience and adaptive capacity of Malaysia's technology sector amid economic uncertainty. The study offers valuable implications for policymakers, investors, and industry stakeholders by identifying influential firms and enhancing understanding of correlation structures during systemic crises. Overall, this research contributes to the growing literature on financial network analysis and sectoral resilience in emerging markets.

CT MathTech 2026-0046 The Stable Marriage Problem with Suggested Pairs

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The Stable Marriage Problem (SMP) is a classic matching problem involving a set of men and a set of women. Each person has a preference list which ranks who they would like to be partnered with in the opposite group. The goal is to find a stable monogamous matching, that is, a matching with no blocking pairs, where there is no man and woman who both prefer each other over their assigned partners. Although the SMP has already been solved, many variations of the problem have been introduced to model more realistic matching situations. In this paper, we introduce a new variation which we call the Stable Marriage Problem with Suggested Pairs (SMP-SP). Here, the goal is to find a matching that is both stable, and that includes at least one representative from each of sets $S_1, S_2, \ldots, S_n$, where each set S_i contains one or more pairings. If such a matching does not exist, we attempt to find one which is as close as possible under some metric. The study proposes three algorithms to solve the SMP-SP: a modified forced pairs algorithm, a tiered algorithm, and a local search algorithm. The results show that the modified forced pairs algorithm always finds a matching that satisfies the SMP-SP, provided such a matching exists. In the absence of such a matching, the tiered and local search methods still yield a matching, whereas the modified forced pairs method does not. Using a cost function based on the sum of the number of unresolved blocking pairs and the number of S_i's with no representatives in the matching, the local search algorithm more consistently finds matchings with lower cost function values as compared to the tiered algorithm. On the other hand, the tiered algorithm provides a higher number of S_i's with at least one representative, but at the cost of having a lower frequency of stable matchings.

CT MathTech 2026-0052 A Comprehensive Empirical Evaluation Of Disaster Preparedness Behaviour Using Structural Equation Modelling: A Case Study In Penang Island

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Penang Island, Malaysia, faces increasing risks from natural disasters such as floods and landslides, due to rapid urbanization and changing of weather patterns. This study evaluates disaster preparedness behaviour (DPB) among residents of two high-risk areas, which are Datuk Keramat and Paya Terubong in Penang Island, using the theory of planned behaviour (TPB). A structured questionnaire was built to collect the primary data. The data were analyzed using independent samples t-tests and structural equation modeling (SEM) with the weighted least squares with mean and variance adjusted chi-square (WLSMV) estimator. The results indicate that residents of Datuk Keramat demonstrated significantly higher DPB scores than those in Paya Terubong. In both regions, attitude and subjective norms significantly predict DPB; notably, attitude is the strongest determinant. However, perceived behavioural control was not found to be a significant predictor. SEM models achieved good comparative fit indices, although limitations were observed in the root mean square error of approximation (RMSEA) and weighted root mean square residual (WRMR) values. The findings further reveal regional differences in preparedness focus, insurance coverage in Datuk Keramat versus mobile phone usage in Paya Terubong and suggest tailored awareness strategies. This study provides practical insights for policymakers to enhance community resilience and informs future studies on disaster preparedness in Malaysian contexts.

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 2026-0002 Modulated Gravity Effects on Double-Diffusive Lorentz-Like Magneto Convection in Viscoelastic Nanofluid Layer

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The double-diffusive magneto-convective system is highly sensitive to its initial state and can exhibit chaotic dynamics. Variations in gravity, such as periodic modulation or g-jitter, may intensify or weaken this chaotic response. This study examines the chaotic behavior of a Lorentz-type model in a horizontal layer of incompressible Oldroyd-B viscoelastic nanofluid subjected to g-jitter and magnetic field. The primary aim is to analyze how the system's behavior evolves under the combined influences of a magnetic field and gravity modulation. The governing equations are expressed in nondimensional form through appropriate scaling and then rewritten using the stream-function formulation. By applying a truncated Fourier series together with rescaled variables, the partial differential equations are reduced to a corresponding set of ordinary differential equations. Critical parameter thresholds associated with the onset of chaotic and steady convection are identified and transitions between stable and chaotic regimes are illustrated.

CT MathTech 2026-0034 On a Steady Turbulent Kinetic Energy Navier-Stokes Model

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We establish the existence of a weak solution for the steady RANS model, where the Navier-Stokes equations are coupled with the equation governing the turbulent kinetic energy. This coupling of the two equations occurs both through the eddy viscosity and eddy diffusion coefficients and also through a Dirichlet boundary condition on a portion of the boundary leading to energy production. Additionally, the right-hand side of the energy equation contains a term with low regularity. The proof of the existence of a weak solution is obtained by regularization of the original problem, relaxing the terms that are not sufficiently regular.

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 2026-0060 Three-Sub-Step Composite Time Integration Method for Solving Electromagnetic Transients in Power Systems

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Electromagnetic transient simulations in power systems frequently yield highly stiff ordinary differential equations. Standard explicit solvers, such as the forward Euler and fourth-order Runge-Kutta algorithms, exhibit severe structural limitations and instability within these stiff regimes. Furthermore, traditional implicit multi-step methods necessitate startup procedures. To address these computational deficiencies, this study introduces a novel composite time-integration scheme that couples an explicit modified Euler as predictor with a fourth-order backward differentiation formula as implicit corrector. The proposed methodology resolves the governing equations using Newton-Raphson iterations and Lagrange interpolating polynomials across two intermediate fractional nodes. The principal advantage of this architecture is its capacity to completely avoid cumulative and bound maximum errors from the initial step by remaining entirely self-starting. The framework is rigorously validated by solving stiff initial value problems representative of electromagnetic transient networks, utilising second-order RLC circuit models under single-phase-to-ground breakdown, linear solenoid actuators, and extremely fast charging stations. Its accuracy and convergence behaviour are benchmarked against standard Euler, RK4, BDF3, and BDF4 solvers using absolute error metrics. The absolute error results demonstrate that the composite Euler-BDF4 method achieves its most significant accuracy advantage at large step size, while conventional methods require highly small step size to achieve acceptable error bounds. Consequently, this approach provides a highly robust, independent, and practical numerical framework for analysing complex electromagnetic transient phenomena.

CT MathTech 2026-0062 Dimension Reduction Framework and Modeling of Sparse High-Dimensional Censored Data

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High-dimensional clinical-trial datasets increasingly incorporate genomic, proteomic, and other molecular measurements, creating challenges related to sparsity, high dimensionality, and right-censored outcomes. Existing sparse dimension-reduction methods have limited support for censored survival data and do not directly address the combined challenges of sparsity, censoring, and high dimensionality. We developed and evaluated a sparse sliced inverse regression (SSIR) framework for right-censored outcomes by incorporating inverse probability of censoring weighting (IPCW) and conditional kernel-based censoring estimation. The proposed approach extends sparse sufficient dimension reduction to survival settings while preserving interpretability through sparse effective dimension-reduction directions. Performance was evaluated through extensive simulations and application to The Cancer Genome Atlas bladder cancer dataset. Across simulation settings, marginal SSIR consistently outperformed non- sparse censored SIR approaches, including DSIR and IPCW-SIR, and demonstrated improved recovery of the latent outcome-related subspace. However, Cox lasso remained the strongest predictive benchmark for survival discrimination and variable-selection performance. Conditional kernel IPCW did not improve predictive accuracy, subspace recovery, or variable-selection performance under the evaluated finite-sample settings and increased computational burden and solution instability. These findings support the use of sparse dimension reduction for censored high-dimensional data while suggesting that marginal IPCW remains the preferred weighting strategy for the proposed SSIR framework.

CT MathTech 2026-0063 Linearized Dispersive Green-Naghdi Level-1 Model for Landslide-Generated Waves

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Submarine landslides are also an efficient tsunami source and generate waves with very short wavelengths in water coupled with strong dispersion (near-field effects). These features are not always well reproduced by standard non-dispersive shallow water models. Hence, for an efficient and accurate prediction of the tsunami hazard, the underlying mathematical model should be capable of capturing the frequency dispersion effects induced by the dynamic seabed deformation. Here, the Green-Naghdi Level-1 (GN-L1) model is used to study the production and propagation of tsunami waves generated by different submarine landslide profiles. Using a third order Strong Stability-Preserving Runge-Kutta method (SSP-RK3) and the Shapiro Filter for dampening high frequency numerical oscillations, the system of equations on staggered grids is integrated in time with a finite volume scheme for solving the governing equations. To fully validate the model, we use an exact analytical solution in spatial Fourier transform as a reference. We perform numerical simulations on five different landslide shapes, namely Gaussian, Parabolic Cap, Quartic Cap, Rectangle and Isosceles Triangle, while preserving equal cross-sectional areas to distinguish the effect of profile shapes on waves behavior. The results indicate that the proposed GN-L1 scheme can accurately capture the complex physics including wave fission and dispersive tails formation when compared to analytical solution. A quantitative analysis shows a very small Root Mean Square Error (RMSE) for all geometries. This illustrates the robustness of the method to extremely spatial discontinuity, without inducing artificial oscillations.These findings confirm that the GN-L1 approach provides an accurate, stable, and efficient framework for modeling tsunamis caused by landslides, and offers significant improvements over non-dispersive models in supporting coastal disaster risk assessment and mitigation.

CT MathTech 2026-0071 Adaptive Intuitionistic Fuzzy Logic Control for Combination Therapy Dosing in an Immune-Cancer Model: A Dual-Modality Comparative Study

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Adaptive intuitionistic fuzzy logic control (A-IFLC) is developed to design effective dosing for cancer treatment. A nonlinear model with normal cells (N), sensitive cancer cells (S), resistant cancer cells (R), and immune cells (E) is considered, capturing the interactions between the immune and cancer cell populations under treatment. Chemotherapy, radiotherapy, and immunotherapy are incorporated as bounded control inputs, with the objective of suppressing the tumor burden while maintaining the immune cells within acceptable ranges. A performance index is introduced to penalize cancer burden together with cumulative dosing effort, thereby quantifying the trade off between therapeutic efficacy and cost. The controller employs intuitionistic fuzzy sets to incorporate membership, non-membership, and hesitancy degrees, enabling robust decision making under biological uncertainty and patient variability. Tracking errors based on tumor burden, immune indicators, and their rate of change are processed by an intuitionistic fuzzy inference mechanism to generate therapy signals. Numerical simulations under parameter perturbations indicate that A-IFLC can reduce both sensitive and resistant cancer populations while lowering cumulative dosing cost and preserving immune activity. Comparative evaluations of three dual-modality combinations of chemotherapy and radiotherapy, chemotherapy and immunotherapy, radiotherapy, and immunotherapy show that the combination of radiotherapy and immunotherapy provides the most effective tumor reduction under the constraints considered.

CT MathTech 2026-0080 Mathematical Analysis of Delayed Typhoid Fever Transmission Model with Control Strategies

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Typhoid fever is a deadly infection that is silent and is caused by the bacterium Salmonella Typhi. Transmitted by contaminated food and water, it can spread to the bloodstream and kill the essential organs without treatment. The victims can experience high fever, extreme weakness, stomach pain and internal bleeding. Typhoid may lead to intestinal perforation, septic shock and death in severe cases. This disease may become life-threatening in a short period, unless it is treated properly. To overcome this public health problem, we extended a nonlinear mathematical model to time delay mathematical model to understand typhoid disease dynamics in an overpopulated society. The impact of environmental measures and time delay on the spread of typhoid disease was considered in the model. An analytical investigation is undertaken to compute the threshold reproduction parameter and evaluate the dynamical behaviour of the infection-free and persistent-disease steady states in both scenarios. The Lyapunov approach is employed to demonstrate the global asymptotic stability of these equilibrium points. We also observed the most critical parameter by sensitivity analysis. Furthermore, we construct non-standard finite difference numerical schemes and then analysed NSFD preserves positivity and boundedness. It is shown that the NSFD approach yields better stability properties with independent of time step size. To validate the theoretical conclusions and discuss the advantages of the NSFD scheme, numerical simulations are also presented. The NSFD approach maintains the significant features of the continuous time delay mathematical model, according to numerical simulations. The results emphasize that combining time delay provides a more effective way for TF mitigation and offering valuable guidance for public health department.

CT MathTech 2026-0090 Blood-Based Williamson Ternary Hybrid Ferrofluid in Magneto-Radiative Hiemenz Flow Subject to Stretching/Shrinking Wall Motion

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Ferrofluids are increasingly viewed as important working fluids for biomedical applications, including magnetically guided therapies and localized thermal treatments. In this work, a blood-based Williamson ternary hybrid ferrofluid (THFF) saturated with magnetite (Fe_3O_4), cobalt ferrite ($CoFe_2O_4$), and copper (Cu) nanoparticles is modeled and analyzed in Hiemenz flow past a stretching or shrinking wall under the combined influence of magnetohydrodynamic (MHD) and thermal radiation effects. In this ternary composition, combining magnetic and non-magnetic nanoparticles is aimed at improving both magnetic control and heat transfer performance. A reduction strategy based on a similarity transformation is utilized to recast the governing equations into a nondimensional form, which is then solved numerically using the MATLAB solver bvp4c. The outcomes suggest that representing blood as a Williamson THFF improves its thermal response compared with pure blood. In addition, a stronger radiative effect causes the thermal boundary layer to be compressed near the wall and to extend farther into the fluid.

CT MathTech 2026-0100 Numerical Analysis of Oldroyd-B Viscoelastic Channel Flow via a Quintic B-Spline Galerkin Method

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This study introduces a numerical method utilizing the quintic B-spline Galerkin method for solving the Oldroyd-B viscoelastic channel flow problem. In a Galerkin variational structure, quintic B-spline function as both basis and test functions for the discretization of the governing momentum and constitutive equations. This results in a system of coupled algebraic equations. A Fourier analysis of the stability study observes if the suggested scheme parameters are stable and verifies unconditional stability with the selected discretization parameters. The problem is used as a test case to confirm the proposed scheme is accurate. The numerical solutions are then compared to the analytical solutions. Furthermore, the accuracy of the proposed scheme is assessed through three error measures, namely the absolute error, the L_∞-norm, and the L_2-norm, with the computed results, presented in both tabular and graphical representations, demonstrating the superior accuracy of the proposed scheme. The influence of the controlling factors on the centerline velocity profile is examined through a parametric study of pressure drop and elasticity number.

CT MathTech 2026-0102 Modeling Drivers of Carbon Emissions in Nigeria using Bayesian Quantile Regression

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This study investigates the drivers of carbon emissions in Nigeria. To identify the key drivers of carbon emissions, we employed Bayesian quantile regression framework as a statistical tool with asymmetric Laplace distribution as the likelihood (ALD). The robustness of this method was validated through the use of a simulation study that compares the performance of Bayesian quantile regression against the classical quantile regression and the linear regression. Time-series dataset of carbon emissions for the period of 1990 to 2021 was then used for the analysis. Using the Markov Chain Monte Carlo (MCMC) method through Gibbs sampling algorithm, the parameters of the Bayesian quantile regression model were estimated, with inference based on posterior means and credible interval. The results show that, incorporating priors to each of the parameter in the model, the Bayesian quantile regression (BQR) framework with low mean square error and root mean square error outperform both the quantile regression and linear regression. It quantifies uncertainty of parameter estimates and enables effective variable selection across different quantile levels. This result would help to improve decision-making by providing robust and accurate models for longitudinal data in fields like healthcare, finance, and environmental studies. The study shows that Bayesian quantile regression can identifies key drivers of carbon emissions in Nigeria than the classical quantile regression and linear regression.

CT MathTech 2026-0104 Travelling-Wave Solutions of Nonlinear Dispersive Equations: An Ansatz-Based Comparison of Parameter Constraints

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This study examines the existence of travelling-wave solutions for a class of nonlinear dispersive partial differential equations whose coefficients are retained as free parameters. By applying a travelling-wave transformation, each governing equation is reduced to an ordinary differential equation, and an ansatz-based construction is used to obtain explicit solitary and periodic profiles by assuming suitable functional forms. The validity of each construction depends on a parameter constraint derived from the reduced equation: substituting the trial form and balancing terms forces a single algebraic relation among the coefficients, and a non-trivial bounded solution exists only when that relation holds. Treating several generalised dispersive models within this common framework, the resulting constraints are assembled into a unified comparative taxonomy. The contribution is organisational: it places admissibility conditions previously reported model by model into a three-layer comparative framework that separates algebraic compatibility, real admissibility, and waveform morphology. It distinguishes equality loci from inequality regions and clarifies the profile families admitted within each stated ansatz regime. No new exact solution, classification theorem, or numerical validation is claimed. The synthesis provides a basis for further study of the qualitative dependence of travelling-wave solutions on model parameters.

CT MathTech 2026-0115 Extracting Long-Term Mortality Improvement Trajectories Using Wavelet Denoising

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Mortality improvement data often show large year-to-year fluctuations, making long-term mortality trends difficult to identify, particularly across different age groups. This study applies wavelet denoising based on the maximal overlap discrete wavelet transform (MODWT) to extract long-term mortality improvement trajectories from annual age-specific mortality rates.Mortality improvement series were constructed from annual age-specific mortality rates for Japan, Italy, Sweden, and the United States (1960–2022) using the logarithmic ratio of consecutive annual observations. The mortality improvement series were decomposed using a five-level MODWT with the Daubechies D4 wavelet filter. Hard thresholding based on the universal threshold was then applied to reduce short-term fluctuations while preserving major mortality events. The resulting trajectories provide a clearer view of long-term mortality patterns across age groups and countries. Although mortality improvement in younger age groups remains relatively variable because of low mortality rates, adult and older age groups show more stable long-term patterns. The proposed approach preserves major mortality shocks, including the COVID-19 pandemic in Italy and the United States and the 2011 Great East Japan Earthquake in Japan. The findings show that MODWT-based wavelet denoising provides a useful tool for extracting long-term mortality improvement trajectories while preserving important demographic events.

CT MathTech 2026-0125 A Pareto-Efficient Second-Best Congestion Pricing Model for McKinley Road: Integrating Nested Logit Estimation and Nonlinear Least Squares Optimization

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Traffic congestion is a global problem that the traditional supply-side solutions (such as expanding roads) fail to solve. The proposed alternative policy, known as congestion pricing, reduces road demand by increasing the cost of using a road during peak hours. This research studied the feasibility of implementing a congestion pricing model on McKinley Road, which connects two major financial hubs in the Philippines: Bonifacio Global City (BGC) and Central Makati, using the Second-Best pricing framework. This framework aims to find the market-clearing toll that maximizes overall social welfare. The study used a synthetic micro-dataset of 10,000 drivers to generate values such as weekly gasoline expenditure and travel time, all of which are anchored on data from other studies done in Metro Manila. The paper identified a unique baseline congestion toll of ₱62.00 for both peak and off-peak periods. Subsequent sensitivity analyses demonstrated that the policy's success relies heavily on commuter schedule flexibility and adjustment of congestion price to macroeconomic shifts, such as wage growth and volatility.

CT MathTech 2026-0142 Bernstein Operational Matrix of Derivative Approach for Nonlinear Lane-Emden Equation

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This study proposes a numerical approach for solving nonlinear Lane-Emden type equations using the Bernstein Operational Matrix of Derivatives (BOMD). The Lane-Emden equation is one of the examples of Ordinary Differential Equations (ODEs) that play a fundamental role in astrophysics and mathematical physics, serving as a model for various phenomena. However, solving this equation is challenging because of its nonlinear characteristics and the singularity at the origin. Previously, BOMD has typically been applied using a fixed type of collocation points, while collocation points derived from different polynomial bases or functions are less frequently applied. This study employs various types of collocation points and evaluates the method's performance using the trade-off graph. The findings show that Chebyshev Gauss-Lobatto (CGL) points offer the best balance between accuracy and computational efficiency. Overall, the proposed method is shown to be effective and accurate for solving nonlinear ODEs by comparing the proposed approach with existing methods.

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 2026-0149 A Composite TR-BDF2 for the Numerical Integration of Stiff Differential Equations

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Stiff ordinary differential equations (ODEs) accurately model widely varying time scale across various engineering and scientific field. However, these varying components cause traditional numerical methods to diverge uncontrollably, demanding step sizes far smaller than required to resolve the desired smooth solution. In this paper, the composite trapezoidal-backward differentiation formula (TR-BDF2) is reformulated for solving stiff ODEs. Generally, this method is a composite time integration method, which combines trapezoidal rule (TR) as the implicit method and second order backward differentiation formula (BDF2). The interpolation process involves Lagrange interpolation polynomial technique with one independent parameter at an intermediate point. The predictor and corrector formulas for TR and BDF2 are derived for the implementation of the predictor-corrector scheme. To implement this efficiently, the explicit forward Euler predictor produces the initial guess, which is subsequently updated by the implicit BDF2 corrector via Newton- Raphson method up to second iterations. The numerical results of selected stiff initial value problems (IVPs) demonstrate the accuracy of the proposed method in terms of maximum and average error. The TR-BDF2 method provides a decreasing error of as the step size decreases compared to conventional BDF and block backward differentiation formulas (BBDF).

CT MathTech 2026-0150 Migration Regulation and Conservation Harvesting Control on a Two-Habitat Single-Species Model

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This paper develops an optimal control framework for a two-habitat, single-species population model that incorporates migration regulation and conservation–based harvesting. The population is divided into two subpopulations: those in a protected habitat and those in an unprotected habitat. The uncontrolled model includes logistic growth in both habitats, one-way migration from the unprotected to the protected habitat, and a Michaelis-Menten-type harvesting function acting on the unprotected population. The qualitative dynamics of the uncontrolled system are rigorously investigated. The model admits a trivial equilibrium, an axial equilibrium corresponding to persistence only in the protected habitat, and an interior equilibrium representing coexistence in both habitats. To improve population persistence, two bounded, time-dependent controls are introduced, namely migration regulation and conservation harvesting. An objective function is formulated to minimize deviations from habitat carrying capacities and the costs of implementing both controls. Numerical simulations demonstrate that appropriate control strategies can shift the system from an axial equilibrium, in which the unprotected population becomes extinct, to an interior coexistence state. The results highlight the importance of integrating migration regulation and conservation harvesting to sustain populations across heterogeneous habitats.

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 $\mu g/m^3$, an MAE of 9.96 $\mu g/m^3$, 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 $\mu g/m^3$ from an initial concentration of 24.66 $\mu g/m^3$. 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 2026-0157 Heat Transfer of Unsteady Micropolar Hybrid Nanofluid Flow Over a Permeable Vertical Stretching and Shrinking Surface

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Heat transfer enhancement in convection-dominated systems has become increasingly important owing to the growing demand for efficient thermal management in modern engineering applications. Although hybrid nano8luids and micropolar 8luids have demonstrated considerable potential for improving thermal performance, studies investigating the combined effects of unsteadiness, micropolarity, hybrid nanoparticles, and wall permeability over vertical stretching and shrinking surfaces remain limited. Therefore, the present study investigates the heat transfer characteristics of an unsteady micropolar Cu–Al_2O_3/water hybrid nanofluid over a permeable vertical stretching and shrinking surface. The governing partial differential equations are transformed into a system of nonlinear ordinary differential equations using similarity transformations and solved numerically using the MATLAB bvp4c solver. The effects of the aluminium oxide nanoparticle volume fraction on the temperature distribution and the reduced Nusselt number are examined. The results reveal that the shrinking surface exhibits higher 8luid temperatures and a thicker thermal boundary layer than the stretching surface. Furthermore, increasing the aluminium oxide nanoparticle volume fraction elevates the 8luid temperature and further thickens the thermal boundary layer owing to enhanced thermal energy retention within the hybrid nanofluid. Consequently, the wall temperature gradient decreases, resulting in a reduction in the reduced Nusselt number and the corresponding surface heat transfer rate. These 8indings demonstrate that the aluminium oxide nanoparticle volume fraction plays a significant role in governing the thermal behaviour and heat transfer performance of micropolar hybrid nanofluids, providing useful insight for the design and optimization of advanced thermal management systems involving permeable vertical stretching and shrinking surfaces.

CT MathTech 2026-0196 How Well Can MCMC Samplers Recover Epidemic Parameters? Evidence from Indonesian COVID-19 Data

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Accurate inference of epidemiological parameters is fundamental to understanding and forecasting infectious disease dynamics. This study examines the performance of two Markov Chain Monte Carlo (MCMC) approaches, namely Metropolis–Hastings (MH) and Hamiltonian Monte Carlo (HMC), within a Bayesian framework applied to compartmental epidemic models. Two model variants are considered: the standard SIR model and its extended SIRD form that explicitly accounts for disease-induced mortality. Indonesian COVID-19 surveillance data spanning January to April 2022 serve as the empirical basis for estimating transmission, recovery, and death rates. Sampling quality is assessed through Gelman–Rubin convergence diagnostics, effective sample size (ESS), and predictive accuracy via Root Mean Squared Error (RMSE). Findings indicate that MH suffers from slow mixing, minimal acceptance rates, and highly correlated samples, rendering its posterior estimates unreliable. HMC, by leveraging gradient information during trajectory simulation, achieves superior convergence and produces substantially larger effective sample sizes. Although both models converge well under HMC, residual prediction errors point to inherent constraints of fixed-parameter compartmental structures in capturing time- varying transmission behaviour. Adopting a lognormal prior for the transmission rate in conjunction with HMC and the SIRD model yields the most accurate fit to observed case counts. These results underscore the value of pairing appropriate prior specifications with gradient-based samplers when performing Bayesian inference in nonlinear epidemic modelling.

CT MathTech 2026-0198 Predicting Calf Production Outcomes in Artificially-Inseminated Philippine Carabaos Using Machine Learning

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The Philippine carabao industry remains an important component of the Philippine agricultural sector, providing milk, meat, hide, and livelihood opportunities for smallholder farmers. Artificial insemination (AI) is widely used to improve genetic quality and productivity; however, not all AI services result in successful calf production. Identifying the factors associated with AI success is therefore essential for improving reproductive efficiency and farmer income. To optimize national breeding strategies, this research provides the first comprehensive analysis of nationwide AI service records (2018–2022) from 12 regional Philippine Carabao Center. The study evaluates how biological, seasonal, and logistical factors work together to predict calf production. To account for the geographic complexity of the Philippines, a geospatial framework was developed to calculate farm-to-center proximity using shortest-path analysis in OSMnx for land routes and a hybrid Haversine–shortest-path method for inter-island transport. This information was then integrated into machine learning models for predicting calf production at a national scale. Several interpretable machine learning models were evaluated using standard performance metrics. Feature importance measures and interpretability techniques were also applied to assess the relative influence of each predictor on AI success. Among the models considered, the Random Forest model achieved the highest predictive performance. The results show that operational factors, including the distance between farms and service centers, regional variation, and technician-related characteristics, have the strongest effect on calf production outcomes, while biological and environmental factors have only moderate influence. These findings indicate that the conditions under which services are delivered play a crucial role in determining the success of artificial insemination. A prototype decision-support dashboard was also developed to help farmers identify cost-effective AI service options and improve breeding decisions. The findings demonstrate the value of integrating geospatial analytics and machine learning to enhance reproductive outcomes and support data-driven livestock management strategies in the Philippines.

CT MathTech 2026-0201 MHD Squeeze Radiative Flow of Ternary Casson Nanofluid with Chemical Reaction Effect

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This study examines the dynamic magnetohydrodynamic flow and radiative heat transfer of Casson Ternary Nanofluid (TN) between two parallel surfaces, influenced by chemical processes. The TN consists of Graphene, Graphene Oxide, and Silver distributed in Sodium Alginate. The governing equations are converted to dimensionless form using suitable similarity variables and then resolved using the Keller-box method. The study examines the influence of squeezing, magnetic fields, chemical processes, and thermal radiation on the flow behavior and physical properties of nanofluids, hybrid nanofluids, and ternary nanofluids. The comparison of the obtained data with previously reported outcomes shows acceptable concordance, thereby confirming the procedure. The findings indicate that compression between parallel surfaces increases fluid velocity, while a deceleration is observed near the upper plate as the Hartmann and Casson numbers increase. Convective heat transfer and temperature increase as the Eckert number and the thermal radiation number increase. Concentration rises, and the mass transfer rate diminishes during constructive chemical processes, whereas the reverse occurs during destructive chemical reactions. Moreover, TN exhibits lower velocity profiles as the plate compression, Casson, and Hartmann numbers rise. TN exhibits higher temperature profiles for increasing squeeze, Casson, Hartmann, Eckert, and thermal radiation numbers. Nanoparticle volume fractions indirectly affect mass transfer. Therefore, the obtained outcome offers practical insights for engineering applications involving radiative and reactive nanofluid flows.

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-CVI = 1.00 and S-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 ob- tained 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.

Operations Research & Statistics

CT MathTech 2026-0018 Gotta Catch All Nodes: A Comparative Framework for Traveling Salesman Problem (TSP) Algorithms

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The Traveling Salesman Problem (TSP) is a cornerstone of combinatorial optimization whose objective is to identify the shortest route that visits every node exactly once and returns to the origin. While numerous algorithms have been proposed to address this problem, they often exhibit trade-offs between computational efficiency and accuracy. Since algorithm performance can vary depending on the dataset considered, it is important to determine which methods remain robust under changes to the problem formulation. Thus, this study presents a comparative framework to examine the sensitivity of selected optimization algorithms to: (1) increasing the number of nodes; (2) scaling the node distances; and (3) varying the initialization and node ordering of the distance matrix. Four algorithms are compared: the nearest neighbor algorithm, Prim's algorithm with preorder traversal, Christofides' algorithm, and the genetic algorithm. The comparative analysis uses the augmented reality mobile game Pokémon Go as the source of geographical nodes to construct a practical TSP scenario that resembles a real-world routing problem. In this formulation, the goal is to determine the shortest route for a player to visit every point-of-interest in a specified area. These game-based datasets naturally allow their distance matrices to be modified according to the three criteria mentioned, demonstrating the framework's applicability to practical TSP instances. Algorithm performance is evaluated based on path optimality and runtime behavior. The results indicate that, while some algorithms achieve lower-cost solutions, their performance can be more sensitive to certain modifications in the distance matrix. Balancing op- timality with sensitivity, the results demonstrate how these algorithms respond to modifications, providing a basis for evaluating their suitability in practical applications. Although game-based datasets are used, the framework presented here is readily applicable to other TSP instances where distance matrices can be modified to fit the problem context, including applications in logistics, urban planning, and routing.

CT MathTech 2026-0026 Reducing Computational Cost in Two-Sample Permutation Tests via the Mean Value Theorem

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Permutation tests are widely employed as nonparametric methods for two-sample hypothesis testing, particularly in settings with small sample sizes or uncertain distributional assumptions. However, when the test statistic relies on maximum likelihood estimators (MLEs) that must be obtained numerically, each permutation requires an iterative optimization procedure, making the overall testing process computationally intensive. This paper proposes an efficient framework that incorporates the Mean Value Theorem (MVT) into permutation testing to avoid unnecessary numerical optimization. By exploiting the relationship between the distribution parameter and the sample mean, the proposed MVT-Pruning framework establishes bounds that determine whether a permuted sample can contribute to the permutation distribution without explicitly recomputing the MLE. The framework is illustrated using the zero-truncated Poisson (ZTP) and Gamma distributions. Simulation studies demonstrate that the proposed method produces permutation p-values that are identical to those obtained from the standard permutation test while substantially reducing computational effort. For the ZTP distribution, the proposed method prunes approximately 85%–100% of permutation iterations and reduces computation time by about 60%–80%, depending on the parameter setting. For the Gamma distribution, it prunes approximately 50%–60% of iterations and achieves a computation time reduction of about 40%. These computational gains remain stable across a range of parameter settings, indicating that the MVT-Pruning algorithm provides an effective and exact approach for accelerating permutation tests involving numerically intractable MLEs.

CT MathTech 2026-0029 Estimating Comeback Probabilities from Half-Time Deficits in English Football

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Football matches are naturally divided into two halves, and the half-time match status often influences tactical decisions and the eventual full-time outcome. Among the nine possible half-time/full-time (HT–FT) outcome combinations, a comeback victory, in which a team wins after trailing at half-time, is one of the rarest yet most strategically significant events. Estimating the probability of such outcomes is challenging because many teams have few or no observed comeback victories, leading to zero maximum likelihood estimates that are statistically valid but unsuitable for probability prediction. This study proposes several modified maximum likelihood estimators to address this prob- lem while preserving the simplicity of the multinomial modeling framework. The proposed estimators are evaluated using historical English Premier League data and compared with the traditional maximum likelihood estimator and a Poisson goal model. Predictive performance is assessed through Monte Carlo simulations using an out-of-sample test set, with macro-averaged accuracy, precision, recall, specificity, and the F1-score as evaluation criteria. The results indicate that all competing methods achieve comparable predictive performance. The proposed estimators successfully eliminate zero-probability estimates and provide modest improvements in prediction for teams affected by sparse outcome classes. Among the proposed estimators, the Schafer-type estimator demonstrates the most consistent performance, while the Poisson goal model achieves the highest overall predictive accuracy. Overall, the proposed estimators offer a statistically robust solution to the zero-probability problem while achieving predictive performance comparable to that of the Poisson goal model.

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 2026-0075 Cointegration Analysis of Animal Bites with Precipitation, Temperature and Humidity in Baguio City, Philippines

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Animal bites, particularly dog bites, are a major public health concern in the Philippines due to the risk of rabies. Baguio City, a highland urban center in the Cordillera Administrative Region, exhibits marked seasonal variability in precipitation, temperature, and humidity that may influence animal behavior, human outdoor activity, and consequently animal bite incidence. However, the long-run equilibrium relationships between these meteorological factors and animal bites remain poorly characterized in this setting. This study examines the long-run relationships between weekly animal bite incidence and precipitation, temperature, and humidity in Baguio City using cointegration analysis. Weekly animal bite counts from the Baguio City Health Services Office - Animal Bite Treatment Center and meteorological data from the nearest PAGASA station (January 2010–December 2023) is compiled, cleaned, and aggregated. Time series diagnostics, including visualization, seasonality assessment, and unit root tests, are conducted. Cointegration tests are applied to determine whether animal bites and meteorological variables share common stochastic trends; for cointegrated systems, vector error correction models quantify long-run equilibria and short-run adjustments. By identifying stable climate–bite relationships and evaluating their forecasting performance, the study aims to inform weather-sensitive planning for post-exposure prophylaxis allocation, bite-prevention campaigns, and integrated rabies control in Baguio City.

CT MathTech 2026-0081 A Mixed-Effects Support Vector Machine Approach to District-Level Poverty Mapping in Malaysia

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Poverty reduction remains a central development priority, yet producing reliable local-level poverty statistics is often constrained by sparse and uneven survey samples across areas. This study develops a mixed-effects support vector machine regression (MESVMR) within the small area estimation (SAE) approach. The estimator modifies the mixed-effects random forest (MERF) framework by replacing the random forest learner with support vector machine regression, while retaining area-specific random effects to account for unobserved heterogeneity. The present study utilises two primary datasets from the Department of Statistics Malaysia (DOSM). The first dataset is the 2022 Household Income and Expenditure Survey (HIES). The second dataset is the 2020 Population and Housing Census (PHC), which covers Malaysian administrative districts. The PHC aligns with the HIES survey districts (domains) and includes the same set of predictors, thereby serving as auxiliary data for the study. The study estimates district-level poverty indicators: the headcount ratio (HCR) and the poverty gap (PG). The proposed MESVMR is compared with direct design-based estimation, the unit-level Empirical Best Predictor (EBP), and MERF. The performance and uncertainty of the estimated indicators are evaluated using the root-mean-square error (RMSE) and the coefficient of variation (CV). The results indicate that MESVMR produces poverty estimates with RMSE and CV that are broadly comparable to those of the unit-level EBP across most districts, and it clearly outperforms both the direct and MERF estimators. However, EBP remains superior in districts with very small survey sample sizes, where MESVMR exhibits relatively higher RMSE and CV and where borrowing strength through the parametric unit-level model is most effective. Overall, these findings highlight the value of model-based SAE in providing policy-relevant poverty measures at fine geographic scales, and thus supporting the identification of high-need districts and the design of more targeted poverty alleviation interventions in Malaysia.

CT MathTech 2026-0096 Modelling and Forecasting Tourism Demand of Malaysia by European Countries Using SARIMA and Transfer Function Models

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Tourism demand for a particular country often fluctuates due to global events and shifting travellers behaviours. This study aims to model and forecast the number of foreign tourist arrivals to Malaysia from six European countries: Denmark, France, Germany, Russia, Sweden and the UK for the period from January 1999 to December 2024. The SARIMA model was applied, utilizing standard modelling procedures of identification, parameter estimation, diagnostic checking and forecasting. Transfer function modelling technique was employed to deal with the drastic change in the number of tourist arrivals during the COVID-19 pandemic period. The best-fitted SARIMA models were identified as: SARIMA(0,1,1)(0,1,1) for Denmark; SARIMA(1,1,1)(0,1,1) for France; SARIMA(0,1,1)(0,1,2) for Germany; SARIMA(1,0,1)(0,1,1) for Russia; SARIMA(3,0,2)(0,1,1) for Sweden; and SARIMA(0,1,5)(1,0,0) for the UK. These models manage to provide reliable within-sample forecasts for tourist arrivals from January 2018 to December 2019. However, the COVID-19 pandemic was found to severely impacted the tourism industry in Malaysia with all the models were unable to predict the drastic drop in the number of arrivals from April 2020 to April 2022 that was due to international travel restriction. Accounting for the impact of COVID-19 pandemic, the most adequate transfer function models were estimated as SARIMA(2,1,0)(0,1,1)- TF for Denmark; SARIMA(0,1,1)(0,1,1)-TF for France; SARIMA(2,1,3)(1,1,1)-TF for Germany; SARIMA(0,1,0)(1,1,1)-TF for Russia; SARIMA(2,0,1)(0,1,1)-TF for Sweden; and SARIMA(0,1,2)(1,0,0)-TF for the UK. While tourist arrivals from France, Germany, Russia, and the UK have rebounded to pre COVID-19 levels, the number of arrivals from Denmark has yet to reach the level recorded before the pandemic. Despite forecasts indicating the arrivals from these countries will exceed the 2019 levels by 2027, the rate of growth appears to be decreasing. To achieve long- term sustainability in the tourism industry, proactive planning and targeted adaptation need to be implemented to strengthens Malaysia as a competitive and attractive global travel destination.

CT MathTech 2026-0097 Mean and Volatility Spillovers from Foreign Stock Markets, Oil Prices and Exchange Rate on the Malaysian Stock Market

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The increasing pace of globalization has led to deeper financial integration, resulting in the rapid transmission of shocks and development information from one stock market to another. This has inspired this paper to investigate the mean and volatility spillover effects from major stock markets of the US, China and the UK to the Malaysian stock market. In addition, the analysis also examines the influence of crude oil prices and exchange rate, on both the mean returns and volatility of the Malaysian stock market. The data used in the study spanned from 1^{st} August 2005 to 31^{st} December 2024. In addition to the whole sample, analysis was conducted on three shorter subsamples to enable a more detailed examination on the behavior of spillovers in different economic environments. The methodological framework in the study is the ARIMA-EGARCH model that was used to capture both the mean and volatility spillover effects as well as possible asymmetric effect of good and bad news on the volatility. Results show significant and positive mean spillovers from all the major stock markets to the Malaysian stock market, with the US exerting the strongest influence. These patterns remain generally consistent across pre-COVID, during COVID and post-COVID subsamples, although shifts in dominant influences were observed during specific period. Lagged oil prices were found to stabilize volatility, with a significant impact on the mean returns only occurred during the whole sample period. Contemporaneous exchange rate was found to reduce both returns and volatility during the whole sample and pre-COVID period, although this effect weakens during post-COVID period. The findings highlight the growing interconnectedness between global financial and commodity markets, underlining the importance of portfolio diversification and monitoring of external shocks emanating from major economies.

CT MathTech 2026-0105 Dividends or Burdens? Assessing the Trade-offs Between Low-Carbon Performance and Social Equity under Carbon Trading in China

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In the context of urgent global climate governance, energy transition has become a central strategy for achieving sustainable development. However, its implications for social equity have received less attention. This study examines the multidimensional impacts of China's Carbon Emission Trading Policy (CETP) from the perspective of the "efficiency-equity" trade-off. Utilizing a Difference-in-Differences (DID) model, we examine the policy effects across environmental, economic, and social dimensions. Results indicate that while CETP effectively promotes energy transformation by significantly reducing the share of non-clean energy consumption, it exerts a temporary inhibitory effect on total factor productivity (TFP). Furthermore, these economic pressures are accompanied by social burdens, as the policy tends to widen income inequality, especially in cities with an industrial orientation. This research highlights the necessity of integrating social equity considerations into low-carbon transition mechanisms, so as to achieve sustainable development goals with fairness and inclusive development.

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 2026-0117 A Network-Theoretic Approach for Assessing Road Traffic Volume Malaysia (RTVM) Census Stations in an Urban Traffic Monitoring System

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Reliable traffic volume data form the backbone of transportation planning, and the effectiveness of a monitoring system depends not only on individual census stations but on how those stations relate to one another as a system. In Malaysia, the Road Traffic Volume Malaysia (RTVM) programme provides long-term traffic census data for federal roads; however, these data are typically analysed at individual stations, leaving the system-level importance of stations within the monitoring network largely unexamined. This study employs network theory to assess the structural importance of eleven RTVM census stations in Klang, Malaysia, using hourly traffic volume data collected over seven consecutive days. Three network configurations were developed to evaluate station importance from different perspectives. First, an undirected correlation-based network was constructed to capture similarities in traffic volume patterns, with eastbound and westbound traffic directions analysed separately. Second, a directed unweighted network was developed to represent directional relationships between census stations. Third, a directed weighted network was constructed by incorporating traffic volume intensity into the network structure. Centrality measures, including degree, betweenness and closeness were applied to quantify the structural importance of each station. A combined station importance scoring framework was then used to integrate the results across the different network configurations. The results show that BR101 and BR110 consistently appeared among the most important census stations across most network experiments, indicating their strong structural and traffic-related roles within the Klang traffic monitoring network. Overall, the findings demonstrate that network analysis provides a systematic approach for identifying important RTVM census stations and can support more informed traffic monitoring, station prioritisation, and data-driven transportation planning. Future work may extend the framework to multilayer networks incorporating vehicle classes or alternative network constructions based on actual road topology.

CT MathTech 2026-0121 POO-LPSP: Parallel Osprey Optimized Least Penalty-Squared Prioritization Methods for Priority Derivation in the Analytic Hierarchy Process

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Pairwise comparison (PC) via pairwise reciprocal matrices (PRMs) is central to the Analytic Hierarchy Process (AHP). Although the traditional eigenvector method is widely applied to derive priorities, its theoretical robustness in reflecting true priority vectors remains debated. Building upon a previous iteration of this study, this research develops the revised Least Penalty- Squared Prioritization (LPSP) optimization models, including the revised Least Product of Penalty and Direct Squares (LPPDS) and revised Weighted Squares (LPPWS), to minimize the revised Root Mean Penalty-Squared Variance (RMPSV) and the revised Root Mean Penalty-Weighted Square Variance (RMPSWV). However, solving these non-linear formulations is computationally complex for decision-makers. To overcome these limitations, this study proposes the Parallel Osprey Optimized Least Penalty-Squared Prioritization (POO-LPSP) method. By integrating an improved bio-inspired metaheuristic Parallel Osprey Optimization Algorithm (POOA), this framework efficiently solves complex LPSP models to minimize RMPSV and RMPSWV, thereby enhancing prioritization reliability. The practical utility and computational efficiency of the POO-LPSP method are validated through a numerical application focusing on a Generative AI (GAI) vendor selection problem. To extend, POO-LPSP can serve as a robust alternative to Saaty's Eigen system method for AHP applications.

CT MathTech 2026-0135 Minimax Quantile Tracking Under Kolmogorov Drift and Weak Dependence

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We study tracking a fixed quantile of a time-varying distribution from a dependent data stream. Marginal distribution functions evolve under uniformly bounded Kolmogorov increments, while observations satisfy a rolling-window concentration condition. For rolling empirical quantiles we prove non-asymptotic bounds with stochastic term $\sqrt{\log W/W}$ and drift term $\delta_T W$. Balancing them yields the benchmark window $W_T^* \asymp \delta_T^{-2/3}$ and tracking error $\delta_T^{1/3}$, up to logarithmic factors. A complete two-point argument gives a matching polynomial minimax lower bound for terminal quantile estimation. We also prove a localized Lepski oracle inequality and report simulations comparing it with practical window-selection rules. All mathematical claims used in the paper are proved in full.

CT MathTech 2026-0137 Time Series Forecasting of Red Chilli Prices in Negeri Sembilan: A Box-Jenkin Application

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Red chilli is an important agricultural product in Malaysia that is commonly used in food production by households and industries. The unpredictable price trend for this agricultural product has been a major issue for the involved stakeholders, as it has affected many aspects of their daily activities such as earning stability, planning and affordability. Forecasting the price of the product, therefore, becomes an important activity to facilitate proper planning in the agricultural industry. The current research intends to forecast the weekly price trend of the red chilli in Negeri Sembilan utilizing the Box-Jenkins approach that stresses on the importance of systematically identifying, estimating, and testing the validity of different models. The weekly price trend data for red chilli was collected from Federal Agricultural Marketing Authority (FAMA) from January 2020 to February 2025. Some Seasonal Autoregressive Integrated Moving Average (SARIMA) models were considered, but the SARIMA (1,1,2) (1,1,1) was selected because of the smallest Akaike Information Criterion (AIC). The findings from the study would be useful to policymakers, agriculture departments, and farmers when addressing problems related to price variations and market stability. This is because such conclusions would help in the preparation of accurate predictions, which in turn contribute to making the agricultural economy of Malaysia strong and helping the small and medium enterprises (SMEs) in the food industry. In the future, studies will focus on applying other machine learning algorithms, such as the Artificial Neural Network (ANN) and LSTM models.

CT MathTech 2026-0143 Stochastic Sustainable EPQ Model with Carbon Tax, Emission Cap, and Endogenous Green Investment under Demand and Defect-Rate Uncertainty: Theory and Application to Semiconductor Manufacturing

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Deterministic sustainable Economic Production Quantity (EPQ) models with carbon taxation and green investment cannot capture the demand and defect-rate stochasticity inherent in semiconductor Outsourced Assembly and Test (OSAT) operations. This paper develops a chance-constrained stochastic EPQ model that jointly optimises lot size Q, green investment G, and safety stock s under random demand for $\tilde{D} \sim (\mu_D, \sigma_D^2)$, random defect rate $\tilde{\delta} \sim (\mu_\delta, \sigma_\delta^2)$, and correlation $\rho \in [-1, 1]$ subject to a carbon tax and a probabilistic emission cap at service level $1 - \epsilon$. Strict convexity and positive definiteness of the Hessian of the expected total cost $\mathrm{ETC}(Q, G, s)$ are proved, guaranteeing a unique global optimum in closed form. A Value-of-Stochastic-Solution theorem quantifies the cost of ignoring uncertainty. Four industry-calibrated examples show that deterministic models underestimate optimal green investment by 7-23% and expected cost by 4-18%. Results support Malaysia's 2026 carbon tax and EU Green Deal compliance.

CT MathTech 2026-0147 An Enhanced Double Exponentially Weighted Moving Average Chart in Short Production Runs

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Short production runs are commonly encountered in high-mix and low-volume manufacturing environments, particularly in job-shop operations where a wide variety of products are manufactured in small batches under limited inspection time. Motivated by these characteristics, this study investigates the performance of the auxiliary information-based double exponential weighted moving average (DEWMA-AI) chart for monitoring changes in the process mean in short production runs (SPR) (denoted as the DEWMA-AI SPR chart). Monte Carlo simulation is used to evaluate its performance using the Truncated Average Run Length (TARL) and Truncated Standard deviation of Run Length (TSDRL) as performance metrics. The proposed chart is then compared with the existing auxiliary information-based Shewhart chart for SPR (denoted as the $\bar{X}$-AI SPR chart) and Exponential Weighted Moving Average chart for SPR (denoted as the EWMA-AI SPR chart). The comparative study reveals that the DEWMA-AI SPR chart generally outperforms the $\bar{X}$-AI SPR and EWMA-AI SPR charts. However, the EWMA-AI SPR chart performs better than the DEWMA-AI SPR chart when smaller smoothing constant and shift size are considered.

CT MathTech 2026-0159 Parametric Bootstrap Goodness-of-Fit Tests for the Skew-normal Distribution with Estimated Parameters

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The skew-normal distribution is widely used for modeling asymmetric data arising in biological, environmental, financial, and engineering applications. However, existing goodness-of-fit tests for the skew-normal distribution often rely on asymptotic approximations that may perform poorly when the parameters are estimated. In this work, we propose two parametric bootstrap goodness-of-fit tests for the skew-normal distribution based on the Kolmogorov–Smirnov and Cramér-von Mises statistics. The proposed procedures incorporate repeated parameter re-estimation within each bootstrap sample, thereby properly accounting for parameter estimation uncertainty. To improve numerical stability, we further propose a modified estimation framework combining maximum likelihood and penalized likelihood estimation, substantially reducing convergence failures encountered in skew-normal fitting. Extensive simulation studies are conducted across multiple sample sizes and a broad range of alternative distributions. The proposed methods are evaluated in terms of estimated size, p-value behavior, and statistical power. Comparisons are made with existing R package implementations of goodness-of-fit test for distributions with estimated parameters, as well as with a modified Shapiro-Wilk test tailored to the skew-normal model. Simulation results show that the proposed bootstrap tests provide better type I error control and improved power performance across most scenarios, with the bootstrap Cramér-von Mises test consistently exhibiting the best overall performance. Several real data sets, including gene expression, earthquake, and financial data, are analyzed to illustrate the practical applicability of the proposed methods. A user-friendly R package is also developed to implement the proposed tests.

CT MathTech 2026-0166 Modified Group Chain Sampling Plans (MGChSP-1) for Gamma Distribution

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Acceptance sampling is an important statistical method in quality control that assists manufacturers in determining whether to accept or reject a production lot based on sample inspection. Single sampling plans (SSP) are simple to implement; however, the SSP may require larger sample sizes or stricter acceptance criteria under certain quality requirements. To address these limitations, the chain sampling plans (ChSP-1), and its modified chain sampling plans (MChSP-1) were developed to achieve a better balance between producer's and consumer's risks. In addition, group sampling plans (GASP) were introduced to reduce the inspection time and cost. The integration of MChSP-1 with GASP leads to the development of the modified group chain sampling plans (MGChSP-1). To the best of the authors' knowledge, MGChSP-1 under the gamma distribution has received limited attention in the literature. This study develops and evaluates the MGChSP-1 under the gamma distribution. The MGChSP-1 focuses on the minimum number of groups while maintaining desirable operating characteristics. The MGChSP-1 integrates GASP and MChSP-1, where samples are randomly selected, divided into groups, and tested at a predetermined termination time. Lot acceptance is determined based on the number of defectives in both the current and preceding lots. The probability of lot acceptance and the proportion of defectives are computed using the cumulative distribution function for gamma distribution. The results indicate that MGChSP-1 requires fewer groups compared to the new group chain sampling plans (NGChSP-1). In addition, the MGChSP-1 provides lower lot acceptance for higher mean life ratios compared with the NGChSP-1. Overall, MGChSP-1 offers

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.

CT MathTech 2026-0205 Multivariate Analysis of ENSO-Related Atmospheric Circulation Variability over Malaysia using ERA5 Reanalysis

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The El Niño–Southern Oscillation (ENSO) is the dominant mode of interannual climate variability over the Maritime Continent. This study examines ENSO-related atmospheric circulation variability over Malaysia using monthly ERA5 reanalysis fields for 1996–2025 over the domain 5°S–15°N, 95°E–120°E. Principal component analysis is applied to 850 hPa geopotential, 850 hPa zonal wind, 850 hPa meridional wind, and 500 hPa vertical velocity. The leading principal components are correlated with the Niño 3.4 SST anomaly index using Spearman rank correlation. Several modes are statistically significant after serial- correlation correction, with the strongest associations found for 850 hPa geopotential and 500 hPa vertical velocity. The significant modes are consistent with a physically interpretable ENSO-related circulation pattern over Malaysia. During El Niño, this pattern suggests anomalous mid-tropospheric subsidence, increased lower-level geopotential, anomalous low-level easterlies, meridional adjustment of the low-level wind field, and a weak southerly anomaly. The opposite tendency is observed during La Niña. Overall, the selected ERA5 circulation fields provide physically interpretable indicators of ENSO-related atmospheric variability over the Malaysian region, particularly anomalous subsidence and reduced-convection conditions.

CT MathTech 2026-0208 Fiscal–Monetary Policy Coordination in Malaysia: Evidence from a Multi-Equation ARDL Analysis

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This study examines fiscal–monetary policy transmission in Malaysia using a seven-equation Autoregressive Distributed Lag (ARDL) framework and quarterly observations from 1979Q1 to 2023Q4. The behavioural equations represent the output gap, real money demand, aggregate demand, inflation, interest rate, money-supply growth and exchange-rate deviation. The ARDL bounds-testing approach is employed to assess long-run relationships, followed by an Error Correction Model (ECM) to quantify short-run dynamics and the speed of adjustment. The unit-root results indicate a mixture of I(0) and I(1) variables with no I(2) variable, satisfying the integration-order requirement for ARDL. Bounds tests indicate a long-run relationship in all seven equations. The ECM coefficients are negative and statistically significant, with adjustment speeds ranging from about 2.5% per quarter for the output gap to about 53% for money-supply growth. Government spending has significant short-run effects on the output gap and aggregate demand, while its long-run effects are weaker. Real GDP has a positive and significant long-run relationship with real money demand, and world inflation is positively associated with domestic inflation in the long run. Forecast performance is heterogeneous: real money demand performs exceptionally well, whereas exchange-rate deviation is more difficult to forecast. These results are consistent with previous evidence that fiscal multipliers, monetary transmission and exchange-rate responses are state- and sector-dependent. The study contributes an integrated empirical framework for comparing adjustment dynamics across macroeconomic sectors and provides policy recommendations for more appropriately sequenced fiscal–monetary coordination in Malaysia.

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 $\mathbb{Z}_n \setminus \mathrm{Nil}(\mathbb{Z}_n)$, 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 $1, 2, \ldots, k$ 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.

CT MathTech 2026-0067 The Locating Proper Rainbow Edge Connection Numbers of Several Graphs with Diameter Two

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

$$rc_\Pi(e) = (d(e, R_1), d(e, R_2), \ldots, d(e, R_k)),$$

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.

CT MathTech 2026-0068 The Locating Proper Rainbow Vertex Connection Numbers of Some Operations of Complete Graphs

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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 $(1-\alpha)p(z) + \alpha p^2(z) + \beta z p'(z)$ 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 2026-0128 Diffraction of a Rectangular Random Block Substitution

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While constant-shaped random block substitutions have been widely studied via their diffraction measures and spectral decompositions, existing work has focused predominantly on square inflation geometries. In this paper, we extend the diffraction measure framework to a class of two-dimensional, rectangular random block substitutions over a binary alphabet with asymmetric scaling factors. Such random substitution is primitive, compatible, and satisfies the scrambling property, which rigorously rules out the presence of a singular continuous spectral component. Consequently, the associated diffraction measure decomposes into a purely mixed spectrum consisting solely of a pure point and an absolutely continuous part. Furthermore, we derive exact recursive formulas for the expected Fourier transforms and covariance terms, providing high-resolution visualizations of both spectral components across various marginal probability configurations to illustrate the role of spatial symmetry in diffraction.

CT MathTech 2026-0129 Palindromic Complexity in SFT Random Substitution Subshifts

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The combinatorial properties of sequences generated by deterministic and random substitution rules have significant applications across physics and computer science [1]. A fundamental metric of interest is the palindromic complexity, which counts the number of distinct palindromes of length k occurring in an infinite sequence [2,3]. In this paper, we determine the palindromic complexity of infinite words in a random substitution subshift X_G associated with a shift of finite type (SFT) defined by an arbitrary finite directed graph G, following the framework established in [4]. We prove that the recurrence relation governing the number of palindromes across different lengths is explicitly determined by the characteristic polynomial of the structural adjacency matrix A_G of the underlying SFT archipelago. Using these algebraic properties, we derive both closed-form expressions via generating functions and direct matrix-power formulations that completely characterize the palindromic growth of the subshift.

CT MathTech 2026-0130 On Some Families of Substitutions over Infinite Alphabets

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We investigate four families of substitutions over infinite alphabets induced by a sequence $a = (a_i)_{i\in\mathbb{N}_0}$ under specific growth and boundary restrictions. For each family, we establish primitivity and prove that the associated substitution operators are quasicompact. For cases where a is eventually periodic, we analyze the resulting geometric inflation rules, explicitly characterizing their inflation factors and natural tile lengths. In particular, for two of these families, we prove that the eventual periodicity of a is equivalent to the substitution yielding an algebraic integer inflation factor and a finite set of distinct tile lengths, a rigidity that stems from their projection onto finite-alphabet systems. Finally, we establish an alignment across these classes by showing that the first and third families share identical natural tile length functions, as do the second and fourth families.

CT MathTech 2026-0131 Dynamical System of a Lotka-Volterra Operator with Non-Isolated Fixed Points

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In this study, we consider a class of non-linear operators known as the Lotka-Volterra operator. Under certain constraints on its component functions, the operator is shown to have non-isolated fixed points in the interior and on the boundary of the 2-simplex. Then, by analysing the Jacobian of the op- erator, the local stability of the fixed points is also determined. Furthermore, the omega-limit set for any initial point in the 2-simplex is described in general for both sign-definite and positive single sign-indefinite component functions. By considering an additional condition to the operator, the omega-limit set is also described for a negative single sign-indefinite component function. Under the assumed constraints and conditions, the dynamical system converges to one of the fixed points for any initial point in the 2-simplex, and consequently the operator is shown to exhibit the property of being regular. Finally, by computing the Schwarzian derivative of the restriction of the operator to the invariant path we give a sufficient condition by which the operator undergoes a supercritical flip bifurcation.

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 nth 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-Pethö 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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